STANDARDIZATION OF INTEGRATED NUTRIENT MANAGEMENT AND ORGANIC NUTRIENT MANAGEMENT FOR DRAGON FRUIT PRODUCTION IN MIZORAM

BY

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Submitted

In partial fulfillment of the requirement of the Degree of Doctor of Philosophy in Horticulture, Aromatic and Medicinal Plants of Mizoram University, Aizawl

MIZORAM UNIVERSITY
(A Central University under the Act of Parliament)
Department of Horticulture, Aromatic & Medicinal Plants
उद्यानिकी, सगन्ध एवं औषधीय पादप विभाग

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CERTIFICATE

This is to certify that **R.C. LALDUHSANGI** has prepared a Thesis under my Supervision on the topic "**Standardization of Integrated Nutrient Management and Organic Nutrient Management for Dragon Fruit Production in Mizoram**" in partial fulfillment for the award of the Degree of Doctor of Philosophy (Ph.D.) in the Department of Horticulture, Aromatic and Medicinal Plants, Mizoram University, Aizawl.

This thesis has been the outcome of her original work and it does not form a part of other thesis submitted for the award of any other degrees.

She is duly permitted to submit the Thesis.

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DECLARATION

Mizoram University

April, 2023

I **R.C. LALDUHSANGI**, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/ Institutes.

This is being submitted to the Mizoram University for the Degree of Doctor of Philosophy in Horticulture, Aromatic and Medicinal Plants.

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"Give thanks to the LORD, for he is good, his love endures forever.

Psalms 107:1

Date: ***(R.C. LALDUHSANGI)***

Dedicated

to

My beloved family

For their endless love, support and encouragement.

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CHAPTER 1

INTRODUCTION

Dragon The genus *Hylocereus* (A. Berger) Britton and Rose (1909) comprises 18 species (Anderson, 2001). Dragon fruits [*Hylocereus spp.* (Hawort) Britton & Rose] have been called the most fascinating fruit in the family Cactaceae. Other names used include Pitaya, strawberry pear, pitahaya, sometimes also called 'moon flower ' or' Lady of the night, and kamalam, Sanskrit for the lotus flower in India. Dragon fruit is a long day plant. The dragon fruit is known for its especial appearance compared with other horticulture fruit crop, which is characterized by a red/pink or yellow skin that is covered in green scales. Dragon fruit has a long history dating back to the pre-Columbian era, where it was cultivated by the indigenous people of Southern Mexico and Central America. The fruit was later introduced to Southeast Asia, where it became popular in countries like Vietnam, Thailand, Malaysia, Sri Lanka, Philippines, Indonesia and Bangladesh. It is now commercially cultivated worldwide in over 20 tropical and subtropical countries such as Bahamas, Bermuda, Indonesia, Colombia, Israel, the Philippines, Myanmar, Malaysia, Mexico, Nicaragua, northern Australia, Okinawa (Japan), Sri Lanka, southern China, southern Florida, Taiwan, Tailand, Vietnam, Bangladesh, and the West Indies (Mercado-Silva, 2018) due to its commercial importance, not demanding cultivation requirements, i.e. high drought tolerance, easy adaptation to light intensity and high temperature, a wide range of tolerance to different soil salinities, and benefits to human health (Nobel and La Barrera 2004; Nie *et al.* 2015; Crane *et al.* 2017; Mercado-Silva 2018). Vietnam has the largest area of pitaya cultivation in Asia and it is grown in 63/65 cities/provinces of the country (Hoat *et al.* 2018; Hien 2019). Vietnam is the main exporter of dragon fruit world wide due to high global demand (Ratnala and Abd Rahman, 2017). The fruit has gained popularity in recent years due to its unique appearance and health benefits.

Dragon fruit is a perennial, epiphytic, climbing cactus with triangular, fleshy, jointed green stems. Each stem segment is composed of three wavy wings with horny scalloped margins. The stem segments may grow to 20 ft long. Each trough of the scalloped wings has one to three short spines, and some varieties are spinier than others. Aerial roots grow from the underside of the stems, providing anchorage for the plants to climb on walls, rocks, or trees. Dragon fruit is a semi-epiphytic plant which prefers a dry tropical or subtropical climate with an average temperature of 21-29 °C, but can withstand temperatures of 38-40 °C and freezing temperature (as low as 0 °C) for short periods. This crop preferred a suitable environmental factors especially tropical and sub-tropical photoperiodic climate, good sunlight and sufficient rainfall of 600-1300 mm with alternating wet and dry seasons and humid sandy soil, etc (McMahon, 2003). All these factors are also required for flowering and fruit setting (Nerd and Mizrahi, 1995; Yen and Chang, 1997, Feng-Ru and Chung-Ruey, 1997). It can be grown from seeds or stem cuttings, but rooted cutting are commonly used for commercial cultivated material. The plant is a heavy feeder of nutrients and requires ample amount of regular watering and fertilization, and it is susceptible to pests and diseases such as mealybugs and bacterial spot. Dragon fruit is typically harvested when the fruit is ripe, which is indicated by the color and texture of the skin. It takes about one to three years for the plant to mature and produce fruit depending on the ages and type of material used for propagation. The flower bloom only at night, the night-blooming, yellowish green flowers are about 1 foot long and 9 inches wide, bell shaped, and excellent fragrant smell as well (Zee *et al.* 2004). The flowers are mainly pollinated by bats and moths. The fruit are oval to round shaped and can grow up to 10 inches long and 4 inches in diameter. The skin of the fruit is thin and easily peeled, revealing a soft, juicy flesh with black, crunchy seeds that is rich in vitamins and minerals, generally each dragon fruits pulp weight about 200 to 700gram / fruit. Pitaya is an exotic fruit due to its distinct appearance e.g., red flesh with pink skin (*Hylocereus polyrhizus*; Britton and Rose 1920), white flesh with pink skin (*Hylocereus undatus*; Britton 1918) or red-purple flesh with red skin (*Hylocereus costaricensis*; Britton and Rose 1909) or yellow skin and white flesh [*Selenicereus megalanthus* (K. Schum. ex Vaupel) Moran 1953 (synonym *Hylocereus megalanthus*)] (Ortiz-Hernández and Carrillo-Salazar 2012; Muniz *et al.* 2019)

Dragon fruits were used for many purposes, but one of major importance is the fruit as a food source (Luders and Mc Mahon, 2006). The nutritional value of dragon fruit varies depending on the species, origin and harvesting time (Liaotrakoon, 2013). Nutritional composition and the phytochemical properties of red dragon fruit significantly differ due to the influence of the growing environmental conditions (Nurul and Asmah, 2014). It is well known for its rich nutrient contents, low in calories and its offers numerous nutrients, including vitamin C, phosphorus, calcium as well as its antioxidant characteristic (Patwary *et al.*, 2013), which help protection against cellular damage and reduce the risk of chronic diseases such as cancer and heart disease. Dragon fruit improves digestive health and prevent constipation due to its high content of fibre. According to the United States Department of Agriculture (USDA), a 1-cup serving of dragon fruit contains: 103 calories, 0 grams of fat, 5.6 grams of fiber, 27.4 grams of carbohydrate. The young stem, also contains high nutritional values, including raw protein (10.0–12.1 g/100 g), raw fibre (7.8–8.1 g/100 g), and several minerals such as P, K, Ca, Mg, Na, Fe, Zn, in which Fe amounts to 7.5–28.8 mg/ kg of dry mass (Ortiz-Hernández and Carrillo-Salazar, 2012). Besides being consumed fresh, dragon fruit can also be processed into juice and puree. Dragon fruit and its products may be used as ingredients for innovative food products that respond to consumers' interest (Le Bellec *et al.*, 2006; Sabbe *et al.*, 2009). They are widely used in various food products such as sweets, yogurts, ice creams, pastries, jams, jellies and wines. This is due to its special colour (especially red/purple pigments in red-flesh dragon fruit), high nutritional values and antioxidative properties of the fruit (Mohd., 2010).

Dragon fruit cultivation in India has gained popularity in recent years due to its high demand and potential for profitable farming. The tropical climate and diverse soil types in India make it suitable for the growth of dragon fruit, which requires well-drained soil, plenty of sunlight, and a warm climate. The major dragon fruit cultivated states in India are Karnataka, Kerala, Maharashtra, Gujarat, Andhra Pradesh, Tamil Nadu, and Telangana. The cultivation of dragon fruit in India has seen a steady increase in recent years due to its high yield and adaptability to different agro-climatic conditions. Presently, the total area under cultivation of dragon fruit in India is more than 3,000 ha. which is not able to meet the domestic demand, hence majority of the dragon fruits available in Indian market is imported from Thailand, Malaysia, Vietnam and Sri Lanka. The fruit cultivation is excellent in a region where less rainfall is expected. under Mission for Integrated Development of Horticulture (MIDH), a roadmap is being prepared for cultivation of this crop in the identified potential area to increase the production of exotic and niche area fruits including dragon fruit. The target for area expansion under MIDH for dragon fruit is 50,000 ha. in 5 years. The cultivation of this fruit has started recently, and a plantation of this healthy fruit is established at ICAR-Central Island Agricultural Research Institute, Port-Blair, Andaman and Nicobar Islands and IIHR, Bengaluru, Karnataka.

Under MIDH, the Ministry of Agriculture & Farmers Welfare has approved a Centre of Excellence (CoE) for dragon fruit to be established by Indian Institute of Horticultural Research (IIHR) at Hirehalli, Bengaluru, Karnataka on 09-03-2023 to focus on production, post-harvest and value addition of dragon fruits.

It is increasingly gaining interest, more and more farmers are turning towards it, including Mizoram which is a state with a climate ideal for its cultivation. In Mizoram approximately the total land area of 430 ha is under dragon fruit cultivation. In Aizawl District alone out of the total 430 ha of land 210 ha is under dragon fruit cultivation (Anon., 2017). The market price of the dragon fruit is relevantly high, which ranges from Rs 200/- to Rs. 400/- according to the quality of the fruit and also the availability with respect to harvest season. This makes it a good prospect for the farmers too. The climatic condition of Mizoram is suitable for the cultivation and also that Mizoram is the pioneer of the cultivation of dragon fruit on a large scale. The Department of Horticulture had chosen the beneficiaries in terms of the area of land which the farmer had and the kind of techniques which had been practiced in the past (Anon., 2017). In general, there are two species of dragon fruits commonly found in Mizoram market i.e. red pulped dragon fruit [*Hylocereus polyrhizus* (Weber) Britton & Rose] and white pulped dragon fruit [*Hylocereus undatus* (Hawort) Britton & Rose].

Dragon fruits are non-climacteric and they are sensitive to chilling injury. Fruits can be harvested 30 days after fruit set, but it is better to delay harvest, to perhaps as much as 50 days after fruit set, to allow more sweetness to develop. The fruit continues to grow in size until harvested, with no noticeable change in sugar content. It was reported that fruits harvested 50 days after flowering are 50 percent heavier than at earlier harvests (30days) (Yen and Chang, 1997).

In India, commercial cultivation of this fruits is picking up, it is increasingly gaining interest in the country and more farmers are turning towards it, including Mizoram which is one of the states in India to successfully produce dragon fruit though its commercial cultivation was started back in 2013 in some part of the State in Mizoram including Aizawl, Kolasib, Lunglei, Mamit, Lawngtlai and Serchhip Districts. With the intervention of the State Department of Horticulture, Government of Mizoram had made a tremendous contribution by emphasizing the cultivation of dragon fruit. However, till date the crop is cultivated in the state with no proper management of either integrated nutrients or organic farming. Therefore, it's become crucial to know the systematic management of nutrient regarding integrated and organic farming in dragon fruits for its successful cultivation to increase the yield. Thus, current study was conducted so that the standardized nutrients management protocol can be suitable to be used for the farmer's practices in dragon fruit growing areas of Mizoram as well as of NEH region.

1.1 Scope of the study:

Dragon fruit is a newly introduced crop to the state of Mizoram and its production is gaining popularity for local, intra state and export market demand of the fruit. With the intervention of the State Department of Horticulture, Govt. of Mizoram, an ample number of farmers are being involved in cultivation of the fruit, though the information on its systematic nutrient management either integrated or organic is not yet available. Moreover, in India, commercial dragon fruit cultivation is also a new venture, which still not yielded enough scientific know-how for crop's organic or integrated nutrient management practices.

Concept of nutrition for proper plant health has got paradigm shift from more inorganic input based cultivation to integrated plant nutrition system. Further, organic production has got tremendous importance so far this eco-geographic region is considered. Systematic combination of different organic inputs viz. manures, bio-fertilizers along with inorganic inputs are to be tried to provide the plant with proper nutrition while maintaining the soil-plant health system to obtain a premium yield of the crop. Besides, organic nutrient management are consider as crucial as organic, garden fresh fruits has got export market and the state long being cultivated through traditional way have got potential to have organic fruit production. Hence, the present study has been designed to have standardized cultivation protocol for Dragon fruit though integrated and organic nutrient management practices with the following broad scope of the study:

a. Standardization of integrated and organic nutrient management package for dragon fruit production at Mizoram will enable to adopt an optimized the nutrient management practice for successful cultivation of dragon fruit in other growing areas of NEH region.

b. Findings of the present investigation will help us to figure out the effect of integrated and organic nutrient management on soil nutrients and microbial organisms in dragon fruit orchard which will definitely help in both integrated and organic nutrient management of other crops.

1.2 Objectives:

i. To standardize the integrated nutrient management (INM) practices in dragon fruit

ii. To standardize the organic nutrient management practices in dragon fruit

iii. To study the benefit cost ratio under INM & organic nutrient management

CHAPTER 2

REVIEW OF LITERATURE

2.1 Impact of integrated nutrient management on fruit crops

Rana and Chandal (1999) revealed that the plant growth, fruit yield and fruit quality of strawberry were significantly increased with the application of mixed bio-fertilizer and nitrogenous fertilizers. Application of Azotobacter inoculation along with 80 kg N/ha showed maximum TSS content in strawberry.

Goramnagar *et al.* (2000) reported that the application of P and K in the form of SSP and MOP increased their respective contents in leaf and soil in proportion to rates applied. Synergistic effects of Mg with N were observed in leaves, but the level of Mg in soil was substantially decreased. N content in soil was increased by all treatments; contents of Phosphorus, Potassium and Calcium were only influenced by the application of fertilizer in combination. Compared to the rest of the treatments, treatment with 15kg FYM+180g P_2O_5 was more efficient. Among organic manures, the application of neem cake was efficient.

Ingle *et al.* (2001) conducted a study in Akola, results showed that the yield and quality of sour lime fruits improved significantly due to the application of neem cake together with chemical fertilizers. Significantly, higher yields with better fruits were obtained from trees that received 600 g N, 300 g P2O5 and 300 g K2O +15 kg neem cake per plant per year.

Suresh and Hasan (2001) evaluated the response of inoculation with Azospirillum and phosphobacteria on fruit quality of banana (*Musa* MA) cv. Giant Governor by manipulating the doses of nitrogen and potassic fertilizers. The result shows that inoculation of bio-fertilizers along with the application of recommended dose of fertilizer proved most effective in improving fruit quality of Dwarf Cavendish banana cv. Giant Governor.

Aariff *et al.* (2004) determined the effect of components of integrated nutrient management on fruit yield and quality of acidic lime in red calcareous soil.

Among treatments, the integrated use of 25kg FYM + 2kg PM/herb together with 200g IP/herb outperformed the other treatments and increased significantly in the direct and cumulative effects treatments relative to the control. While FYM alone gave the highest cumulative effect for acidity at 50 kg/ plant, 25 kg FYM + 2 kg PM +200 g IP/plant recorded the highest acidity at 12-month direct effects.

Baksh *et al*. (2008) reported that the fruit quality in Guava related to their growth parameters viz. plant height, spread and trunk girth, improvement in yield and yield attributing character i.e. fruit set, retention, individual fruit weight and yield, quality of fruits viz. TSS, ascorbic acid, reducing and non-reducing sugar were improved with the application of 100% NPK bio-fertilizers which was at *par* with 75% NPK + bio-fertilizers treatment.

Dalal *et al*. (2004) reported that the application of 75 kg FYM + 1500 g N + 1000 g Pps + 500g Kp + 12.5 g PSB improved the yield of the sapota.

Korwar *et al*. (2006) revealed that the growth, yield and fruit quality of aonla were significantly influenced by the application of combine treatment of organic and inorganic nutrients. Vermicompost play a significant role in the improvement of fruit quality.

Kumar *et al.* (2008) conducted an experiment on various combinations of NPK on fruiting, yield and fruit quality were studied in guava cv. Pant Prabhat and observed that treatments with 150g N, 50g Pand 75g K per plant per year attained maximum yield and fruiting of guava fruits.

Medhi *et al*. (2007)found from the experiment which was conducted on Khasi Mandarin an observed that plants fertilized with Mustard Oil Cake (MOC) (10kg/plant), bio-fertilizers (Azotobacter and PSB) and K_2O (600 g/plant) with no inorganic N showed highest soil pH, available P_2 O_5 , leaf P and K .However, with the application of half of the recommended dose of inorganic N and P_2 O_5 were supplemented through Azotobacter and PSB along with K_2 O (600 g/plant) and Mustard Oil Cake (7.5 kg/plant) highest soil organic carbon available Nitrogen, fruit quality viz. Juice, TSS, total sugar, ascorbic acid and yield with highest economic return (5.75) were obtained.

Ram *et al.* (2007) studied the effect of INM in guava and reported that maximum increases in plant height , plant spread E-W & N-S were recorded with dose of 250 g N, 100 g P_2O_5, 250 g K_2O, 10 Kg FYM and 250 g Azotobacter.

Srivastava *et al.* (2008) examined the use of organic materials such as farmyard manure, cakes of plant origin, vermicompost, and microbial bio-fertilizer on citrus fruit. Mycorrhizal-treated trees had better plant growth and uptake of nutrients like P, Ca, Zn, Cu, and Fe compared to non-mycorrhizal trees.

Bashir *et al.* (2009) studied to determine optimum dose of FYM and NPK fertilizers for improving yield and fruit quality of guava cv. Larkana Surahi. Maximum yield per plant, single fruit weight , pulp weight, fruit size, number of seeds and TSS were obtained by guava plants applied with 40 kg FYM + 1 kg each of N-P-K per plant.

Bhalerao *et al.* (2009) conducted an experiment on integrated nutrient management for tissue cultured Grand Naine banana. Fruit yield of banana were found beneficial by the application of Azospirillum 25 g/plant + PSB 25 g/plant + 10 Kg FYM + 100% recommended dose of NPK/plant.

Dutta *et al*. (2009) examined the effect of bio-fertilizer on growth and productivity of guava. Studied revealed that the combined application of bio-fertilizer and inorganic fertilizer i.e *Azospirillium* + VAM inoculation along with 100% N + 100% P_2O_5 showed significantly increased related to plant height and spread, along with achieving better yield and quality fruits.

Gaikwad *et al.* (2009) studied the effect of bio-fertilizers on nutrient uptake and yield attributes of banana. Studied revealed that the application of 100% RDF+*Azospirillum* (50 g/plant)+PSB (50 g/plant)+VAM (250 g/plant)+*T. harzianum* (50 g/plant) recorded highest yield. Higher N uptake was observed in the treatments where *Azospirillum* bio-inoculant was used. P uptake was higher in the treatments where PSB and VAM were used.

Iqbal *et al.* (2009) investigated the effect of organics FYM integrated with urea and Azotobacter on growth, yield and quality of strawberry cv. Chandler. The fruit quality viz. total soluble solids, total sugars, ascorbic acid and anthocyanin content was highest in fruits obtained from plants supplied with 25 per cent nitrogen through FYM + 75 per cent nitrogen in the form of urea + Azotobacter.

Kumar *et al.* (2009) conducted an experiment to substitute the mineral fertilizer with bio-fertilizer in the field of strawberry cv. Camarosa. Result revealed that the sole inoculation of Azospirillium and Azotobacter and in combination with PSB significantly influenced the plant height and leaf size, fruiting and the yield per hectare area has increased significantly through the application of bio-fertilizer. fruit size in respect to fruit length, width and volume as well as fruit quality attributes viz. TSS:Acid ratio and reducing sugar content was also measured maximum in the treatment consist of 75% RDF + Azospirillium @ 2g/plant + PSB @ 2g/plant + top dressing of 25% K.

Khan *et al.* (2009) observed that application of organic manures - FYM and press mud, bio-fertilizer (VAM) and inorganic agricultural grade iron pyrites either alone or in combinations influenced regarding the active iron, sap pH and total chlorophyll content of acid lime.

Shukla *et al.* (2009) studied the combined application of organic manures, inorganic fertilizers, bio-fertilizers and foliar spray of micronutrients on eight-year-old guava trees cv. Sardar under high density planting. The results revealed that the application of 50 percent dose of recommended NPK + 50 kg FYM + 250 g Azotobacter significantly increased the plant canopy volume.

Singh and Singh (2009) concluded that highest fruit set, yield and optimum fruit quality was recorded in plants inoculated with Azotobacter and Azospirillum along with 60 kg N ha^{-1} (50% N of the standard dose) and 100 ppm GA_3 in strawberry cv. Sweet Charlie.

Yadav *et al.* (2009) reported that maximum number of shoots, number of leaves, number of fruit, fruit weight per shoot and yield as well as fruit size, average weight, juice percentage, total soluble solids and ascorbic acid was observed with soil application of 110g Urea + 125g SSP + 26g MOP + 10 Kg FYM + 25 g Azotobacter + 25 G PSB in phalsa.

Ashraf *et al.* (2010) studied the improvement in yield and quality of kinnow by potassium fertilizer application an result showed increases yield and fruit quality but K at 100 kg K_2O ha^{-1} was more effective in increasing fruit weight, size and peel thickness. The results indicated that all K fertilization rates improved yield and fruit quality and reduced fruit drop, however, the 75 kg K2O ha^{-1} ratio was more effective because of the juice weight and ratio, total dissolved solids/acid ratios and nutrient uptake showed significant improvement.

Dutta *et al.* (2010) study the integrated nutrient management in litchi cv. Bombai. Result revealed that treatment consisting of NPK @ 500g: 250g: 500g +50 Kg/ tree FYM + 150 g Azotobacter + 100g VAM/tree/year showed yield (98.72 kg/plant) and also have a significant improvement in terms of TSS, total sugars, ascorbic acid,TSS: acid ratio, fruit weight and fruit size.

Kirad *et al.* (2010) determined the effect of Integrated Nutrient Management on growth, yield and quality of papaya cv. Surya. The plants fertilized with 75% RDF + 25% vermicompost + rhizosphere bacteria culture treatment was found superior and observed maximum number of leaves, trunk girth, number of fruits per plant, average fruit weight, pulp thickness, shelf life of fruit, vitamin A and TSS under this treatment.

Musmade *et al.* (2010) studied the impact of integrated nutrient management of acid lime. Result revealed higher yield with better quality fruits were obtained in plants which received the combined application of 600:300:600 gm NPK+15 kg each of FYM and neem cake per plant per year.

Baviskar *et al*. (2011) examined the effect of organic, inorganic manures and bio-fertilizers on yield and quality of sapota. Maximum fruit yield, fruit weight, fruit size, fruit volume, pulp and peel weight, total soluble solids and total sugar with lower acidity was obtained with plants fertilized with 1125:750:375 g of NPK + 15 kg vermicompost + 250g Azotobacter + 250g PSB/ plant.

Barne *et al.* (2011) studied the influence of organic, chemical and bio-fertilizer on guava plants and revealed that the fruit yield and fruit quality viz. fruit weight, fruit size, fruit volume were observed maximum in plants which were treated with 250g Azotobactor + 50kg FYM + 487.5g + 243.75g + 281.25g NPK + 250g PSB/plant.

Mishra *et al.* (2011) studied the effect of integrated nutrients management on growth and yield of ber. Results revealed that application of 22 kg vermicompost + 0.82 kg urea + 1.15 kg SSP + 0.41 kg MOP per tree (F_5) and foliar spray of thiourea @ 0.5 per cent (T_2) significantly increased the plant height, plant spread, leaf area, average weight of fruit and fruit yield per tree and reduced the fruit drop.

Kundu *et al.* (2011) studied the impact of bio-fertilizer and inorganic fertilizer in pruned mango orchard cv. Amrapali and concluded that the treatments 100%NPK + Azotobacter + VAM and 75% NPK + Azotobacter + VAM were effective and may be adopted to improve the vegetative growth and productivity with quality fruits.

Yadav *et al*. (2011a) evaluated the response of organic, inorganic, bio fertilizer on mango cv. Amrapali under high density orchard. Result shows that maximum plant growth i.e panicle length, number of flowers per panicle, fruit set per panicle and sex ratio as well as fruit Physico -biochemical characteristic v*iz.*, maximum fruit length, width, weight, pulp weight, stone weight, pulp: stone ratio, number of fruits per tree and fruit yield was recorded with treatment of recommended dose of NPK + vermicompost + *Azotobacter* + PSB + Zn + Fe + paclobutrazol.

Yadav *et al.* (2011b) an experiment was conducted to study the effect of organic, inorganic and bio-fertilizer combination on the growth and physico-chemical attributes of papaya. Result concluded that combination application of 25g of Azotobactor + 10 kg of vermicompost + 100% NPK increase the plant height of papaya fruit as compared to other treatment.

Alila *et al.* (2012) stated that Passion fruit, a perennial climbing plant cv. Kaveri, where yield and soil fertility changes on Alfisol treated manure: 100% NPK, 75% NPK + Azospirillum, 75% NPK + Azotobacter, 75% NPK + Phosphotica, 50% NPK + Azospirillum, 50% NPK + Azotobacter, 50% NPK + Phosphotica, 25% NPK + Azospirillum, 25% NPK + Azotobacter, 25% NPK + Phosphotica, Azoter, Azospirospirillum + Phosphotick +. Studies had provided strong evidence that a starting dose of inorganic fertilizers is necessary to harness the efficiency of microbial transformations about nutrient availability to improve fruit yield.

Gautam *et al.* (2012) reported that maximum plant height, canopy height, plant spread (N-S) and (E-W) as well as tree volume was found with application of 500:250:250 g N:P:K/tree + 50 Kg FYM + 10 Kg vermicompost in mango cv. Sunderja.

Kumar *et al.* (2012) studied on lemon cv. and treated with which include nitrogen, phosphorus, potassium, vermicompost, neem cake and manure, alone or in a mixture. Data were recorded on fruit yield per tree, fruit weight, fruit diameter, fruit per tree, juice content and ascorbic acid content. The results showed that fruit per tree, fruit weight , fruit diameter, yield, juice content and ascorbic acid content were highest in the treatment of 50% NPK + 15 kg vermicompost + 5 kg cake neem.

Shivakumar *et al*. (2012) studied the effect of organic cultivation of papaya on yield, economics and soil nutrient status. The result showed that application of FYM equivalent to 100% recommended dose of nitrogen (RDN) gave significantly higher fruit yield**.** The maximum higher fruit yield was recorded at the application of FYM equivalent to 100% recommended dose of nitrogen (RDN) (154.3 t/ha) .

Binepal *et al.* (2013) evaluated the effect of integrated nutrient management on physico -chemical parameters of guava on seven year old guava tree cv. L-49 and revealed that maximum growth in fruit length, fruit diameter, fruit volume, pulp weight, specific gravity, TSS, total sugars, reducing and non -reducing sugar and other physico-chemical parameters was observed with application of 100% N + 100% P_2O_5 + Azospirillum + PSB + 10 Kg vermicompost.

Hasan *et al*. (2013) studied the influence of integrated nutrients management in improving quality of Mango. Result showed that the maximum plant height was observed with the application of 250g Azospirillium + 50kg FYM + 500:250:250g of NPK/ tree.

Kumar *et al.* (2013a) examined the influence of bio-fertilizers on yield, growth and fruit quality in the low-chilling pear (cv. Gola). The results revealed that the application of 150Kg Nitrogen/ha, is required for higher fruit yield & quality parameters.

Kumar *et al.* (2013b) The results of a field trial conducted to investigate integrated nutrient management on tree height, trunk diameter, tree spread, fruit set, fruit drop and fruit retention in Guava. Treatments were T1-control, T2-recommended fertilizer dose +35 Kg farm manure, T3-100% NPK+15 Kg vermicompost, T4-75 NPK +20 Kg VC, T5-100% NPK+5 Kg neem cake, T6 -75 NPK+10 Kg NC, T7-50% NPK+15 Kg VC+5 Kg NC and T8-50% NPK+20 Kg VC+10 Kg NC.

Kuttimani *et al.* (2013) studied the effect of integrated nutrient management practices on yield and economics of banana under irrigated conditions. The results revealed that the maximum number of hands, number of fingers, bunch weight and total yield were observed with the application of 100% recommended dose of fertilizer along with 40% Wellgro soil.

Kumrawat *et al.* (2013) evaluated integrated nutrient management on quality and yield parameters of Guava cv. L-49. Result revealed maximum number of fruits per trees, fruit weight and yield per tree were recorded with the application of 100 % NPK+ 5 Kg vermicompost + 150 g VAM.

Nandi *et al*. (2013) conducted an experiment on pomegranate cv. Ganesh and observed that plant growth characters such as plant height, canopy spread E-W and N-S, fruit volume and weight/fruit, number of fruits and fruit yield/plant, biochemical properties such as TSS, vitamin C, total and reducing sugar content in juice of pomegranate was improved by the use of enriched vermicompost with 75% and 100% RDF.

Patil and Shinde (2013) studied the effect of integrated nutrient management on growth and yield of banana. Result revealed that application of 50g of Azotobactor + 50g of PSB + 250g of VAM + FYM + 50% RDF (200:160:200 NPK) gives maximum stem girth, maximum plant height in banana.

Rubee *et al.* (2013) reported that with the application of *Azotobactor* (50%) + *Azospirillum* (50%) + NPK (50%) + FYM showed maximum growth in terms of plant height, number of leaves plant^{-1}, length of leaves, width of leaves and plant spread in strawberry plant.

Sharma *et al.* (2013) found from the experiment which was conducted to find out the effect of organic and inorganic sources of fertilizers on yield, quality and nutrient status of winter season guava. Result showed that 25% of N tree^{-1} through FYM + 75% of N tree^{-1} through inorganic fertilizer showed highest fruit yield, maximum fruit length, breadth, weight and pectin. Appilication of Azotobacter + 50% of N tree-^{1} through FYM + 50% of N tree^{-1} through inorganic fertilizer showed highest TSS, total sugars and minimum physiological loss in weight.

Singh and Varu (2013) evaluated the effect of integrated nutrient management in papaya cv. Madhubindu. Result revealed that the growth, yield and fruit quality parameter like maximum fruit length, fruit girth, highest fruit weight, maximum number of fruit per plant, fruit yield per plant, fruit yield per plot, fruit yield per hectare and marketable fruit yield per plot, reducing, non- reducing and total sugars, total soluble solids were observed highest in treatment applications of PSB 2.5g/m^2 + Azotobacter 50 g/plant + half RDF of NPK 100g: 100g: 125g/ plant.

Sharma *et al.* (2023) studied the response of Kinnow mandarin to the application of nitrogen fixing and phosphate solublizingbiofertilizers in different combinations with reduced dose of fertilizer (RDF) in various combinations.The best physico-chemical characters of fruits i.e. (fruit size, fruit weight, TSS, total sugar, reducing sugar and ascorbic acid contents) was found in treatment application of Urea 900g: SSP 1300g + FYM 60kg + Azotobacter.

Verma and Chauhan (2013) reported that maximum values of plant growth parameters, fruits characteristics, yield, leaf and soil nutrient content on apple were recorded under T_5 (IFFCO mixture + Urea + MOP + FYM) treatment. Better quality fruits were also recorded in T_5 treatment.

Wani *et al*. (2013) reported that the application of integrated source of nutrients significantly affects the vegetative reproductive and yield characteristics of the strawberry plants.

Karunakaran *et al.*(2014) reported that integrated nutrient management of 100g of NPK fertilizer (19-19-19), organic manure and neem cake after every three to four months interval is beneficial for obtaining better yield of dragon fruit.

Lal and Dayal (2014) observed that treatment with 50% RDF+Goat Manure showed maximum vegetative growth and fruit yield with the highest fruit length, fruit diameter and fruit weight were recorded on acid lime.

Mahato *et al*. (2014) studied the role of inorganic nutrients on growth, yield and fruit quality on Plantain cv. Nendran. The highest values of macronutrients availability were obtained under N250:P80:K400 g/plant. Adding higher dose of N and K fertilizer resulted in greater bunch weight and number of fingers than the control. TSS, total sugars and TSS:acid ratio were significantly increased with increasing nitrogen and Potassium application. Result revealed that the treatment N250:P80 :K400 g/plant seems to be the promising treatment which produced the highest vegetative growth, yield and improved fruit quality under these experimental conditions due to improving nutritional status of studied soil.

Ray *et al.* (2014) A survey was carried out to increase the production and quality of pomegranate through appropriate nutrient management in pomegranate.. The fruits of plants treated with 300g of nitrogen +1kg of neem cake plant^{-1} recorded the highest total soluble dry matter, total sugar, reducing sugar, non-reducing sugar and ascorbic acid.

Srivastava *et al.* (2014) examined the suitable combination of fertilizer on growth and yield of payaya. Fruit yield of papaya was observed increase significantly with the application of Azotobactor + PSB + 100% NPK+ FYM.

Sharma and Bhatnagar and Singh (2014) conducted trial on the effect of integrated nutrients management on growth attributes on custard apple. The treatment containing Azotobactor 50 g + VAM 20 g + PSB 50 g + 50% N through vermicompost + 50% RDF gave maximum plant, increases the scion and rootstock girth height of custard apple.

Savreet and Bal (2014) reported that there had been improvement with the combination of three types of nutrient sources on growth of lemon. FYM, inorganic nitrogen, and bio-fertilizer proved to be the most reasonable treatments for minimizing fruit cracking and maximizing fruit quality.

Singh *et al.*(2014) reported that the maximum vegetative growth of aonla was recorded in the plants which were applied with standard doses of NPK.

Sharma *et al*. (2014) evaluated the impact of organic and inorganic fertilizers supplemented with bio-fertilizers on growth parameters of custard apple cv. Arka Sahan . Result showed that treatment comprising 50% RDF + 50% N through vermicompost and bio fertilizers (Azotobacter 50 g + PSB 50 g + VAM 20 g) was found significantly influenced the growth parameters such as per cent increase in plant height, rootstock girth, scion girth, plant spread, and number of primary branches per plant.

Sujeet *et al.* (2014) stated that the maximum yield and quality of kinnow fruit was observed at 80% of ETc and 700 g K/plant/year (32.67 t/ha) . Total Soluble Solids (TSS) was found highest in case of 80% of ETc and 700 g K/plant/year. Similar effects on yields, TSS and juice content were obtained between 80% and 100% Etc applications. The treatment (80% ETc and 700 g K/plant/year) was the best as it resulted in high yield and better quality with saving of water. The study helped to select the optimal dose of water and potassium fertilizer at 80% Etc and 700 g K/plant/year.

Tandel *et al.* (2014) studied the effect of Integrated Nutrient Management on Growth and Physiological Parameters on Papaya cv. Taiwan Red Lady by evaluated fertility levels and different treatment combination. Results showed that the treatment 25 % RDN through bio compost + 25 % RDN through castor cake + 50 % RDN through inorganic fertilizer gave higher values of growth characters viz. plant height, stem girth and number of leaves.

Tripathi *et al.* (2014) observed that the combined application of Azotobacter + vermicompost significantly increased the height of plant, number of leaves, crowns and runners of strawberry per plant, whereas, maximum number of flowers, fruits set per plant with increased duration of harvesting and minimum number of days taken to produce first flower and fruit set with significantly more yield were observed with Azotobacter at 6 kg/ha + vermicompost at 30 t/ha applied plants. Plants fertilized with Azotobacter at 6 kg/ha + vermicompost at 30 t/ha also produced the berries with maximum length, width, weight, volume, TSS, total sugars, ascorbic acid with minimum titratable acidity.

Verma *et al.* (2014) determined the effects of integrated nutrient management on plant growth, yield and fruit quality of phalsa plants. On the basis of performance treatment with the application of FYM+75 % NPK+Azotobacter+PSB+ZnSO4 (0.4%) may be applied for better growth, yield, quality and sustainability of phalsa crops.

Bhatnagar *et al.* (2015) Studied the response of INM on custard apple cv. Arkasahan. The studied revealed that the treatment comprising vermicompost with 50% RDF and bio-fertilizer gives higher plant, rootstock girth, plant spread (E-W and N-S) and soil NPK content.

Hadole *et al.* (2015) evaluated the impact of integrated use of organic and inorganic fertilizers with bio-inoculants on yield, quality and soil fertility of Nagpur mandarin. The maximum yield, fruit quality attributes in terms of total soluble solids (TSS), total sugars and ascorbic acid were improved with 100% RDF + VAM 500 g/plant + PSB 100 g/ plant + Azospirillum100 g/plant.

Thakur *et al*. (2015). investigated the effect of integrated nutrient management on soil nutrient and biological status and yield of plum cv. Santa Rosa and reported that application of integrated nutrients management source 75% NPK+Biofertilizers (60 g each tree basin-1)+Green manuring (Sunhemp @ 25 g seeds tree^{-1} basin) showed significant influence in fruit yield and quality rather than the application of chemical fertilizer alone.

Boora (2016) determined the effect of different levels of inorganic fertilizers, organic manure and their time of application on yield and quality of mango fruit cv. Dushehari. The results showed that maximum fruit yield and maximum number of fruits were obtained with the application of 50 kg FYM + 500 g of NPK per tree in the month of September before flower bud differentiation.

Bohane *et al.* (2016) studied different treatment combinations of nutrients sources on five-year-old ber trees cv. Gola under Malwa plateau conditions. The results revealed that the application of 50% recommended dose of fertilizer through vermicompost + 50% RDF through NPK + 50 g Azotobacter + 50 g PSB (T7) significantly increased the plant height, canopy volume, number of primary and secondary branches per shoot.

Chandra *et al*. (2016) examined the effect of chemical fertilizers, organics manure and biofertilizers on growth, yield and quality of mrigbahar guava. The results revealed that maximum yield of guava fruit influenced significantly when treated with the treatment of PSB 100 g per tree + Azospirillum 100 g per tree + cowdung slurry @ 10 litre per tree + 75% recommended dose of fertilizers (RDF)

Dutta *et al.* (2016) studied the influence of organic, chemical and bio-fertilizer on growth ,yield and quality of mango and reported that the application of bio-fertilizer PSM @ 100 g/plant + Azotobactor @ 150g/plant + 50% chemical fertilizer produces maximum plant height, stem girth of Mango.

Ennab (2016) evaluate the effect of farmyard manure and bio-fertilizers with NPK dose on growth, yield and fruit quality of Eureka lemon trees. The application of Azospirillum 25gm/tree + 75% NPK/tree + 27.5kg FYM/year and Azotobactor 25gm/ tree + Azospirillum 25g/tree + 75% NPK/tree + Bacillus circulans 25gm/tree + 27.5kg FYM/year and Bacillus circulans 25gm/tree + Azospirillum 25g/tree + Azotobactor 25gm/tree + 55kg FYM/year + 50% NPK/ tree observed improved in fruit yield in both seasons (summer and spring).

Sharma *et al.* (2016a) evaluated the combined application of organic and inorganic sources along with bio-fertilizer on productivity and profitability in high density orchard of mango cv. Amrapali and revealed that maximum crown height, crown length, crown width E-W &N-S, shoot length, number of panicle and length of panicle were observed with the application of 520: 160: 450 NPK g plant^{-1} along with vermicompost (25 kg) + Oil cake (2.5 kg) + Azotobacter + VAM + TV + PSB (100g each) enhanced the plant growth.

Sharma *et al*. (2016b) reported in guava that the highest soil organic carbon, soil N, P and K, Ca and Mg, as well as highest leaf N, P and K, Ca and Mg contents were obtained with the application of Azotobacter + 75% N poultry manure + 25% N urea along with maximum fruit yield, fruit length, breadth , weight and pulp weight. Whereas, Azotobacter + 50% N/tree through FYM + 50% N/tree through inorganic fertilizer showed highest TSS , total sugars and minimum physiological loss in weight.

Talang *et al.* (2017) examined the effect of chemical fertilizers with bio-fertilizers with and organic manures on growth, yield and quality as well as soil chemical properties of mango cv. Himsagar at Bidhan Chandra KrishiViswavidyalaya, West Bengal. Result revealed that treatment with half (1000:500:1000 g NPK/tree) + 50 kg FYM + Azospirillium (250 g) + 100 g potassium mobiliser showed maximum plant height, girth and plant spread in E-W and N-S directions.

Lesha et al. (2016). examined the combined application of Organic manure, inorganic fertilizer and bio-fertilizers on five year old ber trees cv. Gola under malwa plateau conditions and revealed that maximum increased in the plant height, canopy volume, number of primary and secondary branches per shoot were observed with treatment of 50% RDF through vermicompost + 50% RDF through NPK + 50 g Azotobacter + 50 g PSB.

Gupta and Sangma (2017) conducted trail on the effect of chemical fertilizer and vermicompost on growth and yield of Guava and revealed that maximum number of flowers/plant, fruit set, fruit length, fruit diameter, volume of fruit and specific gravity, average fruit weight and number of fruits per plant, yield per plant were obtained with the application of 50% RDN through chemical fertilizer+50% RDN through vermicompost. Similarly, the maximum total soluble solids, ascorbic acid and minimum titratable acidity were recorded with the soil placement of 50% RDN through chemical fertilizer +50% RDN through vermicompost.

Jugnake (2017) observed that the maximum increase in tree height (0.47m) of Sweet Orange was recorded in the treatment of 80ml Azotobactor + 80ml PSB + RDF 800:400:400g NPK + 50kg FYM.

Jayswal *et al.*(2017) studied the effect of different combinations of pruning intensity and nutrition source on quality of guava. The bio-chemical characteristic viz., the highest TSS, ascorbic acid, total sugar, reducing sugar and non-reducing sugar were observed highest with treatment of 5 kg FYM + 2 kg VC + 75% RDF {225:150:150g NPK} + Azotobactor 150g + PSB 100g / Plant.

Kurer *et al.* (2017) investigated the effect of organic manure on growth and yield of Pomegranate under Northern zone of Karnataka. Result shows that best improvement of that highest vegetative growth (canopy spread, N-S and E-W) and yield was observed with 100 % recommended dose of nitrogen through vermicompost and poultry manure. However, 100% RDN through poultry manure recorded significantly highest number of productive flowers, fruit set and yield of pomegranate.

Kumar *et al.* (2017) evaluated the response of nutrient management for the growth, yield and quality of sweet orange observed that the highest tree height, annual shoot growth, fruit set, fruit yield, fruit weight, fruit size, fruit volume and fruit quality characteristics like TSS, reducing sugar, total sugar and non-reducing sugar were observed with treatment 60% nitrogen of recommended dose of fertilizer + 40% organic manure (FYM).

Mamta *et al.* (2017) studied the influence of integrated nutrients management on the growth, yield & nutrients uptake in papaya. The increase in the tree height, stem girth, tree spreading (E-W & N-S), the no. of fruit, average yield and good yield of fruits was observed in the treatment of 800gm: 400gm :400gm RDF of N:P:K + 50kg FYM+ 80ml of Azotobacter + 80ml PSB.

Talang *et al*. (2017) reported that the application of half (1000:500:1000 g NPK/tree) + 50 Kg FYM + 5 Kg vermicompost + 100 g potassium mobilizer on Mango orchard recorded maximum number of fruits / tree, fruit weight, yield and also have a significant improvement in terms of TSS, total sugars, ascorbic acid , â-carotene and shelf life (9 days) at room temperature.

Vishwakarma *et al.* (2017) evaluateed the response of INM on growth, yield and yield attributing characters and reported that the growth character like plant height, plant girth and plant spread (East-West and North-South), flowering and fruiting behavior like number of flower per shoot, fruit set, fruit retention, fruit yield was observed maximum with minimum fruit drop with integrated application of 50 Kg FYM + 100% NPK + 200g each (Azotobacter + PSB).

Baraily and Deb (2018) reported that all the yield and growth characteristic of pineapple showed significant increase in different plant growth parameters like plant height, total no of leaf, D-leaf initiation days, D-leaf length, D-leaf width and plant grith as well as highest flowering and fruiting, maximum estimated yield along with better nutrient uptake with the application of combined treatment 7.5t/ha vermicompost + 75% RDF of NPK + bio fertilizer.

Ghosh and Laishram (2018) investigated the role of integrated nutrients management in jackfruit under rainfed condition and revealed that the maximum dose of treatment containing 500gm: 300gm: 300gm of NPK per tree/year gave the maximum yield i.e.76.3kg/tree of Jackfruit tree whereas the organic manures containing 4 kilogram mustard cake + 4 kilogram vermicompost + 20 kilogram cowdung per tree/year produced the maximum yield i.e.56.3 Kg/tree along with high 2.17 BCR and good quality of jackfruits.

Jamwal *et al.* (2018) examined the effect of integrated nutrients management on physical characteristics on 3 years old Guava cv. Allahabad Safeda. They reported that the application of Azotobacter + 100% Nitrogen through urea influenced in growing maximum tree height, canopy spread N-S and E-W direction. However, treatment with Azotobacter + 75% nitrogen through urea + 25 % vermicompost obtained maximum in number of fruits/tree , average fruit weight, fruit length , fruit diameter, fruit volume, fruit yield/tree and fruit yield/ha.

Kumar *et al.* (2018) reported an experiment using different combination of chemical fertilizer, organic manure and bio fertilizer was conducted on young growing orchard of cultivar Sahi in order to develop technology for integrated soil management for good quality litchi production. The highest yield was recorded under treatment having Azotobactor 250 g, half of the recommended dose of chemical fertilizers + 50 kg FYM. .

Kushwah *et al.* (2018) studied the effect of Integrated Nutrient Management on strawberry cv. Chandler. The results revealed that maximum plant height (19.53 cm), number of leaves (17.93) and petiole length (10.07 cm) was observed with application of 75% RDF + 25% vermicompost + Azotobacter @ 5Kg ha^{-1} + PSB@ 5Kg ha^{-1}.

Maskar *et al.* (2018) conducted an experiment on the influence of biofertilizers along with the inorganic/chemical fertilizers on quality, growth and yield of Sapota plant. The results shows that the treatment of N1B3 along with application of required composition of chemical fertilizers (100% N, P & K) also combined with the Azospirillum (200gm) and Phosphate Solubilizing Bacteria (200gm) resulted good in growth and yield.

Raghavan *et al.* (2018) studied Integrated Nutrient Management in 7 years old trees of Litchi cv. Muzaffarpur for yield and fruit quality and revealed that application of 500 g N+250 g P+250 g K+100 kg FYM+150 g Azotobacter+100 g PSM+100 g VAM (T9) was most effective treatment with respect to yield and fruit quality of litchi in foothills of Arunachal Pradesh.

Sutariya *et al.* (2018) evaluated the effect of integrated nutrient management on quality of phalsa cv. Local. Quality attributing characters like juice, TSS, total sugar, reducing sugar and ascorbic acid (mg/100 g of fresh pulp) content were significantly higher with 50% N through urea + 25% N through vermicompost per plant + 100 g P_2O_5 through SSP + 50 g K_2O through MOP per plant + AAU PGPR consortium.

Sourabh *et al*. (2018) evaluated the effect of organic growth amendments & bio-fertilizers on yield and growth of guava during season of rain. The results revealed that by application of vermicompost and FYM with the good composition of bio-fertilizers at three levels RDF i.e. 50%, 75% and 100% & Azotobacter + PSB inoculate with 100% RDF + vermicompost resulting with increase in plant height, maximum flowers per branch, fruit setting, total number of fruits, increase weight of the fruit & yield.

Kour *et al.* (2019) concluded from a experiment which was conducted to find out the effect of organic and inorganic sources of fertilizers along with bioinoculants on growth, yield and quality of aonla cv. NA-7. Yield parameters viz., fruit length, fruit diameter, fruit weight, fruit volume, pulp weight, number of fruits per tree were recorded maximum when 25 per cent of nitrogen was applied as FYM and 75 per cent was applied as urea along with Azotobacter application.

Kamatyanatti *et al* (2019) evaluated the effect of integrated nutrient management on growth, yield and quality parameters of plum and observed that maximum increase in plant height, per cent increase in plant height, annual shoot growth, leaf area and chlorophyll index , number of flowers, number of fruit set per feet of shoot, final fruit set and fruit firmness, fruit weight, fruit yield per tree were found by the application of T11: 75% of N + 12.5 % N through vermicompost + 12.5 % N through FYM+ Biofertilizers.

Kanwar *et al.* (2020) revealed that papaya crops treated with 75% RDF + 10 kgVermi-compost + 100 g Azotobacter +100 g PSB/Plant showed highest number of fruits , fruit length, fruit weight , yield per plant , TSS, minimum acidity, total sugar, reducing sugar, ascorbic acid.

Choudhary *et al.* (2020) studied the effect of nutrients on ber cv. Gola and reported that application of K_2SO_4 @ 2 per cent significantly increased the yield attributing characters and fruit yield of ber.

Gajbhiye *et al*. (2020) conducted an experiment on the effect of Integrated Nutrient Management on disease resistance of Pomegranate. Yield attributes viz., number of flowers (204.75), number of fruits (172.88), fruit set (84.39%), fruit weight (244.82 g) and yield (41.21 Kg tree^{-1}) of pomegranate were observed significantly increased due to treatment application of FYM @ 15 Kg, Azotobacter @ 8 ml per tree, PSB@ 8 ml per tree and Trichoderma @ 100 g per tree, 625:250:250 g N, P2O5 and K2O and 25 Kg URHS per tree.

Jain *et al.* (2020) examined the effect of graded doses of fertilizers on flowering and yield attributes in sapota cv. Kalipatti and revealed that maximum number of fruits per tree, fruit yield per tree and yield per hectare were observed with the application of treatment 6 Kg each NPK + 400 Kg FYM Tree^{-1} Year^{-1} in three splits i.e., ⅓ in June, ⅓ in September and ⅓ in January.

Solanki *et al.* (2020) reported that the application of 75% RDF + vermicompost 15kg / tree significantly increased in fruit set (87.70%) and yield

(20.16 kg/tree), fruit length (64.06 mm), breadth (61.89 mm), fruit weight (129.51 g), total soluble solids (13.33 ºB) and total sugars (7.51%) in Peach cv. July Elberta.

Gajbhiye *et al*. (2020) conducted an experiment on the effect of Integrated Nutrient Management on Disease Resistance of Pomegranate. Yield attributes viz., number of flowers (204.75), number of fruits (172.88), fruit set (84.39%), fruit weight (244.82 g) and yield (41.21 Kg $tree^{-1}$) of pomegranate were observed significantly increased due to treatment application of FYM @ 15 kg, Azotobacter @ 8 ml per tree, PSB@ 8 ml per tree and Trichoderma @ 100 g per tree, 625:250:250 g N, P2O5 and K2O and 25 kg URHS per tree.

Singh and Tripathi (2020) studied the influence of nutrient source on growth, yield and quality parameters of papaya and observed that application of 75% RDF + 100 g of Azotobacter + 100 g PSB + 2 kg of vermicompost per plant produced maximum plant height, girth, number and length of leaves, biomass production in plant (green weight), number of flowers and fruits set per plant, fruit yield with minimum number of days taken to first flowering as well as quality properties like longest fruits with more width, weight, total soluble solids (TSS) and total sugar contents with minimum titratable acidity.

Mandal *et al.* (2021) revealed that the treatment with vermicompost 50%+ NPK 50%+ Trichoderma was found significantly superior over all other treatments with respect to plant growth and development characteristics including survival percentage in strawberry.

Sudhir *et al.* (2021) reported that in winter season guava that maximum number of fruits/tree, average fruit weight, polar diameter, radial diameter, fruit volume, highest fruit yield/tree, fruit yield/ha, highest leaf nitrogen, phosphorus , calcium and magnesium was obtained with Azotobacter + (75% Nitrogen through urea + 25% Vermicompost). However, two years pooled data analysis indicate significant effect on growth parameters of guava, maximum increase in tree height, canopy spread N-S direction, E-W were obtained with the application of Azoatobacter + (100% Nitrogen through urea) as well as highest TSS content, pectin, fruit pH , total sugars and minimum physiological weight were obtained with Azotobacter + (50% Nitrogen through urea + 25% Vermicompost + 25% FYM).

Singh and Sadawarti (2021) investigate the effect of INM on Physical and biochemical parameter of strawberry. The maximum plant height, higher number of leaves per plants, leaf area, chlorophyll contents, plant spreading was recorded with treatment under 50% RDF + vermicompost + Azotobacter.

Lakhawat *et al.* (2022) reported the effect of integrated nutrient management on yield, quality and economics of guava that application under treatment i.e. 1 /2 RDF (i.e. 250:100:250 g NPK per tree, respectively) and 25 kg FYM with 250 g Azotobacter recorded higher fruit weight and yield as well as improving plant height, canopy volume, and leaf nutrient status NPK respectively. However, fruit quality attributes i.e., maximum TSS, and lower acidity were observed with full dose of recommended dose of fertilizer (i.e. 500 g N: 200 g P_2O_5: 500 g K_2O/tree) with foliar spray of micronutrients i.e. Zn + B + Mn during August and October. Soil micro-organism counts were recorded maximum in the treatment T10 (5.35 x 108 per g soil) for bacteria and T5 (6.80 x104 per g soil) for fungus. Yield plant^{-1} was significantly and positively associated with leaf nitrogen and potassium content.

Maksudan *et al.* (2022) worked on pomegranate nutrients management and revealed that 80% of RDF + vermiwash + cow urine through drip (1 litre/ week) recorded significantly highest plant growth, plant spread in N-S and E-W, number of flower per plant, fruit quality (total soluble solid, acidity, TSS acid ratio, pH, ascorbic acid, reducing sugar, non-reducing sugar and total sugar).

2.2. Impact of organic nutrient management of fruit crops

Sharma (2002) revealed significant influence in the bunch weight and yield of banana with the application of Azotobacter and organic manures supplements over 100% fertilizer. Azotobacter also enhanced shooting and shortened crop duration.

Dubey and Yadav (2003) evaluated the response of Khasi mandarin to organic versus inorganic fertilization. Result revealed that maximum fruit yield was observed with the application of 110 kg pig manure per tree.

Naik *et al.* (2007) studied organic farming in guava (*Psidium guajava*.) and observed that the vermi-compost was superior over other organic sources in improving vegetative growth, flowering, fruiting, yield and fruit attributes and fruit quality along with improvement in soil fertility and leaf nutrient status of the guava plant.

Ram *et al.* (2007) studied integrated organic farming on 3-yrs-old plant of guava cv. Allahabad Safeda and observed that maximum number of fruits and yield were obtained with 20 Kg FYM inoculated with *Azotobacter*. However, fruit quality parameters TSS and vitamin C were improved with application of 10 Kg FYM along with BD-500.

Umar *et al.* (2008) evaluated the response of integrated nutrients management in strawberry yield andreported that the maximum yield of strawberry was observed with the application 25% nitrogen in the form of FYM + 75% N through urea + Azotobacter.

Rai *et al.* (2009) studied the effect of four different organic amendments viz., FYM, vermicompost, poultry manure and neem cake on yield and quality of pear cultivar Gola. Result showed that the quality parameters TSS, acidity, ascorbic acid content and reducing sugar content, yield and yield attributing characters were found best with the application of 40 kg vermicompost/tree.

Dutta *et al.* (2010) reported that application of bio-fertilizer viz., Azotobacter + Azospirillium + VAM + 2 Kg FYM showed maximum increased in the physico-chemical qualities of fruits and growth parameter of papaya plants.

Osman and El-rhman (2010) studied the effect of organic and bio N-fertilization on growth, productivity of fig Tree (*Ficuscarica* L.).The results clarified that poultry manure + azotobacter and poultry manure + azospirillum treatments gained best vegetative growth, productivity and fruit quality under this condition.

Ravishankar *et al.* (2010) studied the effect of organic manures on growth, yield and quality of Coorg Honey Dew papaya. Result revealed that the maximum total soluble solids, ascorbic acid, total sugar and the least value of titrable acidity was observed with the application of FYM 20 kg/plant.

Ahmad and Mohammad (2012) studied the different organic nutrient combinations on yields and quality of strawberry cv. Kurdistan in Iran. Treatment with manure + Azotobacter + woodash + phosphorus solubilizing bacteria + oil cake improved significantly quality of fruit about diameter, length, volume, weight, total sugars, total soluble solids (TSS), acidity, TSS: acidity ratio) and yields.

Dwivedi *et al.* (2012) conducted a trail on 4-year-old guava trees to evaluated the effect of bio-fertilizer and of organic manures (FYM) on yield and quality of 'Red Fleshed' guava. They recorded that the maximum fruit yield for the rainy and winter season crop was 38.2 and 19.0 kg/tree respectively, with the application of 250 g *Azotobactor* + 20 kg FYM. However highest fruit weight 198.2 and 299.2 g, fruit length 5.9 and 7.2 cm and fruit breadth 7.0 and 7.4 cm were obtained with the application of Phosphobacterin (50 ml/tree). Highest TSS and vitamin C was obtained with the application of VAM. However, acidity was highest under FYM treatment.

Devi *et al.* (2012) evaluated combined treatment of organic and bio-fertilizer source on guava. The application of PSB 100gm per tree + FYM 26kg per tree/ year + potash mobilizers100 gm per tree + Azotobactor100 gm per tree gives the maximum guava fruit yield i.e.114 kg/plant.

Ghosh *et al.* (2012) studied on response of organic manure on growth and yield of pomegranate and observed that FYM performed better regarding the improvement in plant growth and fruit production as compared to vermicompost. Similarly, FYM (20kg/ plant) result in highest basal girth and canopy spread.

Nazir *et al.* (2012) studied the effect of various organic nutrient source on growth of strawberry cv Senga Sengana and showed that treatment of poultry manure + Azotobacter + wood ash + phosphorus solubilizing bacteria + mustard oil cake significantly improved plant height and plant spread.

Singh and Saravanan (2012) evaluated the effect of bio-fertilizers and micronutrients on yield and quality of strawberry cv. Chandler and state that treatment containing 12kg/ha of VAM + 10kg/ha of Azotobactor recorded highest number of fruits per plant, fruit yield per plant, fruit yield per ha, fruit length, fruit diameter, specific gravity, T.S.S, juice content, titrable acidity and vitamin-C.

Trivedi *et al.* (2012) studied the response of organic, inorganic and bio-fertilizer on growth and yield in guava and reported that application of castor cake resulted in the maximum plant height, East-West plant spread.

Yadav *et al.* (2012a) studied the effect of nutrient management through organic source on the productivity of guava and showed that application of poultry manure on guava trees significantly increased number of fruits per plant, higher yield as well as total soluble sugar and total sugar.

Yadav *et al.* (2012b) conducted an experiment to study the effect of media on growth and development of acid lime (*Citrus aurantifolia* Swingle) seedling with or without Azotobacter. The result concluded that application of vermicompost + vermiculite + sand + soil + cocopeat (1:1:1:1:1) with the treatment of Azotobactor gives a maximum height seedling of acid lime after the sowing of 150 days.

Anubha *et al.* (2013) evaluated the response of organic manures on growth, nutrient status and yield of litchi cv. Rose Scented. FYM @ 150 kg/tree resulted in maximum fruit set, fruit retention, fruit yield and minimum fruit drop.

Khalid *et al.* (2013) concluded that the application of farm yard manure (FYM) and vermicompost based organic amendments enhanced vegetative growth and improved quality of strawberry fruits.

Devi *et al.* (2014) reported that application of farm yard manure + *Azotobacter* + phosphorous solubilizers + potash mobilizers resulted in greater fruit weight (24.73 g), total soluble solids (17.79°Brix) and total sugar content (17.57%) in 'Bombai' litchi. Application of nutrients through organic source along with biofertilizers improved soil health by increasing the microbial population in the rhizosphere.

Dutta *et al.* (2014) studied the effect of bio-fertilizers on physico-chemical qualities and leaf mineral composition of guava cv. L-49 and revealed that bio-fertilizer combination Azospirillum + Azotobacter + VAM can be applied for quality fruit production of guava in New Alluvial Zone.

Lembisana *et al.* (2014) reported that application of vermicompost at (42.86 kg/tree/year) + Azotobacter + phosphorous solubilizer + potash mobilizers each at 100 g/tree/year in two split doses is recommended for the organic production of the 'Bombai' litchi.

Hassan (2015) investigated the effect of nutrients source on growth, yield and quality of strawberry plants cv. Sweet Charlie. Results concluded that bio-fertilization increased plant growth characters, chemical composition, total fruit yield and its components, physical quality and chemical constituents of fruit, i.e., TSS%, vitamin C, titratable acidity, anthocyanins and total sugars.

Hazarika *et al*. (2015) conducted an experiment on the effect of biological fertilizer and bio regulators on yield, growth & quality of strawberry plant (*Fragaria* × *ananassa*). Quality characters of fruit like TSS & ascorbic acid, titrable acidity, total sugar and total reducing sugar were also affected by combined use of different source of nutrient. Efficient to highly efficient positive co-relation was recorded among different yield and growth allocating characters with yield.

Kumar *et al.* (2015) reported that treatment combination of vermicompost and PSB showed highest plant height, leaves plant^{-1}, primary branches plant^{-1}, secondary branches plant^{-1}, first flowering, flowers plant^{-1}, first fruit setting and fruits plant^{-1}. Similarly, the bio-chemical characteristic viz., total Soluble Solids

(TSS), titrable acidity, vitamin C, total sugars and juice content were also found highest under this treatment.

Khachi *et al*. (2015) examined on comparative efficacy of bio-organic nutrients on kiwi fruit. They reported that sufficient improvement in fruit quality and plant nutrient contents were found with the combined treatment of FYM@ 15 kg/vine, green manure, vermicompost at 15kg/vine, Bfat50-g/ vine and vermin-wash at 2kg/vine.

Nazir *et al.* (2015) studied the effect of various organic nutrient source on yield and quality of strawberry and revealed that maximum yield and different physical characters of fruits in respect of length, diameter, volume, weight and chemical characters viz., total sugars, total soluble solids, acidity and TSS/acidity ratio was observed with application of poultry manure + Azotobacter + wood ash + phosphorus solubilizing bacteria + mustard oil cake.

Singh *et al.* (2015) examined the effect of vermicompost and bio-fertilizers on growth, flowering and yield of strawberry. Result revealed that the application of vermicompost + Azotobacter + PSB + AM produced maximum plant height, plant spread, maximum number of leaves as well as maximum yield of strawberry fruit.

Tripathi *et al*. (2015) reported in strawberry cv. Chandler that combined application of 7 Kg/ha of Azotobacter + 30 t/ ha of vermicompost significantly increased the height of plant, number of leaves, crowns and runners per plant.

Sharath and Ghost (2015) observed in karonda that highest fruit yield (3.0 Kg/plant) was recorded in plants where cow dung manure at 4 kg/plant/year was applied. The treatment also resulted in maximum fruit weight with highest TSS, reducing sugar and ascorbic acid content. The soil pH in organic manures treated plots was improved and was near to neutral whereas inorganic fertilizers applied plots were acidic.

Tripathi *et al.* (2016) investigated the influence of Azotobacter, Azospirillum and PSB on vegetative growth, flowering, yield and quality of strawberry cv. Chandler. Maximum average length, width, weight, TSS, total sugars and ascorbic acid were obtained with plants fertilized with 7 kg of Azotobacter per hectare.

Das *et al.* (2017) examined the response of different bio-fertilizers on yield, fruit quality and leaf mineral composition of guava cv. L-49. and revealed that the combined treatment of bio-fertilizer i.e. Azospirillum brasilense + Arbuscular mycorhizal fungi resulted in production of higher yield and quality fruit of guava.

Narayan *et al.* (2016) investigate the effect of different doses of organic manure on flowering, fruiting and yield of peach (cv. Florida Prince) and revealed that the application of organic manure alone or in combination like 30 kg FYM + 10 kg vermicompost + 2.5 kg poultry manure + 3 kg neem cake per tree significantly influenced the flowering, fruiting and yield of peach.

Sau *et al.* (2016) investigated the influence of integrated nutrient source on growth and yield of mango and reported that application of bio-fertilizer along with organic manure is a good alternative nutrients source for getting higher yield and quantity for mango production by maintaining soil health condition.

Pathak e*t al*. (2017) concluded that the use of bio-fertilizers nutrients like Azotobacter, Azospirillum and VAM along with PGPRs improve the quality of fruits.

Poonia *et al.* (2018) evaluated the effect of bio-fertilizers on growth and development of mango plants cv. Dashehari. Result revealed that maximum percentage increase in rootstock girth, scion girth, number of shoots per plant, tree height percentage of mango plants was increased with the application of treatment Azotobacter 25 g + PSB 50 g + 3 kg Vermicompost.

Soni *et al.* (2018) conducted a trail on the effect of organic manure and bio-fertilizers on growth, yield and quality of strawberry cv Sweet Charlie. The results revealed that the treatment with 50% vermicompost + 50% poultry manure + Azotobacter was found to be the best among the various treatment and recorded maximum plant height, number of leaves, plant spread, number of flowers, number of fruit, fruit length, fruit width, fruit weight and the maximum fruit yield.

Dheware *et al*. (2020) conducted an investigation on the organic nutrient with biofertilizers management protocol for guava. The result showed maximum average weight of fruits, yield of fruits and minimum acidity was recorded with vermicompost 30 kg/plant + Azospirillum culture 250 g/tree + PSB @ 250 g/tree + Vermi wash foliar spray (dilution with water @ 1:1). Maximum number of fruits produced per plant was found from plant fertilized with FYM 30 kg/plant. He concluded that combined application of bio-fertilizers along with organic manures was more effective than use of organic manure alone in enhancing fruit growth and qualitative parameters in guava.

Mamatha *et al.* (2021) evaluated the response of organic nutrients source on different commercial banana cultivars and revealed that with the application of poultry manure + Azospirillum + AMF, maximum number of fruits per bunch , highest plant height, bunch weight, yield and maximum number of hands per bunch was recorded.

Rani *et al.* (2021) reported that use of bio-fertilizers with organic manures was found to be a good approach for production of quality guava fruits and revealed that combined application of vermicompost 30 Kg/ plant + Azospirillum @ 250 g/tree + PSB @ 250 g/tree showed maximum plant height, canopy spread, trunk girth.

2.3 Role of integrated and organic nutrient management in dragon fruits

Ke (1997) reported that in Vietnam, young (less than 3 years old) plants are fertilized with 10-15 kg of farmyard manure and 100g of super phosphate/plant at the time of planting. During the first two years, 300g of urea and 200 g of NPK (16-16-8) were applied to each plant every year. The fertilizer is applied in three lots, at one months, six months and twelve months after planting, respectively.

Tri *et al*. (2000) reported that mature plants (at least three years old) should be given 540 g N,720 P_2O_5, 300 g K_2O and 20 kg of farmyard manure/plant/year. The quantity was divided into four lots. The first was applied immediately after harvest, and includes 40% N, 30% of the P_2O_5 and all the farmyard manures. The second was applied two months later 30% N, 20% P_2O_5, 15% K_2O and the third just before flowering 10% N, 40% P_2O_5, 40% K_2O. The fourth contained the remaining fertilizer and was applied when young fruits are developing

Alwis (2006) reported that in Sri Lanka, The Agricultural Reachearch Station at Mankandura used a mixture of NPK 1:1:2 at 30-40 g/vine applied 3 times/year. The plantation at Bulathsihala used organic manures at different rates with a special fertilizer mixture (5N-5P-15K-8S-1.6Mg-TE) imported from Thailand at 100g/plant/ year.

Peter (2008) reported that dragon fruit required judicious application of fertilizer in early phase of growth for higher yields. Though, recommendation vary widely. The recommended dose in Taiwan is 4 kg of organic manure plant^{-1}in every 4 months, supplemented with 100 g plant^{-1} of a commercial 13-13-13 fertilizer. In Hawaiian plantations, a 16-16-16 NPK mixture is applied at 4-6 monthly intervals at 180-230 g/plant. Calcium and micronutrients are also applied to enhance fruit growth and firmness. Super Bloom fertilizer which has a composition of 0-10-10 0r 2-10-10 is recommended for dragon fruit. These are low nitrogen fertilizer mixtures.

Muchjajib and Muchjajib (2012) investigated on the effect of optimal fertilizer application for Pitaya plants of non-fertilizer, organic manure, NPK 46-0-0, 0-46-0, 24-24-0, 16-16-16 and 12-24-12. The study showed that the highest number of shoots, flowers and fruits as well as the heaviest fruits, with the highest TSS content, and the highest yield were obtained under the treatment of NPK @ 46-0-0, 24-24-0, 16-16-16. Yields in these treatments were equal to 22.17, 21.44 and 20.68 t ha^{-1} from 8-11 fruiting cycles of harvest.

Chakma *et al.* (2014) reported that fertilizer trials on Dragon fruit cultivated in Bangladesh showed increased dragon fruit yield from 12.88 t ha^{-1} to 31.64 t ha^{-1} when fertilizer combination of NPK @ 540 g, 250 g and 310 g is given per plant.

Then (2014) investigated the effect of compost application in improving the yield of red pitaya (*Hylocereus polyrhizus*) under various inorganic fertilizer rates. Two compost rates at 6 and 12 kg/plant/year were applied under three N:P:K:Mg mixture fertilizer (9.6:4.8:17.6:2.4) rates at 0, 1.2 and 1.8 Kg/pillar/year. The cumulative yield data showed the treatments with highest compost application rate of 12 Kg/pillar/year in combination with 1.2 and 1.8 kg mixture fertilizer pillar $^{-1}$ year^{-1} produced higher yields at 24.5 and 24.2 kg/pillar, respectively.

Karunakaran *et al.*(2014) reported that integrated nutrient management of 100g of NPK fertilizer (19-19-19), organic manure and neem cake after every three to four months interval is beneficial for obtaining better yield of dragon fruit.

Rao and Sasanka (2015) reported that dragon fruit responds well to water soluble fertilizers at low concentration. They also suggest incorporation of well decomposed FYM, compost, vermicompost and neem cake - 10 – 15 Kg per pole for better harvest and quality yield.

Perween *et al*. (2018) reported integration of organic nutrition and mineral N,P,K fertilizer at a dose of N- 450, P_2O_5 -350 K_2O-300 to dragon fruit plants @ 10, 10 and 30% of total, before flowering, 20, 40 and 25% at fruit set, 30, 20 and 30% at harvest and finally 40, 30 and 15 % and total N, P_2O_5, K_2O after two months of harvest gave best response on yield and quality.

Fernandes *et al*. (2018) reported that potassium fertilization of dragon fruit should be from 106.0 to 133.3 g K_2O in the first year and 200 g K_2O in the second and third year of planting increased production and quality of fruits. The result also proves that *H. undatus* was more productive than *H. polyrhizus* under the same treatment of K_2O.

Huang *et al.* (2019) studied the effects of biogas residue organic fertilizer on the yield and quality of dragon fruit. The results showed that dragon fruit treated with biogas residue organic fertilizer increased the yield per ha and sugar-acid ratio of fruit by 12.84% and 60.55% . Therefore, biogas residue organic fertilizer has a good application prospect in dragon fruit cultivation.

Verma *et al.* (2019) revealed that maximum growth and growth attributing characters like plant height (129.30 cm), number of branches per plant (7.61), number of thorns (58.41) and stem diameter (19.13 cm) were observed under the various treatments consisting of organic, inorganic and bio-fertilizers. Hence, treatment combination FYM + 75%NPK +Azotobacter +PSB can be considered as best treatment for enhancing vegetative growth characters in dragon fruit under Lucknow conditions.

Fratoni *et al.* (2019) evaluated the effect of an NPK fertilizer formulation (N-P_2O_5-K_2O: 8-20-20) on yellow pitaya grown in greenhouse conditions, using as substrate sand and organic compost (3:2). The treatments consisted of the following rates of the NPK fertilizer: 0, 200, 250, 300, 350, and 400 g per pot. The application of 300 g per pot resulted in higher concentrations of N, P, K, Ca, Mg, S, Fe, and Zn, the sole use of the organic fertilizer (compost) mixed with sand was enough for adequate fresh weight and dry weight yield of cladodes.

Herawati *et al.* (2020) investigated effect of organic fertilizers on yield of dragon fruit in Western Lombok, Indonesia, with six organic fertilizer treatments, namely: cow manure, goat manure, chicken manure, rice husk compost, sand, and control (no fertilizer). Each plant was given 5 kg of organic fertilizer with 3 replications. The results show that the application of cow manure produced the highest number of shoots, while the application of chicken manure was attributable to the highest fruit weight.

Moreira *et al.* (2016) evaluate the growth and nutrition of the red pitaya (*Hylocereus ucranendatus*) as function of phosphorus fertilization with five doses of P_2O_5 (0, 45, 90, 180 and 360 mg per dm^{-3} of soil) incorporated into the soil. Result showed that the application of 180 mg of P_2O_5 per dm^{-3} of soil promoted the greatest growth and provided adequate level of nutrients in cladodes of the red pitaya.

Magallanes *et al*. (2021) studied the effect of potassium fertilizer on dragon fruit and how it influenced by five different potassium levels imposed as fertilizer treatments: T1: $N_{60}P_{120}K_{60}$; T2: $N_{60}P_{120}K_{120}$; T3: $N_{60}P_{120}K_{180}$; T4: $N_{60}P_{120}K_{240}$; and T5: $N_{60}P_{120}K_{300}$. The results showed that most of the physical and physico-chemical parameters were influenced positively by the application of 180 kg K relative to the other rates that were applied.

Jesus *et al*. (2021) examined the effect of mixed organic and inorganic fertilizers on growth, leaf macronutrient contents and yield of dragon fruits under field conditions. The results clearly indicated that the application of combined dose of mineral and organic fertilizer influenced better vegetative performance and yield of dragon fruit crop.

Carlesso *et al.* (2021) stated from the experiment which was conducted on dragon fruit with the use of low doses of a compound based on remineralizer. The treatment with the compost with 50% organic fertilizer and 50% remineralizer obtained the highest number of flowers and fruits per plot, highest productivity and the highest financial return.

Siddiqua *et al*. (2022) investigated the effect of organic manures and bio-fertilizers on plant growth and yield of dragon fruit (*Hylocereus undatus*) and (*Hylocereus polyrhizus*) treatments comprising of 100 per cent N through vermicompost + PSB @ 10 kg/ha along with VAM @ 10 kg/ha showed superiority in growth and yield of white fleshed and pink fleshed dragon fruits.

Alves *et al.* (2021) stydied the productive potential and quality of pitaya with nitrogen fertilization . Nitrogen fertilization increased the yield, fruit quality, and cladode nutrient content of the dragon fruit species.

Prajapat *et al.* (2021) investigated the response of the growth of dragon fruit (*Hylocereus polyrhizus*) with the treatment of different levels of control released fertilizer. The results revealed that maximum plant height (38.25cm), number of branches (3.73), main stem width (18.53cm), number of sprouting (3.83), stem length (between two nodes)18.14cm and survival percentage (100%) of plant were recorded at controlled release fertilizer @ 9g.

Chen *et al.* (2022) evaluated the combined impact of biochar (with carbon fertilizer ratios of 0%, 3%, and 6% w/w) and organic fertilizer 22.5, 45, and 90 t ha^{-1}) on the soil properties, yield and quality of red pitaya (*Hylocereus polyrhizus*). Result shoes that 3% biochar +45 t ha^{-1} organic fertilizer was the recommended combination that showed the best synergistic effect.

Rawat *et al*. (2022) reported that on dragon fruits application of organic (vermicompost and farm yard manure) and inorganic fertilizer (RDF) in the form of 75% RDF+4 kg FYM showed maximum vegetative growth parameters viz. plant length, number of primary branches per plant, number of segment per plant, number of areoles per segment, stem girth, stem circumference, number of spines per areoles, distance between areoles and arch height as well as highest increase in plant length, number of primary branches per plant, number of segment per plant, number of areoles per segment, stem girth, stem circumference, number of spines per areoles, distance between areoles and arch height were recorded due to application of 75% RDF+4 kg FYM.

Raut *et al*. (2022) reported that the maximum plant height, number of branches, main stem circumference, plant canopy north to south, plant canopy east to west, number of sprouting, new shoots height was recorded in treatment T9 (200:50:50 N:P:K g/plant). The available nitrogen, phosphorous, potassium content in soil were maximum under treatment T9 (200:50:50 N:P:K g/plant).

CHAPTER 3

MATERIALS AND METHODS

The experimental information, items used and methodology employed during the progress of the research work are given below:-

3.1 Experimental Site

The present investigation were performed at a cultivator's farm of Ailawng village, Mamit district of Mizoram for two consecutive years viz. 2018-2019 and 2019- 2020 on newly planted dragon fruits (*Hylocereus polyrhizus*), situated at 23.42'46" ºN and 92.38'44" ºE with 380 m elevation from mean sea level.

3.2 Initial soil characteristic of the experimental field

Soil from the experimental site was collected randomly within 15- 45 cm depth of soil before the initiation of the experiment. Collected soil samples were dried and allowed to pass through a fine sieve and made it to powder form and were carried off to the research laboratory to evaluate the chemical properties of the primary soil. The evaluated values of the primary soil constituents are under:

Table 3.1: Chemical properties of the primary soil of the experimental plot 1

Soil depth (cm)	Soil pH	Organic Carbon (%)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available Potassium (kg/ha)
0-15	5.02	0.35	289.68	24.54	214.54
15-30	4.80	0.28	257.24	19.65	195.56
30-45	4.85	0.27	244.57	19.30	186.50

Table 3.2: Chemical properties of the primary soil of the experimental plot 2.

Soil depth (cm)	Soil pH	Organic Carbon (%)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available Potassium (kg/ha)
0-15	5.13	0.38	270.56	19.03	196.74
15-30	5.00	0.30	248.56	18.05	182.74
30-45	4.98	0.29	258.03	19.48	177.96

Table 3.3: Methods used for soil analysis

pH	glass electrode method by Jackson (1973)
Organic Carbon	Walkey and black method by Jackson (1973)
Nitrogen	Micro-Kjeldahl's method by Jackson (1973)
Phosphorus	Colorimetric method by Dickman and Bray (1940)
Potash	Flame photometric method by Jackson (1973)
Iron	Atomic Absorption spectrophotometry
Manganese	Atomic Absorption spectrophotometry
Copper	Atomic Absorption spectrophotometry
Zinc	Atomic Absorption spectrophotometry
Boron	Atomic Absorption spectrophotometry

3.3 Meteorological data recorded during the period of the experimentations.

The experimental site generally falls under sub-tropical and humid climatic condition.

Table 3.4: Monthly records of temperature, relative humidity and total rainfall during the period of the experimentation (2018)

Year & Month	**Average temperature (°C)**		**Average relative humidity (%)**		**Monthly annual total rainfall (mm)**
	Maximum	**Minimum**	**Maximum**	**Minimum**	
2018					
March	30.0	14.3	91.7	80.4	1.5
April	29.6	12.0	88.0	76.8	3.8
May	30.2	10.5	85.5	74.7	7.4
June	30.0	12.0	96.5	93.1	15.4
July	30.0	13.0	97.3	95.0	7.5
August	29.9	13.8	96.4	94.0	13.5
September	30.4	18.3	96.2	93.0	4.4
October	29.9	16.1	95.1	91.2	2.9
November	30.5	12.7	92.0	84.1	0.1
December	23.6	11.2	91.9	83.8	0.0

Source : State Meteorological Centre, Directorate of Science & Technology

Table 3.5: Monthly records of temperature, relative humidity and total rainfall during the period of experimentation (2019)

Year & Month	Average temperature (ºC)		Average relative humidity (%)		Monthly annual total rainfall (mm)
	Maximum	Minimum	Maximum	Minimum	
2019					
January	27.2	13.1	84.5	80.6	0.0
February	29.7	14.3	84.0	80.0	1.5
March	28.5	15.8	82.4	76.6	1.2
April	34.0	17.1	90.5	85.6	3.5
May	32.2	18.0	90.9	81.0	6.2
June	24.0	24.8	95.3	90.2	5.1
July	27.2	21.1	93.6	88.8	17.4
August	29.5	20.9	93.6	86.6	8.4
September	26.0	15.9	93.9	88.7	6.0
October	28.2	28.2	87.0	78.9	4.1
November	16.4	25.6	78.5	60.0	2.4
December	11.5	19.0	74.5	57.1	0.1

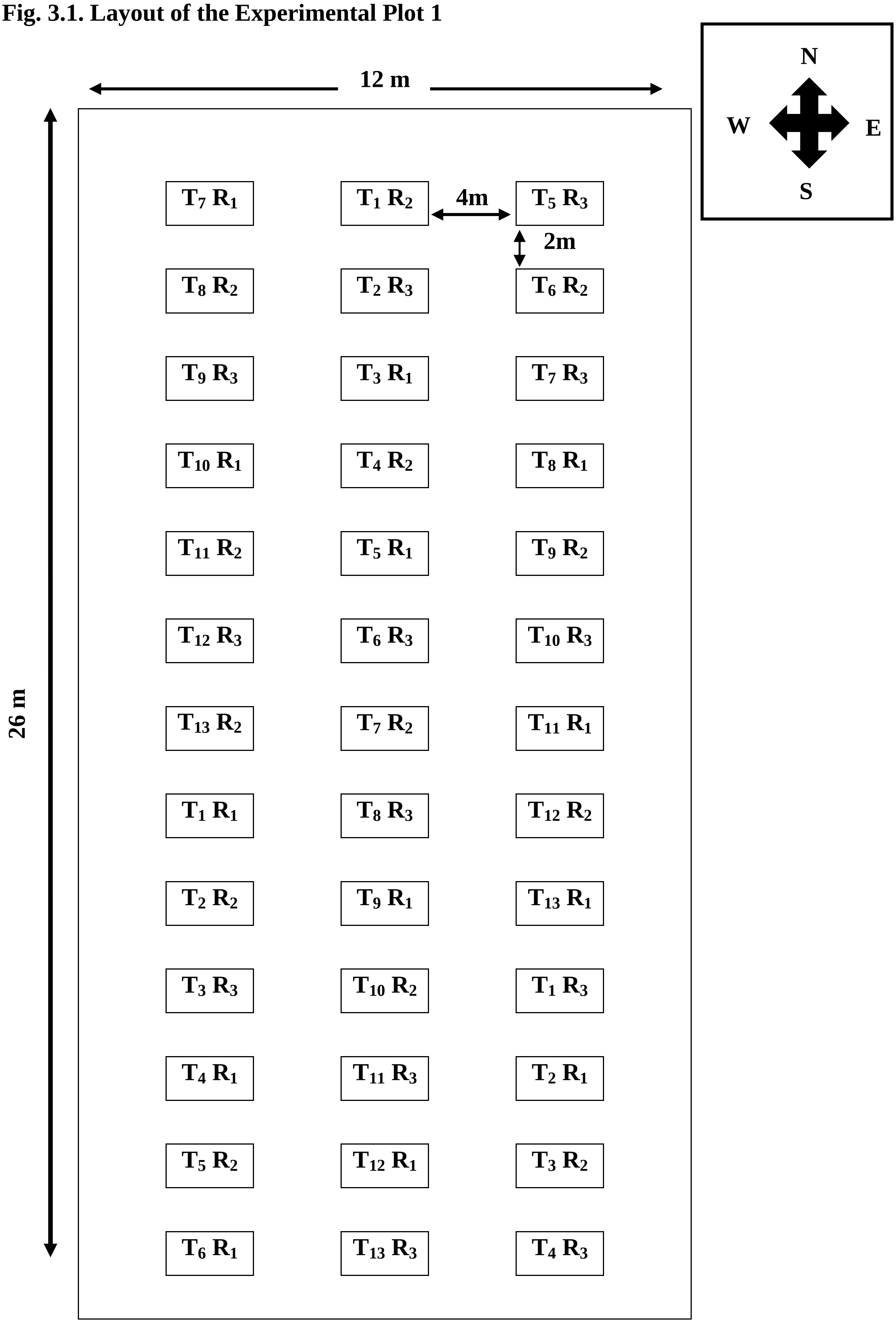
Source: State meteorological Center, directorate of Science & Technology

Table 3.6: Monthly records of temperature, relative humidity and total rainfall during the period of experimentation (2019)

Year & Month	Average temperature (ºC)		Average relative humidity (%)		Monthly annual total rainfall (mm)
	Maximum	Minimum	Maximum	Minimum	
2020					
January	21.8	11.1	73.8	57.6	1.6
February	24.4	11.9	64.5	51.8	0.7
March	28.4	16.3	57.4	46.5	0.0
April	29.5	18.3	64.8	52.4	3.6
May	28	19.9	79.6	67.6	9.4
June	28.4	20.8	86.9	78.3	7.3
July	28	20.8	87.1	79.1	8.1
August	29.5	21.3	82.8	74.3	5.1
September	28.8	20.3	81	73.1	7.9
October	29.7	20.6	83.6	74.2	12.4

Source: State meteorological Center, directorate of Science & Technology

Fig. 3.1. Layout of the Experimental Plot 1



3.4. Experiment 1: Integrated Nutrient management of dragon fruits

Table3.7: Details of the Experiment 1

a.	**Plant/ variety**	**:**	***Hylocereus polyrhizus*** **(red flesh)**
b.	**Age of plant**	**:**	**Newly planted**
c.	**Spacing**	**:**	**4m x 2m**
d.	**Experimental design**	**:**	**Randomized block design**
e.	**Total no. of treatments**	**:**	**13**
f.	**Total no. of replications**	**:**	**3**
g.	**Plants per replication**	**:**	**3**
h.	**Total no. of Plants**	**:**	**117**
i.	**Experimental Plot size**	**:**	**312 m^2**
j.	**Total experimental area**	**:**	**624 m^2**

3.4.1 Treatment details

T_1: NPK 100 % Recommended dose of fertilizer (RDF)

T_2: 50% RDF of NPK + Farm Yard Manure (FYM) to supply 50% K

T_3: 50% RDF of NPK + 50% K through vermi-compost (VC)

T_4: 50% RDF of NPK + 50% K through Neem Cake (NC)

T_5: 50% RDF of NPK + 50% K through Farm Yard Manure (FYM) + Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB)

T_6: 50% RDF of NPK + 50% K through VC+AZ+PSB+ KSB

T_7: 50% RDF of NPK + 50% K through NC+AZ+PSB+ KSB

T_8: 50% RDF of NPK + 25% K through FYM + 25% K through VC+ AZ+PSB+ KSB

T_9: 50% RDF of NPK + 25% K through FYM + 25% K through NC+ AZ+PSB+ KSB

T_{10}: 50% RDF of NPK + 25% K through VC + 25% K through NC+AZ+PSB+ KSB

T_{11}: 50% RDF of NPK+ 25% K through FYM + 25% K through VC + 25% K through NC.

T_{12}: 25% RDF of NPK + 25% K through FYM+ 25% K through VC+ 25% K through NC +AZ+PSB+ KSB

T_{13}: Control (no fertilizer).

Table 3.8: Nutrient composition of different organic fertilizer measured before application

Organic matter	Nitrogen(%)	Phosphorus(%)	Potash(%)
Farm yard manure	0.65	0.22	0.35
Vermi compost	1.24	0.18	0.74
Neem cake	4.08	1.03	1.78
Poultry manure	3.17	0.56	1.27

3.4.2 Application method for manure and fertilizer

Initially the necessary amount of organic manures and chemical fertilizers and the nutrient composition of the inputs (table 3.8) were calculated based on RDF. Since dragon fruit is a heavy nutrients feeder, 540: 720 :300g pillar^{1} year^{-1} (Tri *et al.*, 2000) is the recommended amount of NPK which was followed in this trial. The calculated nutrients were divided in two, half split dosage of Nitrogen, Phosphorus and Potash were put in during mid- March prior to flowering month. The left dosage of chemical fertilizer were given in the month of mid- September.

Bio-fertilizers used in this experiment are Azotobacter, Phosphate Solubilizing Bacteria (PSB) and Potash Solubilizing Bacteria (KSB) were mixed with organic nutrients at the rate of 100 g pillar^{-1} year^{-1} were applied in single dose in the month of March.

Organic manure used are FYM, poultry manure, vermi-compost and neem cake were applied in single doses in the month of March, the organic fertilizer for each treatments were calculated to supply 50% and 25 % K requirement.

3.4.3 Intercultural operations

Intercultural practices that were conducted throughout this study are mention down below.

3.4.3.1 Land preparation

Initially the experimental field was cleaned of weeds or any unwanted objects, pits were dug and pillars were installed prior to one month before planting the material.

3.4.3.2 Nutrients management

The plot was cleaned of weeds, loosened up the soil and encircle for the spreading of chemical fertilizers and manure. Earthing up was done after applying fertilizers to promote desired growth and give better anchorage to the dragon fruit plants.

3.4.3.3 Training

Training is done in Dragon fruit at the initial stage by tying up the main stem with a rope or plastic wires to the support given till it reaches the top where further support is given with tyres hanging above the ground. During climbing, side shoots are not allowed to develop from the main stem or shoot and are pruned off. When the vines reach the top, side shoots are allowed to produce. pruning is given in order to remove the undesired or crowded plant parts to give aeration and to increase the fruit quality.

3.4.3.4 Pruning

Pruning is given in order to remove all the infected stems from the plant in supplement to those that are tangled with one another to give aeration and increase the fruit quality. Post-harvest pruning is done in the month of February to encourage the newly shoot growth that will endure flowers the next year.

3.4.3.5 Plant Protection

The infected and dead branches were removed and were sprayed with FUNGURAN (Copper hydroxide) @ 2gm/litre of water at regular intervals for the control of diseases present in Dragon fruit under integrated nutrients management.

3.4.3.6 Weeding

Weeding is done an average of 3 times per year under dragon fruit cultivation. The hand-weeding method is followed and is done purely by the organic method.

3.4.3.7 Harvesting

Dragon fruits is ready for harvesting after a month of flowering mostly in between 35-45 days from flowering. Fruit is usually harvested when the colour changes from bright green to fully red in colour. Fruit is harvested manually by twisting it or cutting it off the stalk using a cutter. Harvesting or picking up of the fruits can be done several times as the harvesting period start from the end of June and extends up to early December.

3.4.4 Observations recorded

3.4.4.1 Plant growth parameter

The physical growth of plants were measured and noted at the time of planting and three months intervals during the period of the investigation and expressed finally as per cent promotion of growth over initial.

a. Cladode length

   With the help of measuring tape vine length was measured by taking the soil surface as the basic point and till the tip of the vine.

b. Cladode Circumference

   Cladode circumference was also measured by using a measuring tape, taking 15 cm from the ground level and measured around the vine.

c. Number of cladode/Plant

   Numbers of existing vine/cladodes are individually counted from each plant and total numbers of counted vines/cladodes were recorded.

3.4.4.2 Fruit growth and development

a. Number of Fruit per pillar

   It was calculated by counting the total number of fruits per pillar at the time of harvest and was expressed in number.

b. Number of Flower per pillar

   It was calculated by counting the total number of flower per pillar during entire period of plant growth and was expressed in number.

c. Fruit set (%)

   Existing number of fruits set was divided by the available number of flowers per pillar and was conveyed in percentage.

Fruit set (%) = (Numbers of fruit set per pillar/ total number of flowers per pillar) X 100

d. Flower bud drop (%)

Flower bud that drop from the vines per pillar were counted from date of flower bud development to till harvest and that were expressed in percentage. Formulation for the evaluation of flower bud drop percentage mention below:

Flower bud drop (%) = (no. of flower bud drop /total number of flower bud) X 100

e. Days required from fruit set to maturity.

Total numbers of days required were counted for the development of fruit from fruit set until it is mature enough to harvest.

f. Yield per plant (kg pillar^{-1})

The average fruit weight was multiplied with overall number of harvested fruits per pillar.

g. yield per ha (t ha^{-1})

The yield per pillar of the fruits was multiplied by the overall number of pillars ha^{-1}

3.4.4.3 Fruit Physical and Biochemical Parameters

a. Physical Parameters

i. Fruit length

The fruits length was measured with the help of a vernier caliper and their mean value was expressed in mm.

ii. Fruit diameter

The horizontal length of the fruit was measured in the broaden part by using a slide caliper and was expressed in mm.

iii. Fruit weight

Fruit weight was estimated by using analytical balance by selecting a representative fruits radomly from each pillar, these were weight and conveyed in g (average fruit weight).

iv. Fruit volume

Water displacement method was used to measure the fruit volume and their mean value was conveyed in cubic centimeters (cc).

v. Specific gravity

By dividing the average fruit weight and average fruit volume the specific gravity of the fruit was worked out.

vi. Peel weight

Peel weight was recorded using a analytical weighing balance and conveyed in grams (g).

vii. Peel thickness

Digital slide calliper was used to measure peel thickness of the fruit and conveyed in millimeter (mm).

viii. Pulp weight

Pulp weight was recorded using digital weighing balance and conveyed in grams (g).

ix. Pulp recovery (%)

Pulp recovery percentage was calculated by following formula:

Pulp recovery (%) = {(Pulp weight/ Fruit Weight)X100}

x. Pulp: peel ratio

Mean weight of pulp and peel of ripe fruit was recorded separately and expressed in grams and ratio was calculated by dividing the pulp weight by the peel weight.

b. Biochemical parameters

a) Total Soluble sugar (TSS)

TSS content of harvested fruit was determined by using a hand refractometer by putting a single drop of harvested liquid fruit extract on the detector and conveyed in terms of degree Brix with following standard temperature correction.

b) Acidity

The standard technique of (AOAC, 2016) was followed for the determination of titratable acidity, the extracted juice was titrated against N/10 NaOH and Phenolphthalein was used as an indicator and was expressed in percentage.

c) TSS:Acid ratio

The ratio was analyzed by dividing the TSS value by the titratable acidity content of the fruit.

d) Total sugar and reducing sugar

Total and reducing sugar content of freshly harvested fruits juice were estimated by the standard method of AOAC (2016) using a mixture of Fehling's reagents with methylene blue as an indicator through the copper reduction method.

Calculation

$$\%\text{Total sugar} = \frac{\text{mg of Dextrose X Volume made up X 100}}{\text{Titre X Weight of sample taken X100}}$$

$$\%\text{ Reducing sugar} = \frac{\text{mg of dextrose Volume made up X100}}{\text{Titre X Weight of sample taken X 100}}$$

e) Ascorbic acid

The standard procedure as described by (A.O.A.C, 2016; Ranganna, 1986) were used for the evaluation of Vitamin –C content of the fruit and expressed as mg/ 100 g of fruit.

Procedure

(a) Standardization of dye

For this purpose, take 5g of the fruit sample, add 30 ml of 4% oxalic acid and crushed it. And then filter using a muslin cloth or filter paper and by adding 4% oxalic acid, make the volume up to 50 ml. 5ml of aliquot was taken out and then add 10ml of 4% oxalic acid to it and titrated against the dye solution until the color changes from light pink to dark which persists for 10 seconds. The dye factor (mg of ascorbic acid per ml of dye) is as follows

Standard dye Factor (D.F.) = 0.5/Titre

(b) Ascorbic acid(mg/100g) = $\frac{\text{Titre x Factor x volume made up x 100}}{\text{Volume of sample taken (ml/g) vol. f aliquot taken}}$

f) Pulp and peel anthocyanin

2 g of pulp/ peel was extracted with 20 ml of methanolic HCL (85:15 v/v) and the extracted tube was refrigerated (4^0C) for one hour and then centrifuged at 7500 rpm for 15 mins and the supernatant was taken and process repeated and combined supernatant for obtaining standard volume and total anthocyanin was measured at 530 nm absorbance in a digital spectrophotometer and expressed as mg per 100g (Ryu et al.,2013) .

3.4.4.4. Soil analysis (N, P, K, Fe, Mn, Cu, Zn)

a. Preparation of soil samples:

The soil samples under each experimental plot were collected from the depth of 15-30 cm within the root zone. The entire soil collected from each plot within the same treatment were totally mixed and then dried. The dried soil samples were then pulverized and make them into a powder form and kept in a brown bag for soil composition analysis. Soil samples were taken initially and after installation of 1^{st} year and 2^{nd} year treatment. Soil samples were taken at least 20-25 cm apart from the plant area around the rhizosphere of the plant where manures were applied.

b. Chemical analysis:

i. **Estimation of nitrogen**: overall nitrogen content of the sampling was estimated by micro- Kjeldahl's method (Jackson, 1973).

ii. **Estimation of phosphorus**: phosphorus content of the soil sampling was examined by colorimetrically following the standard technique by Dickman and Bray (1940).

iii. **Estimation of Potassium:** Available potassium in the sample was evaluated by leaching the soil with neutral ammonium acetate and readings were measured by a flame photometer (Jackson, 1973).

iv. **Estimation of Micronutrient**:

Micronutrients (Fe, Mn, Cu and Zn) content of the soil sample were measured using Atomic Absorption Spectrophotometer.

v. **Soil organic carbon** content of the sample was estimated by 'wet digestion method' as described by Walkley and Black (1934).

vi. Soil pH was determined using digital pH balance.

vii. C: N ration of soil was estimated by dividing the organic carbon by the total nitrogen.

3.4.4.5. Soil Microbial analysis (AZ, PSB and KSB)

Serial dilution plating method as described by Vincent (1970) was followed for microbial population count. The prepared soil sample collection from the research farm were used for the counting of microbial population of azotobacter, phosphate solubilising bacteria (PSB) and potash mobilizers Bacteria (KSB).

a.Isolation of azotobacter from treated soil:

Serial dilution plating up to 10^6 of the sampling with distilled water was performed for the isolation of azotobacter. Johnson's agar media has been made and sterilized. This melted warm media was pour into a sterilized petri plates and then solidified. And then add 1ml of diluted aliquot to the petri plates and allowed to spread the aliquot on the surface of the media and incubated at 28± 2^o C for 3 days and numbers of colonies were observed and were recorded by counting them and conveyed in colony forming units (CFU) per g of soil.

b.Isolation of phosphate solubilising bacteria and potash solubilizing bacteria from treated soil:

Serial dilution of soil sampling up to 10^6 was conducted. And then pour this sample aliquot in the prepared media and incubated at 28± 2^o C for 3 days and numbers of colonies were observed and were recorded by counting them and expressed in colony forming units (CFU) per g of soil.

c. Composition of different media used for the microbial count

Table 3.9 : Johnson's agar media for identification of Azotobacter colonies

1	Sucrose	20g
2	K_2HPO_4	1.0g
3	$MgSO_4.7H_2O$	0.5g
4	NaCl	0.5g
5	$FeSO_4$	0.1g
6	$CaCO_3$	2.0g
7	Agar	15.0g
8	Distilled water	1ltr.

Table 3. 10 Sreber's media for solubilisation test and identification of phosphate solubilizing bacteria:

1	Glucose	10g
2	Soil extract/ tap water	250 ml
3	Stock solution A ($K_2HPO_4$10%)	20 ml
4	Stock solution B ($Cacl_2$10%)	30 ml
5	$CaCl_2$	0.1g
6	$MgSO_4$	0.2 g
7	Yeast extract	0.5 g
8	Agar Agar	20 g
9	Distilled water	750 ml

Note: Stock solution A and B are prepared separately, autoclaved and added to the medium while planting at 60 ^{0}C.

Table 3. 11 Media composition for potash mobilizers identification

1	D- glucose	2.0
2	Yeast extract	0.8
3	Peptone	0.5
4	Ethanol	0.3
5	Calcium carbonate ($CaCO_3$)	0.3
6	Agar agar	2

3.4.4.6 Cladode analysis (N, P, K, Fe, Mn, Cu, Zn and C:N ratio)

Cladode sampling

Cladode samples were collected from healthy branches at randomly from each pillar under each treatment. Cladode which is very young or aged should be avoided for sampling. The collected cladodes were cleaned and chopped into small pieces and then sun-dried. The dried caldodes are then grinded and make it in to a powder form and kept in paper bags. Labelling was done on each package.

Digestion of cladode samples

Estimation of total nitrogen available present in the vine sample was carried out by taking one gram of powder sample in to the concentrated H_2S0_4 in the presence of a digestion mixture of chemicals comprising of 400 parts of Potassium sulphate, 20 parts of Copper sulphate, 3 parts of Mercuric oxide, 1 parts of Selenium powder.

The digestion of vines sample for P, K, Ca, Mg, Fe, Cu, Zn and Mn estimation was conducted by taking 0.5g of samples were digested in di acid mixture consisting of HNO_3 and $HC1O_4$ in the ratio of 4: 1 following the standard method as suggested by Piper (1966).

Chemical analysis

a. Available nitrogen (% on dry weight basis) on the cladode sample was estimated using Micro-Kjeldahl method as described by Black (1965).

b. Estimation of the Phosphorus content of the cladode sample was determined by the Vanadomolybdate yellow colour method (Chapman and Pratt, 1961).

c. Potassium content from cladode sample was estimated by using a flame photometer as described by Jackson (1973).

d. Atomic Absorption Spectrophotometer were used for the estimation of available Micro nutrient viz. Fe, Mn, Cu and Zn of the cladode sample.

e. Standard method as outlines by Hodge and Hofreiter (1962) were used for the calculation of carbohydrate and the ratio of total carbohydrate to the total nitrogen (C: N ratio) of the cladodes was calculated.

Estimation of total carbohydrate content of cladode samples

Collected cladode samples were chopped in to a small piece and then sun-dried. Dried sample were grinded into a dust form and 100 mg of aliquot was added into a tube, place it in a water bath to hydrolysed the vine sample for 3 hours with 5ml of 2.5 N HCl and cool at ambient temperature. Solid Sodium carbonate was used to neutralize the hydrolysed sample until it produce the effervescence ceases and volume was made up to 100ml and then centrifuged. Collect the supernatant and measured out 0.5 and 1 ml of aliquots for analysis. Prepared the standard curve by taking 0, 0.2, 0.4, 0.6, 0.8 and 1ml of the working standard. 0 served as blank. Using distilled water volume was made up to 1ml in all tubes and then 4ml of anthrone reagent was added and heat the samples for eight minutes in a water bath and allowed to cool rapidly. Read the green to dark green colour changes at 630nm in a spectrophotometer. Draw a standard graph by plotting concentration of the standard on the X- axis versus absorbance on the Y- axis. The amount of carbohydrate present in the sample tube was determined from the graph and evaluation of carbohydrates was done as-

Amount of carbohydrate per 100mg of the sample = (mg of glucose/ volume of the test sample) x 100.

3.4.4.7 Cost - Benefit analysis

It was evaluated by comparing the total expenditure of different treatments and net return by considering the current price of planting materials, employee wages, organic manures, chemical fertilizers, bio-fertilizers, plant protection and sale price of the mature fruits and the value per rupee of investment was calculated and were expressed on per hectare basis.

3.4.4.8 Statistical analysis

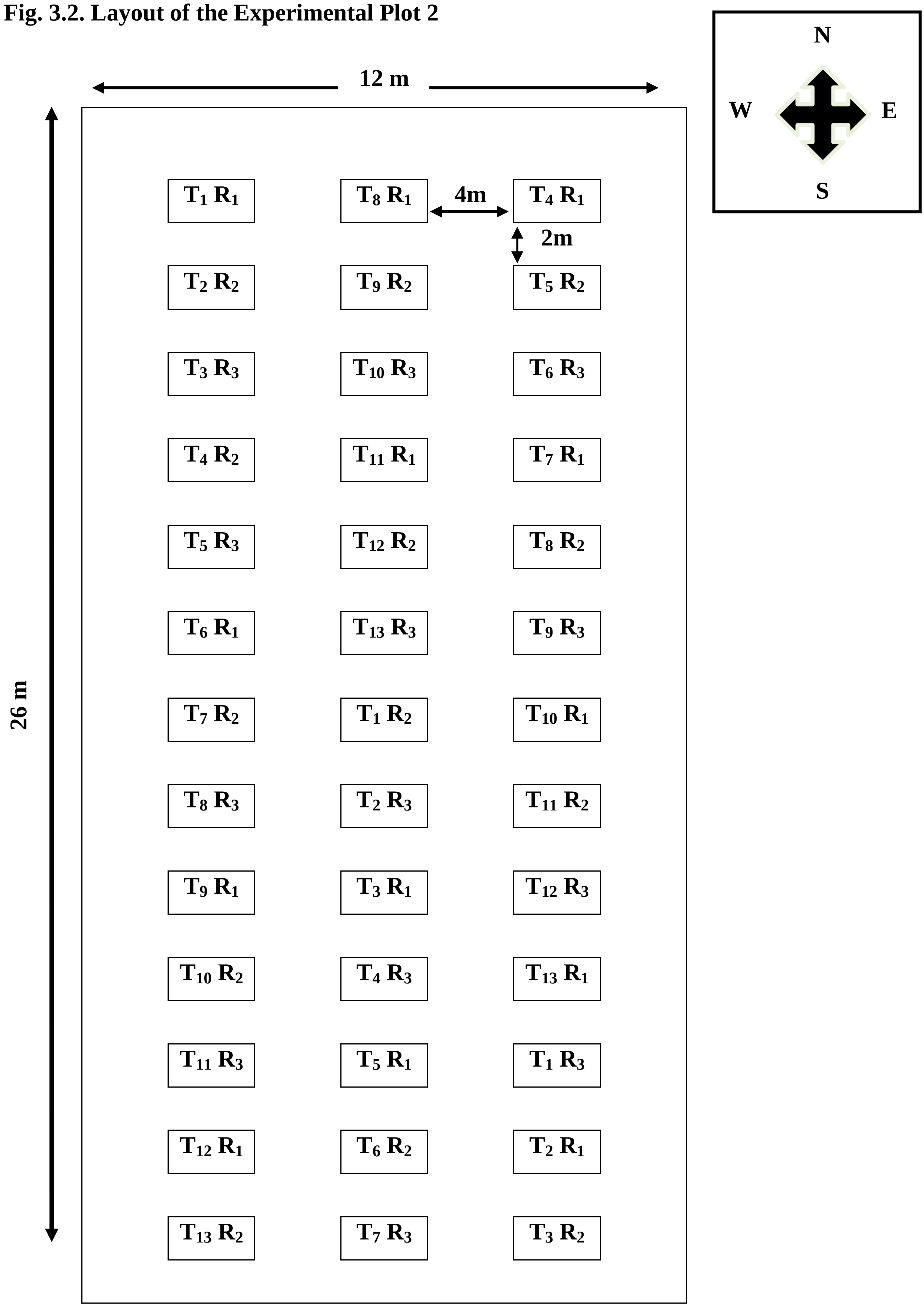
Data were inspected statistically by the standard technique of analysis for Randomized Block Design (RBD) as represented by Gomez and Gomez (1984) in order to examine the significance of the experimental work.

3.5. Experiment 2: Organic Nutrient management of dragon fruits

Table 3.12: Details of the Experiment

a.	**Plant/ variety**	**:**	***Hylocereus polyrhizus* (red flesh)**
b.	**Age of plant**	**:**	**Newly planted**
c.	**Spacing**	**:**	**4m x 2m**
d.	**Design of experiment**	**:**	**Randomized block design**
e.	**Number of treatments**	**:**	**13**
f.	**Number of replications**	**:**	**3**
g.	**Plants per replication**	**:**	**3**
h.	**Total no of Plants**	**:**	**117**
i.	**Experimental Plot size**	**:**	**312 m^2**
j.	**Total experimental area**	**:**	**624 m^2**

Fig. 3.2. Layout of the Experimental Plot 2



3.5.1 Treatment details

T_1: Farm Yard Manure (FYM)

T_2: Vermi compost (VC)

T_3: Neem Cake (NC)

T_4: Poultry Manure (PM)

T_5: Azotobacter (AZ)

T_6: Phosphate Solubilizing Bacteria (PSB)

T_7: Potash Solubilizing Bacteria (KSB)

T_8: FYM +AZ+PSB+ KSB

T_9: VC +AZ+PSB+ KSB

T_{10}: NC +AZ+PSB+ KSB

T_{11}: PM +AZ+PSB+ KSB

T_{12}: AZ+PSB+ KSB

T_{13}: Control (no fertilizer)

3.5.2 Time and methods of application of fertilizers

The amount of organic manure i.e. farm yard manure, vermi compost and neem cake were calculated based on 50 % of K equivalent of RDF (N:P:K= 540: 720 :300g pillar^{1} year^{-1}) and were applied in the month of March along with Bio-fertilizers such as Azotobacter, Phosphate Solubilizing Bacteria and Potash Solubilizing Bacteria were applied in a single dose each at the rate of 100 g pillar^{-1} Year^{-1}.

3.5.3 Intercultural operations

Intercultural practices that were conducted throughout this study are mention down below.

3.5.3.1 Land preparation

Initially the experimental field was cleaned for weeds or any unwanted objects, pits were dug and pillars were installed prior to one month before planting the material.

3.5.3.2 Nutrients management

The plot was cleaned of weeds, loosened up the soil and ring basins were prepared for the spreading of manure. Earthing up was done after applying manure to promote desired growth and give better anchorage to the dragon fruit plants.

3.5.3.3 Training

Training was done in Dragon fruit at the initial stage by tying up the main stem with a rope or plastic wires to the support given till it reached the top where further support was given with tyres hanging above the ground. During climbing, side shoots were not allowed to develop from the main stem or shoot and are pruned off. When the vines reached the top, side shoots were allowed to produce. pruning were given to remove the undesired or crowded plant parts to give aeration and to increase the fruit quality.

3.5.3.4 Pruning

Pruning was given to remove all the spoiled stems from the plant in accumulation to those that were intertwined with one another to give aeration and to increase the fruit quality. Post-harvest pruning was done in the month of February to encourage the growth of new young shoots that will bear flowers the following year.

3.5.3.5 Plant Protection

The dead and diseased branches were removed and sprayed with Neem Oil @ 5 ml/litre of water at regular intervals for the control of diseases present in Dragon fruit.

3.5.3.6 Weeding

Weeding was done an average of 3 times per year under dragon fruit cultivation. The hand-weeding method was followed and was done purely by the organic method.

3.5.3.7 Harvesting

Dragon fruits were ready for harvest within a month of flowering. Fruit was harvested when the colour changes from bright green to fully red in colour. Fruit was harvested manually by twisting it or cutting it off the stalk. Harvesting or picking up of the fruits can be done several times as the harvesting period start from the end of June and extends up to early December.

3.5.4 Observations recorded.

3.5.4.1 Plant growth and development

The following parameters were recorded at initial and two months intervals during the period of experiment and articulated finally as per cent promotion of growth over initial.

a. Cladode length

   With the help of measuring tape vine length was measured by taking the soil surface as the basic point and till the tip of the vine.

b. Cladode Circumference

   Cladode circumference were also measured by using a measuring tape, taking 15 cm from the ground level and measured around the vine.

c. Number of cladode/Plant

Numbers of existing vine/cladodes were individually counted from each plant and total numbers of counted vines/cladodes were recorded.

3.5.4.2 Fruit growth and development

Fruit growth and development

a. Number of Fruit per pillar

It was calculated by counting the total number of fruits per pillar at the time of harvest and was expressed in number.

b. Number of Flower per pillar

It was calculated by counting the total number of flower per pillar during entire period of plant growth and was expressed in number.

c. Fruit set (%)

Existing number of fruits set was divided by the available number of flowers per pillar and was conveyed in percentage.

Fruit set (%) = (Numbers of fruit set per pillar/ total number of flowers per pillar) X 100

d. Flower bud drop (%)

Flower bud that drop from the vines per pillar were counted from date of flower bud development to till harvest and that were expressed in percentage. Formulation for the evaluation of flower bud drop percentage mention below: Flower bud drop (%) = (no. of flower bud drop /total number of flower bud) X 100

e. Days required from fruit set to maturity.

Total numbers of days required were counted for the development of fruit from fruit set until it is mature enough to harvest.

f. Yield per plant (kg pillar^{-1})

The average fruit weight was multiplied with overall number of harvested fruits per pillar.

g. yield per ha (t ha^{-1})

The yield per pillar of the fruits was multiplied by the overall number of pillars ha^{-1}

3.5.4.3 Fruit Physical and Biochemical Parameters

1. **Physical Parameters**

   i. Fruit length

   The Fruits length was measured with the help of a vernier caliper and their mean value was expressed in mm.

   ii. Fruit diameter

   The horizontal length of the fruit was measured in the broaden part by using a slide caliper and was expressed in mm.

   iii. Fruit weight

   Fruit weight was estimated by using analytical balance by selecting a representative fruits radomly from each pillar, these were weight and conveyed in g (average fruit weight).

   iv. Fruit volume

   Water displacement method was used to measure the fruit volume and their mean value was conveyed in cubic centimeters (cc).

   v. Specific gravity

   By dividing the average fruit weight and average fruit volume the specific gravity of the fruit was worked out.

   vi. Peel weight

   Peel weight was recorded using an analytical weighing balance and conveyed in grams (g).

   vii. Peel thickness

   Digital slide calliper was used to measure peel thickness of the fruit and conveyed in millimeter (mm).

   viii. Pulp weight

   Pulp weight was recorded using digital weighing balance and conveyed in grams (g).

ix. Pulp recovery (%)

Pulp recovery percentage was calculated by following formula:

Pulp recovery (%) = {(Pulp weight/ Fruit Weight)X100}

x. Pulp: peel ratio

Mean weight of pulp and peel of ripe fruit was recorded separately and expressed in grams and ratio was calculated by dividing the pulp weight by the peel weight.

Biochemical parameters

1. Total Soluble sugar (TSS)

TSS content of fruit was determined by using a Refractometer by putting a single drop of harvested liquid fruit extract on the detector which was calibrated at 20^{o}C and expressed in terms of Brix.

2. Acidity

By titrating the extracted juice against N/10 NaOH using phenolphthalein as an indicator , the total titratable acidity was determined and expressed in percentage (AOAC, 2016).

3. TSS:Acid ratio

The ratio was analyzed by dividing the TSS value by the titratable acidity content of the fruit.

4. Total sugar and reducing sugar

The total sugar and reducing sugar content of freshly harvested fruits juice were determined by the standard method of AOAC (2016) using a mixture of Fehling's reagents with methylene blue as an indicator through the copper reduction method.

Calculation

$$\%\text{Total sugar} = \frac{\text{mgofDextroseXVolumemade up X 100}}{\text{TitreX Weight of sample taken X100}}$$

$$\%\text{ Reducing sugar} = \frac{\text{mg of dextrose Volumemadeup X100}}{\text{TitreX Weight of sample taken X 100}}$$

5. Ascorbic acid

The standard procedure as described by (A.O.A.C, 2016; Ranganna, 1986) was used for the estimation of Vitamin –C content of the fruit and expressed as mg/ 100 g of fruit.

Procedure

a. Standardization of dye

For this purpose, 5g of the sample was taken and crushed it with 30 ml of 4% oxalic acid, filtered using a muslin cloth or filter paper and made the volume up to 50 ml with 4% oxalic acid. 5ml of aliquot was taken and then add 10ml of 4% oxalic acid to it and was titrated against the dye solution until the color changes from light pink to dark which persists for 10 seconds. The dye factor (mg of ascorbic acid per ml of dye) is as follows

Standard dye Factor (D.F.) = 0.5/Titre

b. Ascorbic acid(mg/100g) = $\frac{\text{TitrexFactor x volumemadeupx100}}{\text{Volume of sample taken (ml/g) vol. f aliquot taken}}$

6. Pulp and peel anthocyanin

2 g of pulp/ peel was extracted with 20 ml of methanolic HCL (85:15 v/v) and the extracted tube was refrigerated (4^0C) for one hour and then

centrifuged at 7500 rpm for 15 mins and the supernatant was taken and process repeated and combined supernatant for obtaining standard volume and total anthocyanin was measured at 530 nm absorbance in a digital spectrophotometer and expressed as mg per 100g (Ryu et al.,2013) .

3.5.4.44 Soil analysis (N, P, K, Fe, Mn, Cu, Zn)

Preparation of soil samples:

The soil samples under each experimental plot were collected from the depth of 15-30 cm within the root zone. The entire soil collected from each plot within the same treatment were totally mixed and then dried. The dried soil samples were then pulverized into a powder form and kept in a paper bag for chemical analysis. Soil samples were collected initially and after installation of 1^{st} year and 2^{nd} year treatment. Soil samples were taken at least 20-25 cm apart from the plant area around the rhizosphere of the plant where manures were applied.

Chemical analysis:

i. Estimation of nitrogen: Total nitrogen content of the soil was estimated by micro- Kjeldahl's method (Jackson, 1973).

ii. Estimation of phosphorus: phosphorus content of the soil sample was examined by colourimetrically following the standard technique by Dickman and Bray (1940).

iii. Estimation of Potassium: Available potassium in the soil sample was determined by leaching the soil with neutral ammonium acetate and readings were measured by a flame photometer (Jackson, 1973).

iv. Estimation of Micronutrient: Micronutrients (Fe, Mn, Cu and Zn) content of the soil sample were measured using Atomic Absorption Spectrophotometer.

v**. Soil organic carbon** content of the sample was estimated by 'wet digestion method' as described by Walkley and Black (1934).

vi. Soil pH was determined using digital pH balance.

vii. C: N ration of soil was estimated by dividing the organic carbon by the total nitrogen.

3.5.4.5. Soil Microbial analysis (AZ, PSB and KSB)

Serial dilution plating method as described by Vincent (1970) was followed for microbial population count. The prepared soil sample collection from the research farm were used for the counting of microbial population of azotobacter, phosphate solubilising bacteria (PSB) and potash mobilizers Bacteria (KSB).

a.Isolation of azotobacter from treated soil:

Serial dilution up to 10^6 of soil samples with Distilled water was performed for the isolation of azotobacter. Johson's agar media was prepared and sterilized. This melted warm media was pour into a sterilized petri plates and then solidified. And then add 1ml of diluted aliquot to the petri plates and allowed to spread the aliquot on the surface of the media and incubated at 28± 2^o C for 3 days and numbers of colonies were observed and were recorded by counting them and expressed in colony forming units (CFU) per g of soil.

b.Isolation of phosphate solubilising bacteria and potash solubilizing bacteria from treated soil:

Serial dilution of soil samples up to 10^6 was conducted. And then pour this sample aliquot in the prepared media and incubated at 28± 2^o C for 3 days and numbers of colonies were observed and were recorded by counting them and expressed in colony forming units (CFU) per g of soil.

3.5.4.6 Caldode analysis (N, P, K, Fe, Mn, Cu, Zn and C: N ratio)

Claode sampling

1. Samples were collected from healthy plants only.
2. Cladode sample under each treatment were collected.

3. Three representative cladodes from each replication were selected.
4. Sample collected were wiped and clean using distilled water.
5. Selected cladodes were chopped into a small piece and were sun-dried.
6. Dried sample were grinded and make it in to a dust form.
7. Clean brown paper bags were used to collected and stored the sample.
8. Labelling was done with a clear indication from under which treatment the sample was taken.

Precaution

1. Immature or aged cladodes were avoided for their rapidly changing composition.
2. Diseased, insect-damaged, or dead cladodes were not collected for sampling.

Digestion of cladode samples

Estimation of total nitrogen available present in the cladode sample was carried out by taking one gram of powder sample in to the concentrated H_2S0_4 in the presence of a digestion mixture of chemicals comprising of 400 parts of Potassium sulphate, 20 parts of Copper sulphate, 3 parts of Mercuric oxide, 1 parts of Selenium powder.

The digestion of vines sample for P, K, Ca, Mg, Fe, Cu, Zn and Mn estimation was conducted by taking 0.5g of samples were digested in di acid mixture consisting of HNO_3 and HC1O4 in the ratio of 4: 1 following the standard method as suggested by Piper (1966).

Chemical analysis.

a. Available nitrogen (% on dry weight basis) on the cladode sample was estimated using Micro-Kjeldahl method as described by Black (1965).

b. Estimation of the Phosphorus content of the cladode sample was determined by the Vanadomolybdate yellow colour method (Chapman and Pratt, 1961).

c. Potassium content from caldode sample was estimated by using a flame photometer as described by Jackson (1973).

d. Micro nutrient viz. Fe, Mn, Cu and Zn of the cladode sample were estimated using Atomic Absorption Spectrophotometer.

e. Available Carbohydrate present on the caldode sample was determined by following the methods of Hodge and Hofreiter (1962) and the C: N ratio of the vines was calculated as the ratio of total carbohydrate to the total nitrogen.

Estimation of total carbohydrate content of cladode samples

Collected cladode samples were chopped in to a small pieces and then sun-dried. Dried samples were grinded into a dust form and 100 mg of aliquot was added into a tube, place it in a water bath to hydrolyse the vine sample for 3 hours with 5ml of 2.5 N HCl and then cooled at ambient temperature. Solid Sodium carbonate was used to neutralize the hydrolysed sample until it produce the effervescence ceases and volume was made up to 100ml and then centrifuged. Supernatant was collected and measured out 0.5 and 1 ml of aliquots for analysis. The standard curve was prepared by taking 0, 0.2, 0.4, 0.6, 0.8 and 1ml of the working standard. 0 served as blank. Using distilled water volume was made up to 1ml in all tubes and then 4ml of anthrone reagent was added and heat the samples for eight minutes in a water bath and allowed to cool rapidly.Green to dark green colour changes was read at 630nm in a spectrophotometer. A standard graph was drawn by plotting concentration of the standard on the X- axis versus absorbance on the Y- axis. The amount of carbohydrate present in the sample tube was determined from the graph and evaluation of carbohydrates was done as-

Amount of carbohydrate per 100mg of the sample = (mg of glucose/ volume of the test sample) x 100.

3.5.4.7 Benefit:Cost analysis

It was evaluated by comparing the total expenditure of different treatments and net return by considering the current price of planting materials, employee wages, organic manure, bio-fertilizers, plant protection and market sale value of the harvested fruits and the net out turn per rupee of investment was calculated and were expressed on per hectare basis.

3.5.4.8 Statistical analysis

Data were analyzed statistically by following the standard technique of analysis for Randomized Block Design (RBD) as described by Gomez and Gomez (1983) in order to examine the significance of the experimental work.

CHAPTER 4

RESULTS AND DISCUSSIONS

Experiment 1: integrated Nutrients management of Dragon fruit

4.1 Results

4.1.1 Plant growth and development

Observation was taken on plant growth physiology for the following parameter such as cladode length, cladode circumference, number of cladode per plant. Recordings were made on the following aspects at initial and on specific interval during the process of experiment with measuring implement. Each character was presented with the help of tables and figures as shown below.

4.1.1.1. Cladode length (cm)

Data presented in Table 4.1.1 clearly showed that dragon fruit plants had consistent growth in terms of cladode length since planting. It was found that at 3MAP (months after planting), plants manured with neem cake (NC) to supply 50% K+ 50% RDF (T_4) had maximum cladode length (85.78 cm) followed by plants applied with vermi compost (VC) to supply 25% K + NC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_{10}; 84.22 cm) compared with control (66.78 cm). Six months after planting , cladode length was found highest (120.22 cm) at FYM to supply 25% K + NC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_9) against control (83.67 cm), likewise, at 9 MAP cladode length was recorded maximum (155.11 cm) in T_9 compared with control (97.56 cm). However, at 12 and 15 MAP, cladode length was significantly higher (195.22 cm at 12 MAP and 242.78 cm at 15 MAP) at T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) compared with control (120.33, 155.44 cm at 12 and 15 MAP, respectively). Data on percentage promotion of cladode length over initial (Table 4.1.2, Fig. 4.1.1) manifested that at 15 MAP, plants at T_5 [Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash

Solubilizing Bacteria (KSB)] had highest percentage (209.70%) of cladode length compared with control (132.76%).

Analysis of 2nd year (2019-20) data revealed that at 18 and 21 MAP, cladode length was found highest (253.33 cm and 259.89 cm) at T_8 compared with control (167.33 cm and 180.33 cm, respectively). Whereas, cladode length was maximum (271.11 cm) at T_4 at 24 MAP and T_{11} (293.33 cm) at 27 MAP compared with control (Table 4.1.3 and Fig. 4.1.2). After 30 months of planting, dragon fruit plants applied with FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) had maximum cladode length (314.44 cm) followed by T_{12} (302.89 cm) compared with control (217.56 cm). At 30 MAP, plants at T10 had maximum length promotion (81.24%) whereas, plants at T_7 had the least percent (38.51%) promotion of cladode length over 15 MAP.

4.1.1.2. Cladode circumference (cm)

Perusal of the data presented at Table 4.1.5 and Fig. 4.1.3 clearly showed that dragon fruit plants had consistently high cladode thickness when manured with Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_5). It was observed that plants under this treatments had highest cladode circumference at 3 MAP (19.67 cm), 6 MAP (22.11cm), 9MAP (22.89cm), 12MAP (23.11cm) and 15 MAP (23.22 cm) compared with other treatments. At 15 MAP, plants at T_1 [Recommended dose of fertilizer (RDF) as 100% inorganic] had the highest promotion of cladode circumference (24.76%) followed by T_7 (24.23%) compared with T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB) where it was found lowest (16.15%) (Table 4.1.6).

After 30 months of planting, cladode circumference was found maximum (23.67 cm) in T_5 followed by T_8 (22.56 cm) compared with control (19.11 cm) (Table 4.1.7). Besides, percentage promotion of cladode circumference over initial showed maximum in T_3 (7.54%) whereas, it was recorded minimum promotional growth in T_5 (1.94%) (Fig. 4.1.4).

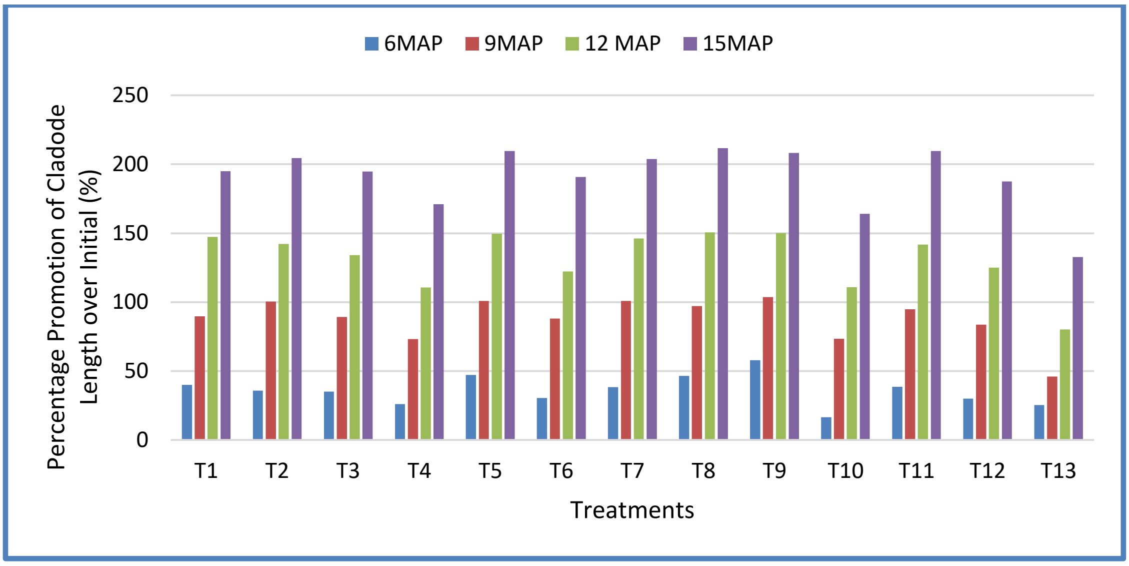


Fig. 4.1.1 Influence of integrated nutrient management treatments on percentage promotion of cladode length over initial (2018-19)

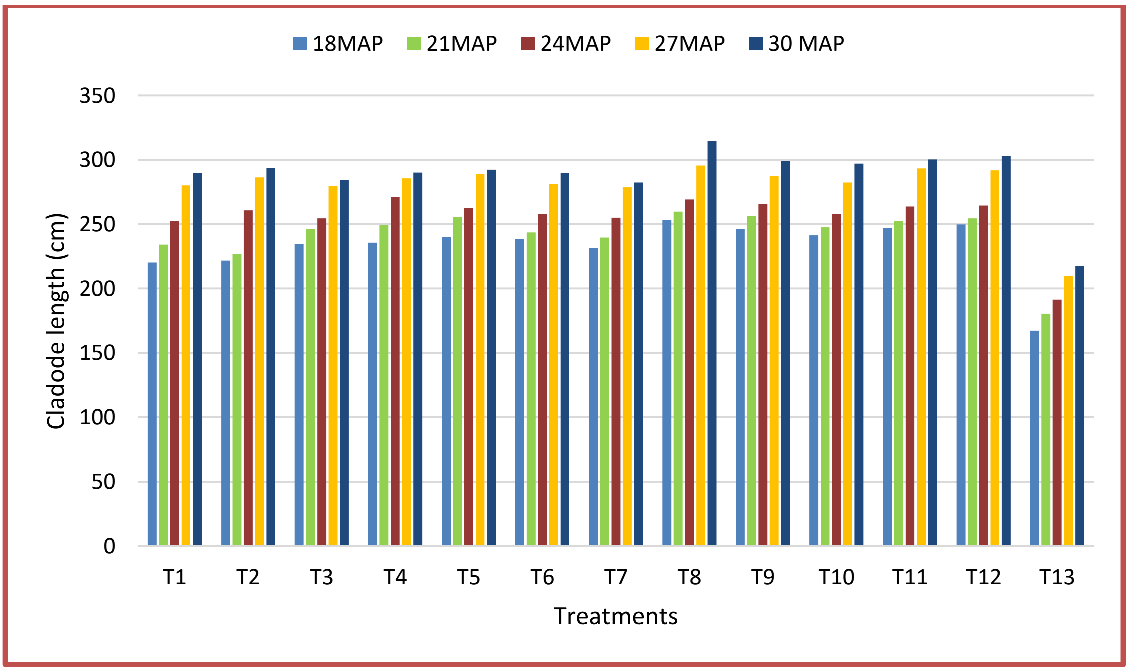


Fig. 4.1.2 Effect of integrated nutrient management treatments on cladode length (2019-20)

Table 4.1.1 : Effect of integrated nutrient management on cladode length of dragon fruit plants (2018-19)

Treatments	Cladode Length (cm)				
	2018-19				
	3MAP	**6MAP**	**9MAP**	**12 MAP**	**15MAP**
T_1	69.22	96.89	131.33	171.22	204.22
T_2	71.78	97.56	143.89	173.89	218.67
T_3	75.33	101.89	142.67	176.44	222.11
T_4	85.78	108.11	148.67	180.67	232.56
T_5	76.56	112.67	153.89	191.22	237.11
T_6	74.56	97.33	140.22	165.67	216.89
T_7	67.56	93.44	135.78	166.33	205.33
T_8	77.89	114.11	153.67	195.22	242.78
T_9	76.11	120.22	155.11	190.44	234.64
T_{10}	84.22	98.11	146.11	177.67	222.33
T_{11}	75.56	104.67	147.22	182.78	233.89
T_{12}	82.56	107.33	151.67	185.89	237.44
T_{13}	66.78	83.67	97.56	120.33	155.44
SEm(±)	**2.162**	**2.223**	**2.470**	**2.105**	**3.398**
CD(0.05)	**6.311**	**6.488**	**7.209**	**6.145**	**9.918**

*MAP= months after planting

Table 4.1.2 : Effect of integrated nutrient management on percentage promotion of cladode length over initial (2018-19)

Treatments	Percentage Promotion of Cladode Length over Initial (%)				
	2018-19				
	3MAP	6MAP	9MAP	12 MAP	15MAP
T_1	0	39.97	89.73	147.36	195.03
T_2	0	35.92	100.46	142.25	204.64
T_3	0	35.26	89.39	134.22	194.85
T_4	0	26.03	73.32	110.62	171.11
T_5	0	47.17	101.01	149.76	209.70
T_6	0	30.54	88.06	122.20	190.89
T_7	0	38.31	100.98	146.20	203.92
T_8	0	46.50	97.29	150.64	211.70
T_9	0	57.96	103.80	150.22	208.29
T_{10}	0	16.49	73.49	110.96	163.99
T_{11}	0	38.53	94.84	141.90	209.54
T_{12}	0	30.00	83.71	125.16	187.60
T_{13}	0	25.29	46.09	80.19	132.76
SEm(±)	**-**	**4.123**	**7.209**	**6.780**	**9.586**
CD(0.05)	**-**	**12.036**	**21.042**	**19.792**	**27.980**

*MAP= months after planting

Table 4.1.3 : Effect of integrated nutrient management on cladode length of dragon fruit plants (2019-20)

Treatments	Cladode Length (cm)				
	2019-20				
	18MAP	21MAP	24MAP	27MAP	30 MAP
T_1	220.33	234.22	252.33	280.22	289.56
T_2	221.78	226.89	260.89	286.33	293.78
T_3	234.56	246.44	254.56	279.78	284.22
T_4	235.56	249.33	271.11	285.67	290.11
T_5	239.78	255.44	262.89	288.78	292.44
T_6	238.44	243.56	257.78	281.22	289.78
T_7	231.56	239.67	255.11	278.67	282.44
T_8	253.33	259.89	269.22	295.67	314.44
T_9	246.44	256.22	265.78	287.33	299.11
T_{10}	241.33	247.56	258.11	282.33	297.22
T_{11}	247.22	252.67	263.78	293.33	300.33
T_{12}	249.78	254.56	264.56	291.78	302.89
T_{13}	167.33	180.33	191.33	209.78	217.56
SEm(±)	**3.552**	**2.117**	**2.627**	**2.008**	**3.047**
CD(0.05)	**10.368**	**6.181**	**7.668**	**5.861**	**8.895**

*MAP= months after planting

Table 4.1.4: Effect of integrated nutrient management on percentage promotion of cladode length over initial (2019-20)

Treatments	Percentage Promotion of Cladode Length over Initial (%)				
	2019-20				
	18MAP	21MAP	24MAP	27MAP	30 MAP
T_1	12.97	20.09	29.38	43.68	48.47
T_2	8.38	10.87	27.49	39.92	43.56
T_3	20.38	26.48	30.64	43.59	45.87
T_4	37.67	45.71	58.44	66.95	69.55
T_5	14.34	21.81	25.36	37.71	39.46
T_6	24.91	27.59	35.04	47.32	51.80
T_7	13.55	17.53	25.10	36.66	38.51
T_8	19.66	22.76	27.17	39.66	48.53
T_9	18.32	23.01	27.60	37.95	43.60
T_{10}	47.16	50.96	57.39	72.16	81.24
T_{11}	17.98	20.58	25.89	39.99	43.33
T_{12}	33.14	35.69	41.02	55.53	61.46
T_{13}	26.04	35.83	44.12	58.01	63.87
SEm(±)	**1.023**	**1.095**	**1.458**	**2.191**	**1.978**
CD(0.05)	**3.712**	**3.196**	**4.255**	**6.395**	**5.773**

*MAP= months after planting

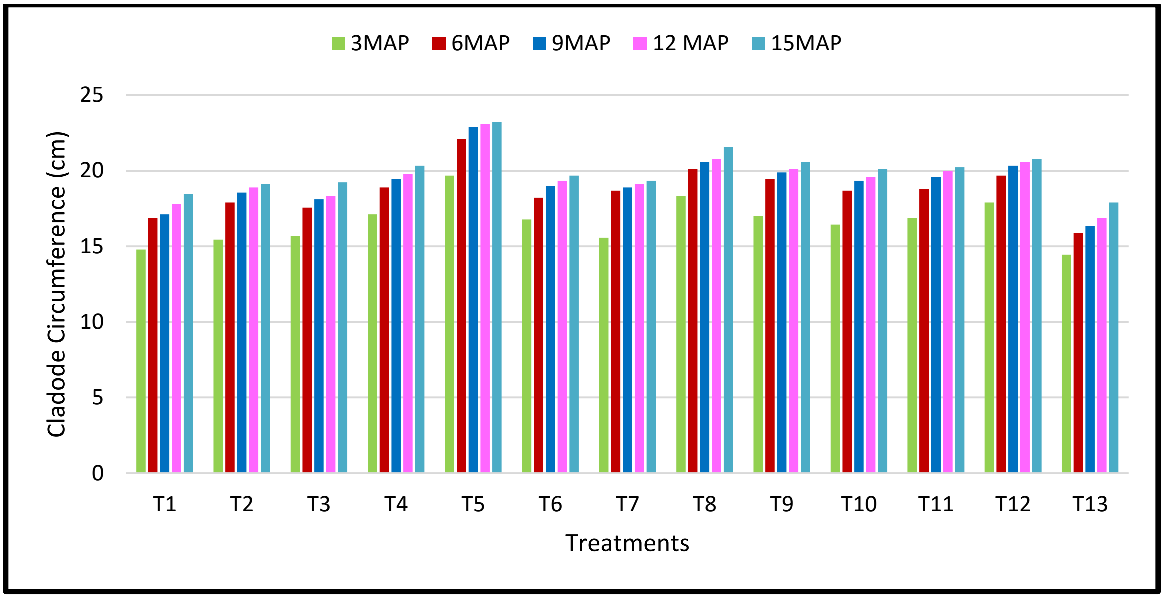


Fig. 4.1.3 Effect of integrated nutrient management treatments on cladode circumference (2018-19)

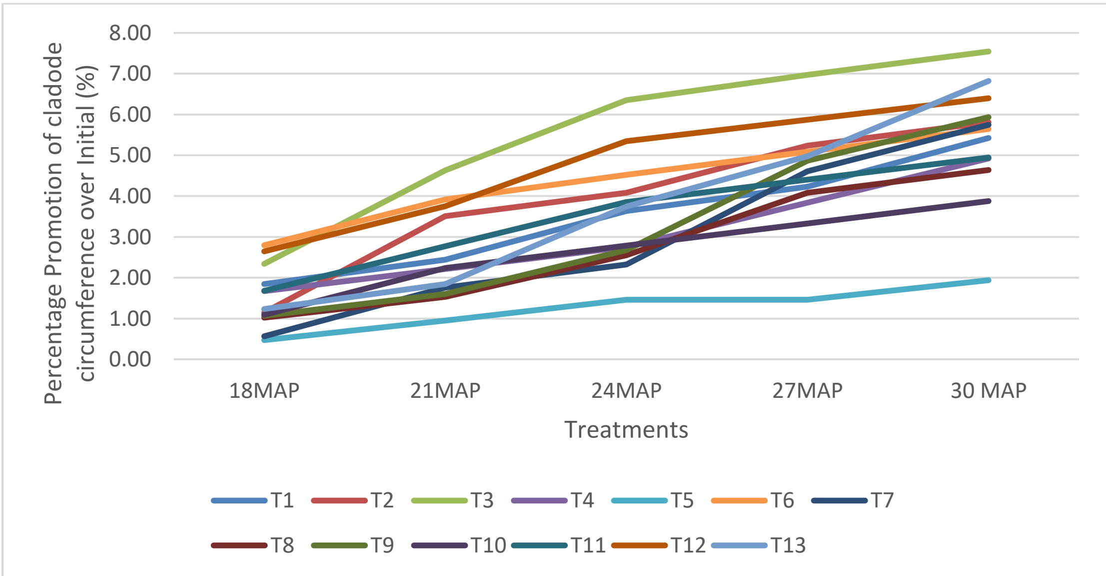


Fig. 4.1.4 Influence of integrated nutrient management treatments on percentage promotion of cladode circumference over initial (2019-20)

4.1.1.3 Number of Cladode per plant (No.)

Data presented in Table 4.1.9, Fig.4.1.5 suggested that there was no significant variation in case of number of cladode per plants at 3 MAP, however, at 6 MAP, it was recorded highest (3.33) at T_{12} which was statistically at par with T_1 compared with control (1.78). At 9 MAP number of cladode per plants was recorded highest (7.22) in case of T_1[Recommended dose of fertilizer (RDF) as 100% inorganic] which was statistically at par with T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) compared with control (2.11). AT 12 and 15 MAP, highest number of cladode per plant was recorded in T_8 (8.89; 10.11) compared with control (2.78, 3.11).

After 30 months of planting, number of cladodes were found maximum (26.22) in T_8 followed by T_{12} (25.56) and T_5 (25.44) compared with control (9.89) (Table 4.1.10).

4.1.2 Fruit growth and development

4.1.2.1 Number of Flower per pillar (No.)

Data presented from table 4.1.11 showed significant influence among plants in number of flower due to various treatment. Maximum number of flower per pillar (22.67 and 24.67) was observed under T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB)(22.00 and 23.00) at 2018-19 and 2019-20 and it was found lowest (4.33 and 5.67) at control (T_{13}) for two consecutive years of experimental study.

The pooled data analysis showed that maximum number of flower per pillar (23.67) was observed at T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB) (22.50) and the lowest (5.00) was observed with control(T_{13}).

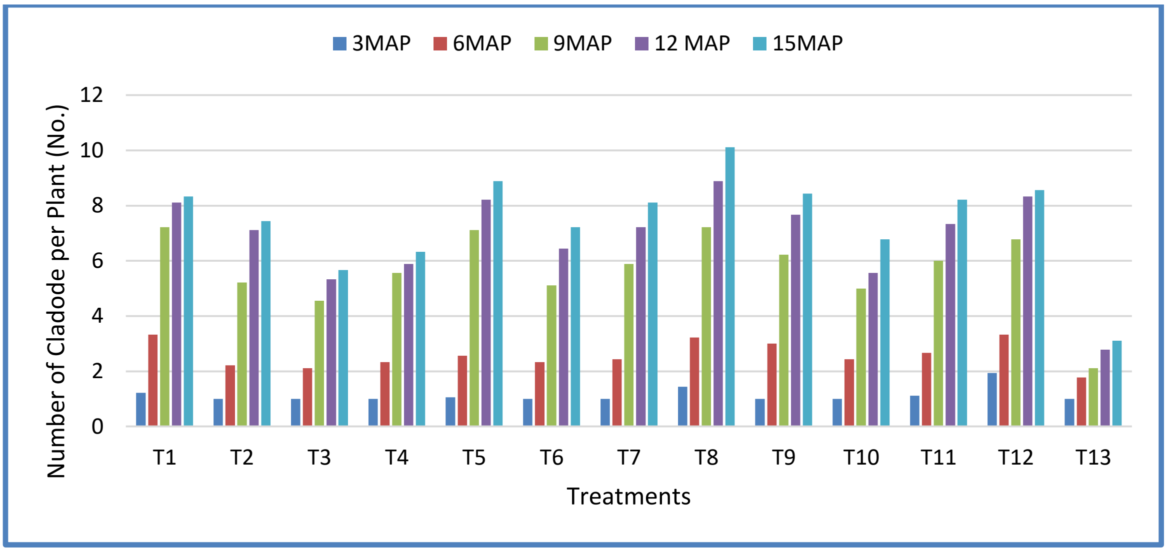


Fig. 4.1.5 Effect of integrated nutrient management treatments on number of cladodes per plant (2018-19)

4.1.2.2. Number of fruits per pillar (No.)

Number of fruit per pillar was presented in Table 4.1.11 clearly showed that there was a significant variation among the plant due to various treatment. Maximum number of fruit per pillar (21.33 and 23.67) was recorded in treatment T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB) (19.67 and 21.67) in both year (2018-19 and 2019-20). The minimum number (2.33 and 3.67) of fruits per pillar was obtained in plants under control.

The pooled analysis showed highest number of fruit per pillar (22.50) which was obtained in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) followed by T_{12} (20.67) and T_5 (19.50). The lowest recorded number of fruit per pillar was in control (3.00).

Table 4.1.5 : Effect of integrated nutrient management on cladode circumference of dragon fruit plants (2018-19)

Treatments	Cladode Circumference (cm)				
	2018-19				
	3MAP	6MAP	9MAP	12 MAP	15MAP
T_1	14.78	16.89	17.11	17.78	18.44
T_2	15.44	17.89	18.56	18.89	19.11
T_3	15.67	17.56	18.11	18.33	19.22
T_4	17.11	18.89	19.44	19.78	20.33
T_5	19.67	22.11	22.89	23.11	23.22
T_6	16.78	18.22	19.00	19.33	19.67
T_7	15.56	18.67	18.89	19.11	19.33
T_8	18.33	20.11	20.56	20.78	21.56
T_9	17.00	19.44	19.89	20.11	20.56
T_{10}	16.44	18.67	19.33	19.56	20.11
T_{11}	16.89	18.78	19.56	20.00	20.22
T_{12}	17.89	19.67	20.33	20.56	20.78
T_{13}	14.44	15.89	16.33	16.89	17.89
SEm(±)	**0.213**	**0.153**	**0.126**	**0.253**	**0.184**
CD(0.05)	**0.620**	**0.447**	**0.367**	**0.737**	**0.538**

*MAP= months after planting

Table 4.1.6 : Effect of integrated nutrient management on percentage promotion of cladode circumference over initial (2018-19)

Treatments	Percentage Promotion of Cladode Circumference over Initial (%)				
	2018-19				
	3MAP	6MAP	9MAP	12 MAP	15MAP
T_1	0.00	14.28	15.76	20.30	24.76
T_2	0.00	15.87	20.21	22.34	23.77
T_3	0.00	12.06	15.57	16.98	22.65
T_4	0.00	10.40	13.62	15.60	18.82
T_5	0.00	12.40	16.37	17.49	18.05
T_6	0.00	8.58	13.23	15.20	17.22
T_7	0.00	19.99	21.40	22.81	24.23
T_8	0.00	9.71	12.17	13.37	17.62
T_9	0.00	14.35	17.00	18.29	20.94
T_{10}	0.00	13.56	17.58	18.98	22.32
T_{11}	0.00	11.19	15.81	18.41	19.72
T_{12}	0.00	9.95	13.64	14.92	16.15
T_{13}	0.00	10.04	13.09	16.97	23.89
SEm(±)	**-**	**1.542**	**1.077**	**1.118**	**1.801**
CD(0.05)	**-**	**4.501**	**3.145**	**3.263**	**5.256**

*MAP= months after planting

Table 4.1.7 : Effect of integrated nutrient management on cladode circumference of dragon fruit plants (2019-20)

Treatments	Cladode Circumference (cm)				
	2019-20				
	18MAP	21MAP	24MAP	27MAP	30 MAP
T_1	18.78	18.89	19.11	19.22	19.44
T_2	19.33	19.78	19.89	20.11	20.22
T_3	19.67	20.11	20.44	20.56	20.67
T_4	20.67	20.78	20.89	21.11	21.33
T_5	23.33	23.44	23.56	23.56	23.67
T_6	20.22	20.44	20.56	20.67	20.78
T_7	19.44	19.67	19.78	20.22	20.44
T_8	21.78	21.89	22.11	22.44	22.56
T_9	20.78	20.89	21.11	21.56	21.78
T_{10}	20.33	20.56	20.67	20.78	20.89
T_{11}	20.56	20.78	21.00	21.11	21.22
T_{12}	21.33	21.56	21.89	22.00	22.11
T_{13}	18.11	18.22	18.56	18.78	19.11
SEm(±)	**0.328**	**0.276**	**0.240**	**0.269**	**0.306**
CD(0.05)	**0.956**	**0.807**	**0.699**	**0.785**	**0.892**

*MAP= months after planting

Table 4.1.8: Effect of integrated nutrient management on percentage promotion of cladode circumference over initial (2019-20)

Treatments	Percentage Promotion of cladode circumference over Initial (%)				
	2019-20				
	18MAP	**21MAP**	**24MAP**	**27MAP**	**30 MAP**
T_1	1.84	2.44	3.63	4.23	5.42
T_2	1.15	3.51	4.08	5.23	5.81
T_3	2.34	4.63	6.35	6.97	7.54
T_4	1.67	2.21	2.75	3.84	4.92
T_5	0.47	0.95	1.46	1.46	1.94
T_6	2.80	3.91	4.52	5.08	5.64
T_7	0.57	1.76	2.33	4.60	5.74
T_8	1.02	1.53	2.55	4.08	4.64
T_9	1.07	1.61	2.68	4.86	5.93
T_{10}	1.09	2.24	2.78	3.33	3.88
T_{11}	1.68	2.77	3.86	4.40	4.95
T_{12}	2.65	3.75	5.34	5.87	6.40
T_{13}	1.23	1.84	3.75	4.97	6.82
SEm(±)	**0.178**	**0.214**	**0.181**	**0.470**	**0.342**
CD(0.05)	**0.587**	**0.623**	**0.530**	**1.372**	**0.999**

*MAP= months after planting

Table 4.1.9 : Effect of integrated nutrient management on number of cladode per dragon fruit plants (2018-19)

Treatments	Number of Cladode per Plant (No.)				
	2018-19				
	3MAP	6MAP	9MAP	12 MAP	15MAP
T_1	1.22	3.33	7.22	8.11	8.33
T_2	1.00	2.22	5.22	7.11	7.44
T_3	1.00	2.11	4.56	5.33	5.67
T_4	1.00	2.33	5.56	5.89	6.33
T_5	1.06	2.56	7.11	8.22	8.89
T_6	1.00	2.33	5.11	6.44	7.22
T_7	1.00	2.44	5.89	7.22	8.11
T_8	1.44	3.22	7.22	8.89	10.11
T_9	1.00	3.00	6.22	7.67	8.44
T_{10}	1.00	2.44	5.00	5.56	6.78
T_{11}	1.11	2.67	6.00	7.33	8.22
T_{12}	1.94	3.33	6.78	8.33	8.56
T_{13}	1.00	1.78	2.11	2.78	3.11
SEm(±)	**0.396#**	**0.303**	**0.147**	**0.127**	**0.293**
CD(0.05)	**1.154#**	**0.884**	**0.428**	**0.370**	**0.855**

*MAP= months after planting, #= data are not significant

Table 4.1.10 : Effect of integrated nutrient management on number of cladode per dragon fruit plants (2019-20)

Treatments	Number of Cladode per Plant (No.)				
	2019-20				
	18MAP	**21MAP**	**24MAP**	**27MAP**	**30 MAP**
T_1	10.67	12.67	16.22	19.67	22.78
T_2	9.89	11.78	15.33	18.44	21.89
T_3	8.44	10.56	14.44	17.89	20.44
T_4	9.11	11.56	15.44	18.33	22.89
T_5	10.89	13.78	16.56	20.11	25.44
T_6	9.33	11.44	14.56	18.56	22.33
T_7	10.11	12.33	15.56	19.33	23.11
T_8	14.22	17.11	18.44	20.67	26.22
T_9	10.44	14.22	16.78	20.56	23.89
T_{10}	9.56	11.89	15.22	19.22	22.56
T_{11}	10.78	12.56	15.78	20.00	24.22
T_{12}	11.22	15.67	17.56	21.11	25.56
T_{13}	4.44	5.67	7.11	7.67	9.89
SEm(±)	**0.239**	**0.288**	**0.248**	**0.290**	**0.431**
CD(0.05)	**0.699**	**0.841**	**0.723**	**0.847**	**1.259**

*MAP= months after planting

Table 4.1.11 : Effect of integrated nutrient management on number of flower and fruits per pillar in dragon fruit plants

Treatments	Number of Flower per Pillar (No.)			Number of Fruits per Pillar (No.)		
	2018-19	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**
T_1	16.67	18.67	17.67	14.00	15.33	14.67
T_2	19.00	21.33	20.17	16.67	19.00	17.84
T_3	15.33	18.00	16.67	12.33	14.67	13.50
T_4	16.67	19.33	18.00	14.67	17.00	15.84
T_5	21.33	22.00	21.67	19.33	19.67	19.50
T_6	15.33	18.33	16.83	13.33	15.67	14.50
T_7	17.67	20.33	19.00	15.67	17.33	16.50
T_8	22.67	24.67	23.67	21.33	23.67	22.50
T_9	19.67	22.33	21.00	17.67	20.33	19.00
T_{10}	16.33	19.67	18.00	14.33	17.67	16.00
T_{11}	18.33	21.00	19.67	16.33	18.67	17.50
T_{12}	22.00	23.00	22.50	19.67	21.67	20.67
T_{13}	4.33	5.67	5.00	2.33	3.67	3.00
SEm(±)	**0.678**	**0.780**	**0.462**	**0.513**	**0.444**	**0.304**
CD(0.05)	**1.978**	**2.277**	**1.350**	**1.498**	**1.297**	**0.889**

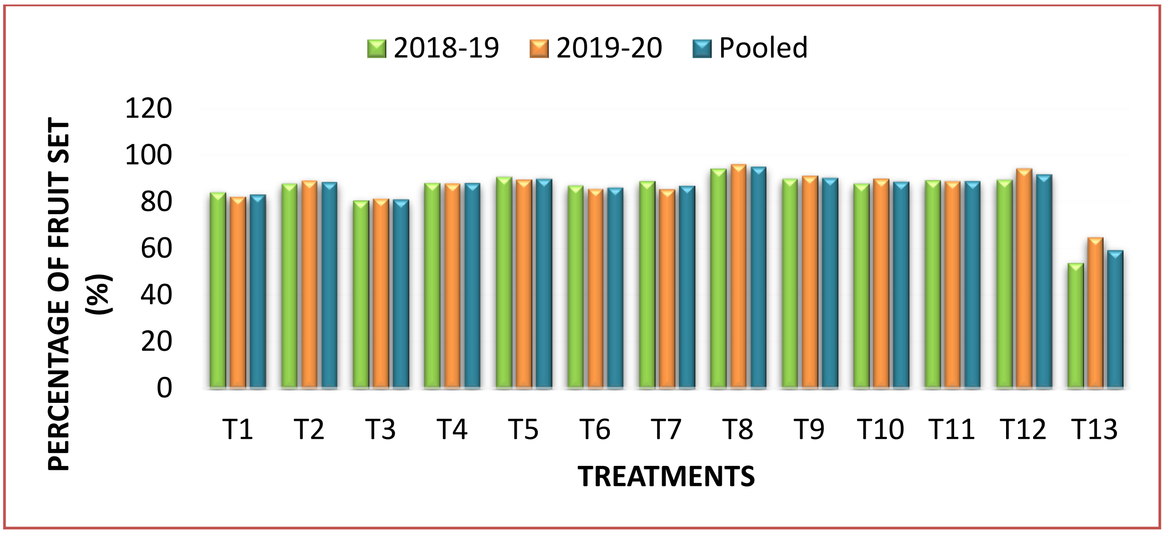


Fig. 4.1.6 Effect of integrated nutrient management treatments on percentage of fruit set

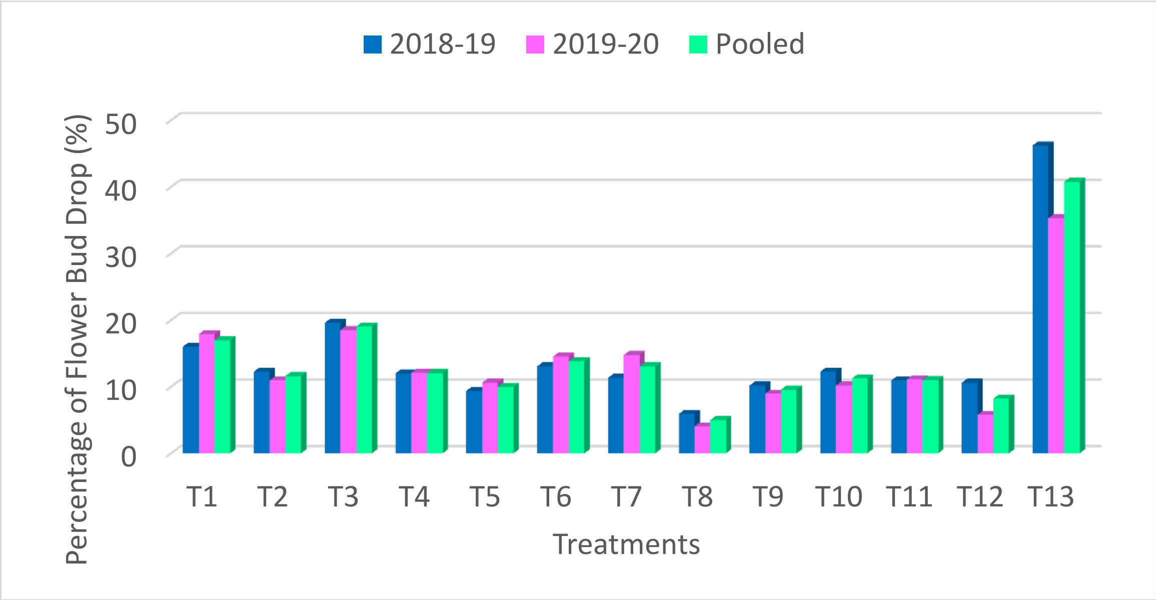


Fig. 4.1.7 Effect of integrated nutrient management treatments on percentage of flower bud drop

4.1.2.3. Fruit set (%)

From the data demonstrated at Table 4.1.12, Fig. 4.1.6; fruit set percentage significantly varied under different treatments and it ranged between 53.81% to 94.09% in 2018-19 and 64.73% to 95.95 % in 2019-20. Plant treated with T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) recorded highest fruit set percentage i.e. 94.09% and 95.95 % in two consecutive year, which was followed by T_5 (Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (90.62%) during 2018-19. Whereas, in 2019-20, second highest fruit set percentage (94.22%) was observed under treatment T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB).

The pooled data showed that maximum fruit set percentage (95.02%) was in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) which was followed by the T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB) (91.81%). However, control recorded the lowest (53.81%, 64.73%, 59.27%) in both year and at pooled analysis.

4.1.2.4. Flower bud drop (%)

Data for flower bud drop percentage for different treatment are presented in Table 4.1.12 and Fig. 4.1.7. From the table it is evident that the lowest flower bud drop (5.91% and 4.05%) was observed with T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) in both year i.e. 2018-19 and 2019-20, which was followed by T_5 [Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB)] (9.38%) during 2018-19 and T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB) (5.79%) in 2019-20. However, the highest percent flower bud drop (46.19% and 35.27%) was recorded in control for both years.

The pooled data showed that the lowest flower bud drop percentage (4.98%) was observed in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) and the highest (40.73%) was recorded in T_{13} (control).

4.1.2.5. Yield

It is clear from the table 4.1.13 that significant difference was obtained among the treatment with respect to yield. Yield varied from 0.37 kg per pillar or 0.47 t per ha to 7.97 kg per pillar or 9.96 t per ha in 2018-19 (Fig. 4.1.8), whereas, it varied from 0.85 kg per pillar or 1.07 t per ha to 8.31 kg per pillar or 10.39 t per ha during 2019-20. Highest yield per pillar was recorded with T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (7.97 kg per pillar or 9.96 t per ha and 8.31kg per pillar or 10.39t per ha) during 2018-2019 and 2019-2020, which was followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB) (6.48kg per pillar or 8.10t per ha and 7.86 kg per pillar or 9.82t per ha).

From the pooled analysis it was observed that T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) was recorded with maximum yield (8.14 kg per pillar or10.18 t per ha) followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB) (7.17 kg per pillar or 8.96 t per ha) , lowest yield was recorded with control (0.61 kg per pillar or 0.77 t per ha).

4.1.2.6. Days from fruit set to maturity

From table 4.1.13, Fig. 4.1.9 it can be concluded that days required from fruit set to maturity varied between 30.67 to 34 days in 2018-19 and 35.33 to 46.33 days in 2019-20. Result showed that days required for the fruit to get matured varied significantly among the treatment. Maximum days (34.33 days) were observed in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB) which was followed by T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) i.e. (34 days) in 2018-19 whereas longest days required (46.33 days) were recorded under treatment T_8 (FYM to supply 25% K +

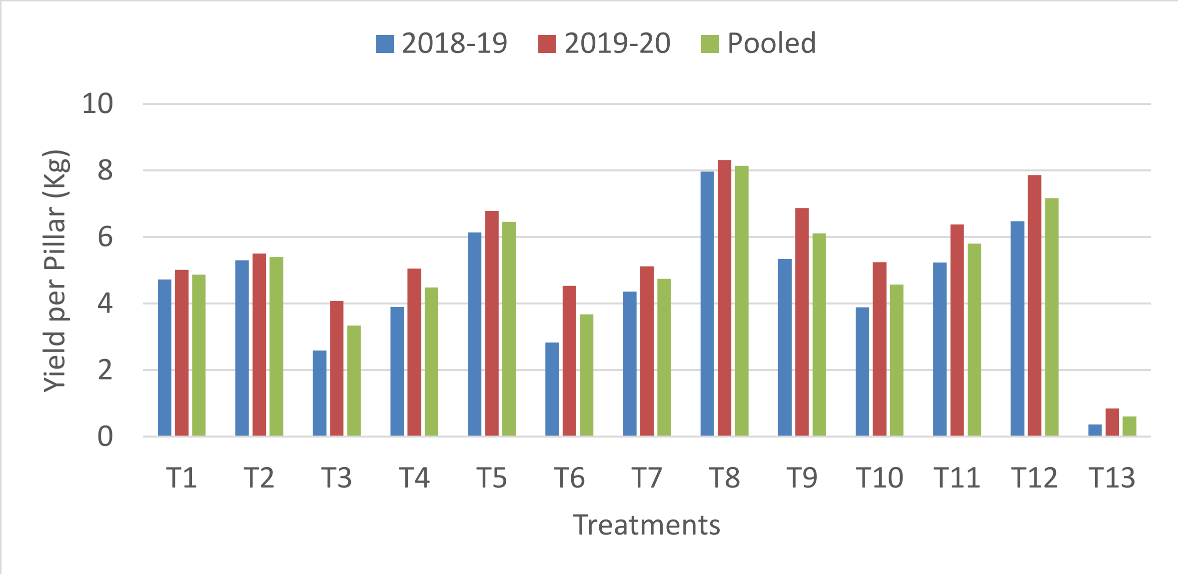


Fig. 4.1.8 Effect of integrated nutrient management treatments on yield of dragon fruits per pillar

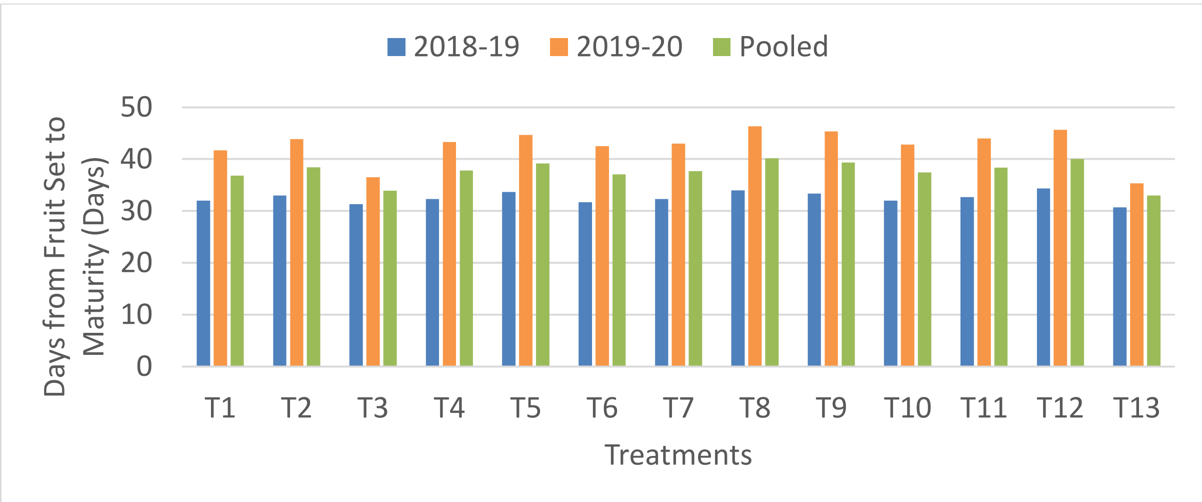


Fig. 4.1.9 Effect of integrated nutrient management treatments on days from fruit set to maturity of dragon fruits

VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) in 2019-20, followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB) (45.67 days).

Table 4.1.12 : Effect of integrated nutrient management on percentage of fruit set and flower bud drop in dragon fruit plants

Treatments	Percentage of Fruit Set (%)			Percentage of Flower Bud Drop (%)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	83.98	82.11	83.05	16.02	17.89	16.95
T_2	87.74	89.08	88.41	12.26	10.92	11.59
T_3	80.43	81.50	80.97	19.57	18.50	19.03
T_4	88.00	87.95	87.97	12.00	12.05	12.03
T_5	90.62	89.41	90.02	9.38	10.59	9.98
T_6	86.95	85.49	86.22	13.05	14.51	13.78
T_7	88.68	85.24	86.96	11.32	14.76	13.04
T_8	94.09	95.95	95.02	5.91	4.05	4.98
T_9	89.83	91.04	90.44	10.17	8.96	9.56
T_{10}	87.75	89.83	88.79	12.25	10.17	11.21
T_{11}	89.09	88.90	89.00	10.91	11.10	11.00
T_{12}	89.41	94.22	91.81	10.59	5.78	8.19
T_{13}	53.81	64.73	59.27	46.19	35.27	40.73
SEm(±)	**5.147**	**3.040**	**2.401**	**4.016**	**2.498**	**2.426**
CD(0.05)	**15.022**	**8.874**	**7.009**	**11.724**	**7.290**	**7.080**

Table 4.1.13 : Effect of integrated nutrient management on yield and days from fruit set to maturity in dragon fruit plants

Treatments	Yield per Pillar (Kg)			Yield per Hectare (Tons/Hectare)			Days from Fruit Set to Maturity (Days)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	4.72	5.01	4.87	5.90	6.26	6.08	32.00	41.67	36.84
T_2	5.30	5.50	5.40	6.62	6.87	6.75	33.00	43.83	38.42
T_3	2.59	4.08	3.34	3.24	5.10	4.17	31.33	36.50	33.92
T_4	3.90	5.05	4.48	4.88	6.32	5.60	32.33	43.33	37.83
T_5	6.14	6.78	6.46	7.68	8.48	8.08	33.67	44.67	39.17
T_6	2.83	4.53	3.68	3.53	5.66	4.60	31.67	42.50	37.09
T_7	4.36	5.12	4.74	5.45	6.40	5.92	32.33	43.00	37.67
T_8	7.97	8.31	8.14	9.96	10.39	10.18	34.00	46.33	40.17
T_9	5.34	6.87	6.11	6.67	8.59	7.63	33.33	45.33	39.33
T_{10}	3.89	5.24	4.57	4.87	6.55	5.71	32.00	42.83	37.42
T_{11}	5.23	6.38	5.80	6.53	7.98	7.25	32.67	44.00	38.34
T_{12}	6.48	7.86	7.17	8.10	9.82	8.96	34.33	45.67	40.00
T_{13}	0.37	0.85	0.61	0.47	1.07	0.77	30.67	35.33	33.00
SEm(±)	**0.540**	**0.475**	**0.301**	**0.675**	**0.594**	**0.376**	**0.525**	**0.994**	**0.562**
CD(0.05)	**1.577**	**1.387**	**0.877**	**1.971**	**1.734**	**1.097**	**1.533**	**2.901**	**1.641**

The pooled data showed that maximum day required from fruit set to maturity was recorded in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (40.17days) which was followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB) (40 days). The shortest duration (33 days) was observed under control (T_{13}).

4.1.3. Fruit physical parameter

4.1.3.1 Fruit length (mm)

Data presented at table 4.1.14, Fig. 4.1.10 revealed that the dragon fruit length was significantly increased under various treatments which ranged from 67.02 mm to 96.47 mm during 2018-19 and 83.00 mm to 106.67 mm in the year 2019-20. Maximum fruit length was recorded in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (96.47mm) which was followed by T_{10} (VC to supply 25% K + NC to supply 25% K+ 50% RDF+AZ+PSB+ KSB)(95.25 mm) during 2018-19. Whereas, T_{10} (VC to supply 25% K + NC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) recorded maximum (106.67mm) followed by T_5 [Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB)] (102.50mm) in the year 2019-20 .

The pooled data for two consecutive years had shown that maximum fruit length were recorded in T_{10} (VC to supply 25% K + NC to supply 25% K+ 50% RDF+AZ+PSB+ KSB)(100.96 mm) followed by T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (98.15mm) compared with control (75.01mm).

4.1.3.2. Fruit Diameter (mm)

The data presented in table 4.1.14; Fig.4.1.11 clearly showed that the highest fruit diameter (86.71 mm) were observed in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) followed by T_5(Farm Yard Manure

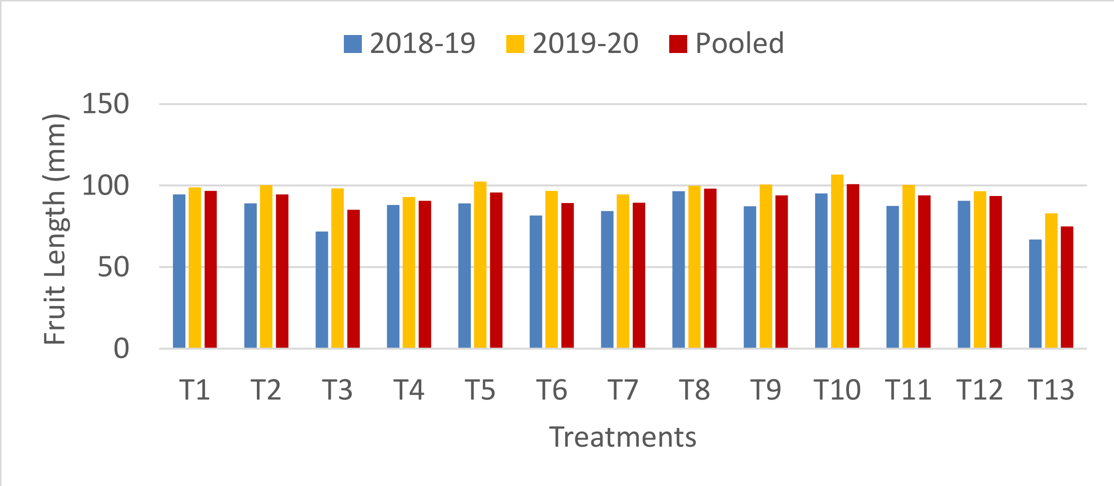


Fig. 4.1.10 Effect of integrated nutrient management treatments on fruit length of dragon fruits

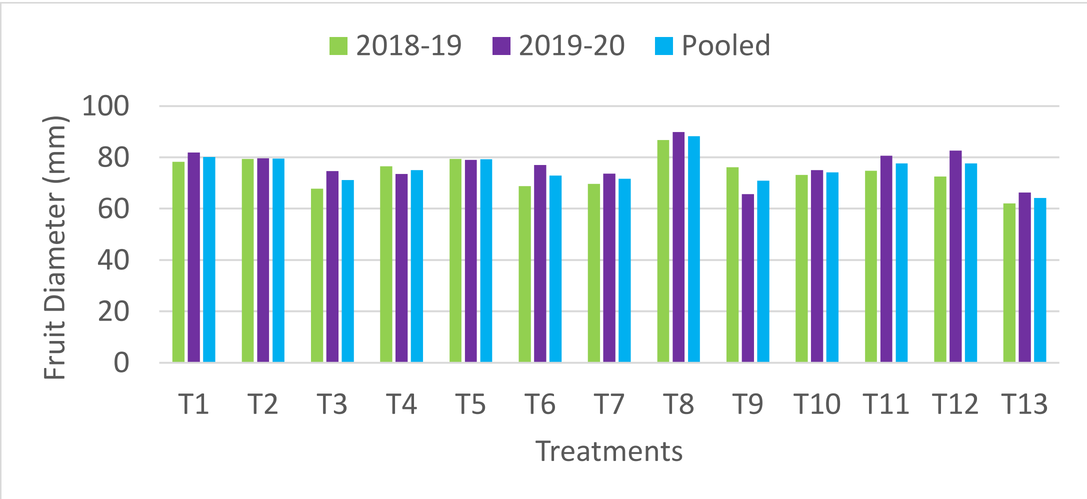


Fig. 4.1.11 Effect of integrated nutrient management treatments on fruit diameter of dragon fruits

(FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) and T_2 (Farm Yard Manure (FYM) to supply 50%K+ 50% RDF) which were statistically at par (79.38 mm) during 2018-19. Whereas, in 2019-20, the highest diameter (89.83 mm) were recorded in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50%

RDF+AZ+PSB+ KSB) followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB) (82.67 mm).

However, the pooled data for both the year shown that the highest fruit diameter was recorded in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (88.27mm) which was followed by T_1 [Recommended dose of fertilizer (RDF) as 100% inorganic] (80.07mm), while the lowest (64.18 mm) was recorded in control (T_{13}).

4.1.3.3. Fruit weight (g)

It is evident from the data shown in Table 4.1.15; Fig. 4.1.12 that the fruit weight got significantly influenced by the application of various INM treatments. The highest fruit weight (373.67g) was observed in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) during 2018-19 which was followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) (362.67g) in the year 2019-20 while the least (160.00g and 232.83g) was in control (T_{13}) for two consecutive years.

The pooled data for both the years showed that the highest fruit weight (362.42g) was observed in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) while the lowest (196.42g) was recorded in control (T_{13}).

4.1.3.4. Fruit volume (cc)

From the data shown in Table 4.1.15 the fruit volume showed a significant variation among various treatments. The highest fruit volume (306.67cc and 336.67 cc) was recorded in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) in both years. Whereas, the second highest (300.00 cc) was recorded in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) during 2018-19 and 326.67cc were observed under T_5 (Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) and T_{11} (FYM to supply 25% K + VC to supply 25% K+ NC to supply 25% K + 25% RDF)

Table 4.1.14 : Effect of integrated nutrient management on fruit length and diameter of dragon fruits

Treatments	Fruit Length (mm)			Fruit Diameter (mm)		
	2018-19	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**
T_1	94.57	98.83	96.70	78.30	81.83	80.07
T_2	89.04	100.33	94.69	79.38	79.67	79.52
T_3	71.93	98.33	85.13	67.73	74.67	71.20
T_4	88.20	93.00	90.60	76.54	73.50	75.02
T_5	89.04	102.50	95.77	79.38	79.00	79.19
T_6	81.68	96.83	89.26	68.82	77.00	72.91
T_7	84.34	94.50	89.42	69.71	73.67	71.69
T_8	96.47	99.83	98.15	86.71	89.83	88.27
T_9	87.29	100.67	93.98	76.17	65.67	70.92
T_{10}	95.25	106.67	100.96	73.19	75.00	74.10
T_{11}	87.63	100.50	94.06	74.72	80.67	77.69
T_{12}	90.70	96.50	93.60	72.48	82.67	77.58
T_{13}	67.02	83.00	75.01	62.02	66.33	64.18
SEm(±)	**0.741**	**0.960**	**0.699**	**0.930**	**0.525**	**0.636**
CD(0.05)	**2.162**	**2.802**	**2.042**	**2.714**	**1.531**	**1.855**

Table 4.1.15 : Effect of integrated nutrient management on fruit weight and volume of dragon fruits

Treatments	Fruit Weight (g)			Fruit Volume (cc)		
	2018-19	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**
T_1	337.33	326.67	332.00	292.50	309.17	300.83
T_2	317.67	289.33	303.50	293.33	275.00	284.17
T_3	210.00	278.33	244.17	188.33	261.67	225.00
T_4	266.00	297.33	281.67	263.33	284.17	273.75
T_5	317.67	344.83	331.25	293.33	326.67	310.00
T_6	212.00	289.00	250.50	193.33	275.00	234.17
T_7	278.00	295.33	286.67	245.00	258.33	251.67
T_8	373.67	351.17	362.42	300.00	315.00	307.50
T_9	302.00	338.17	320.09	268.33	315.83	292.08
T_{10}	271.67	296.50	284.09	266.67	305.00	285.83
T_{11}	320.00	341.83	330.92	285.00	326.67	305.83
T_{12}	329.33	362.67	346.00	306.67	336.67	321.67
T_{13}	160.00	232.83	196.42	140.83	221.67	181.25
SEm(±)	**15.872**	**17.883**	**10.312**	**13.179**	**11.462**	**9.297**
CD(0.05)	**46.329**	**52.199**	**30.100**	**38.468**	**33.457**	**27.138**

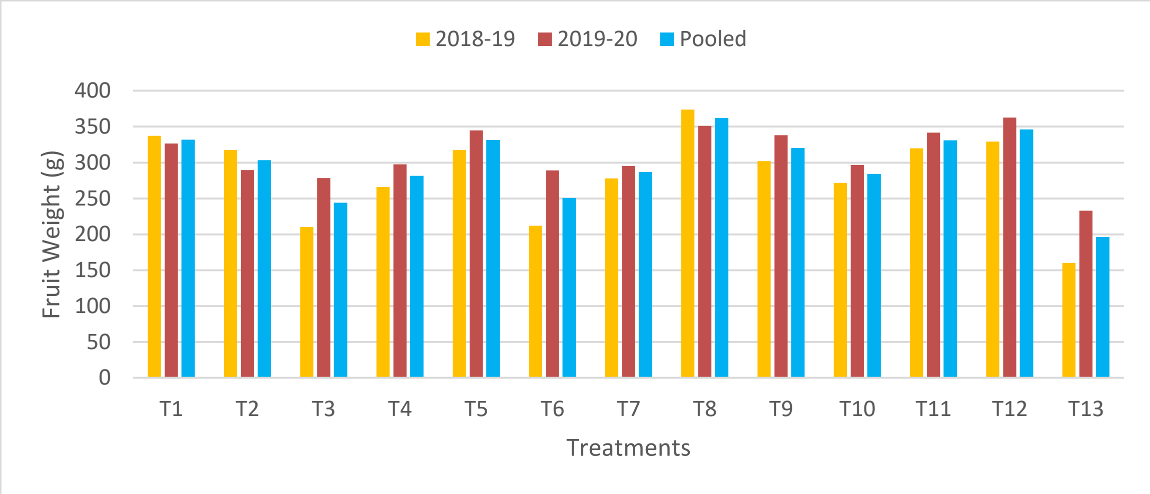


Fig. 4.1.12 Effect of integrated nutrient management treatments on fruit weight of dragon fruits

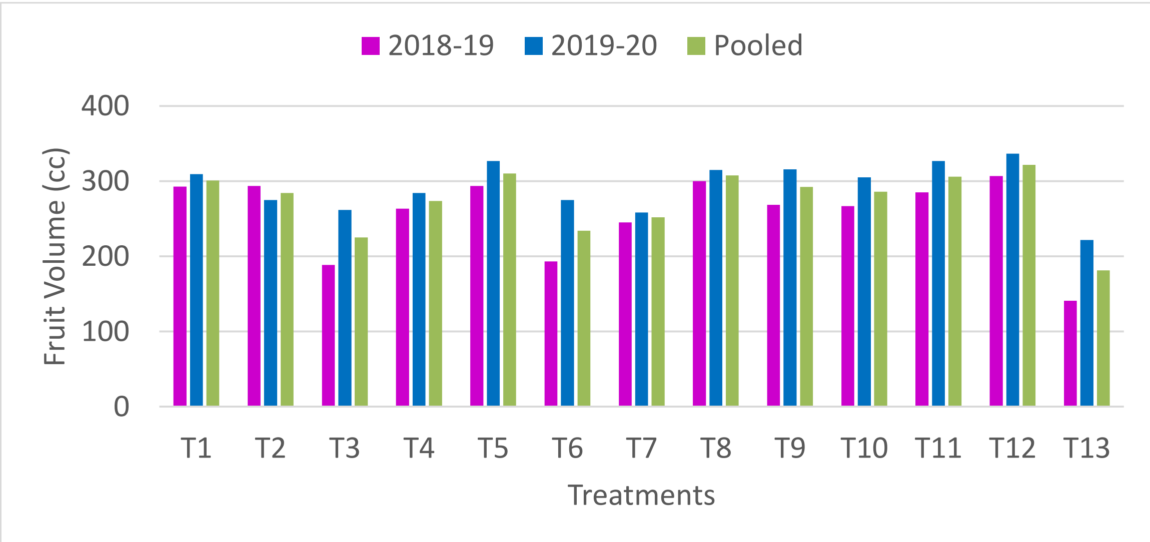


Fig. 4.1.13 Effect of integrated nutrient management treatments on fruit volume of dragon fruits

in the year 2019-20 (Fig.4.1.13).

The pooled data showed that the highest (321.67cc) was in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) followed by T_5 (Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+

Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (310.00cc) and T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (307.50 cc). However, the lowest value (181.25cc) was recorded in control (T_{13}).

4.1.3.5. Specific gravity

The presented Table 4.1.18 showed that there was variation in fruit specific gravity which range from 1.02 to 1.25 in the first year (2018-19) and 0.97 to 1.14 during second year (2019-20) of study. Maximum specific gravity (1.25) was found in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) during 2018-19 and second highest (1.15) was in T_1 (Recommended dose of fertilizer (RDF) as 100% inorganic). During 2019-20; T_7 (NC to supply 50% K+ 50 % RDF+ AZ+ PSB + KSB) had a maximum specific gravity (1.14) followed by T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (1.11).

The pooled analysis shown that the highest (1.18) specific gravity was observed in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) and the lowest was in T_4 [Neem Cake (NC) to supply 50% K+ 50% RDF] (1.03).

4.1.3.6. Peel weight

The data showed on Table 4.1.17, Fig. 4.1.14 revealed that there was significant variation among treatment regarding the peel weight. The highest peel weight (116.50g) were recorded in T_1(Recommended dose of fertilizer (RDF) as 100% inorganic) followed by T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (104.00 g) during the first year 2018-19.

However, T_5 (Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB)) was recorded highest (120.50g) in the second year (2019-20). From the pooled analysis the highest peel weight (108.42g) was observed in T_1 (Recommended dose of fertilizer (RDF) as 100% inorganic) and lowest (68.33g) was recorded in T_{13} (control).

Table 4.1.16 : Effect of integrated nutrient management on pulp weight and pulp recovery percentage of dragon fruits

Treatments	Pulp Weight (g)			Pulp Recovery (%)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	220.83	226.34	223.58	65.46	69.29	67.38
T_2	223.84	206.16	215.00	70.46	71.26	70.86
T_3	136.83	202.66	169.75	65.16	72.81	68.99
T_4	179.33	211.33	195.33	67.42	71.08	69.25
T_5	223.84	224.33	224.08	70.46	65.06	67.76
T_6	133.50	205.83	169.67	62.97	71.22	67.10
T_7	198.00	209.66	203.83	71.22	70.99	71.11
T_8	269.67	252.84	261.26	72.17	72.00	72.08
T_9	219.50	246.50	233.00	72.68	72.89	72.79
T_{10}	183.67	205.33	194.50	67.61	69.25	68.43
T_{11}	222.33	244.00	233.17	69.48	71.38	70.43
T_{12}	238.33	255.34	246.83	72.37	70.40	71.39
T_{13}	96.67	159.50	128.08	60.42	68.50	64.46
SEm(±)	**13.957**	**5.683**	**8.151**	**2.265**	**0.734**	**1.221**
CD(0.05)	**40.741**	**16.588**	**23.793**	**6.610**	**2.144**	**3.563**

Table 4.1.17 : Effect of integrated nutrient management on peel weight and peel thickness of dragon fruits

Treatments	Peel Weight (g)			Peel Thickness (mm)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	116.50	100.33	108.42	2.76	2.17	2.47
T_2	93.83	83.17	88.50	2.28	2.54	2.41
T_3	73.17	75.67	74.42	2.57	2.70	2.63
T_4	86.67	86.00	86.33	2.78	2.59	2.68
T_5	93.83	120.50	107.17	2.28	2.39	2.33
T_6	78.50	83.17	80.83	2.27	2.54	2.41
T_7	80.00	85.67	82.84	2.19	2.53	2.36
T_8	104.00	98.33	101.17	2.16	2.30	2.23
T_9	82.50	91.67	87.08	1.94	2.65	2.29
T_{10}	88.00	91.17	89.58	2.43	2.50	2.46
T_{11}	97.67	97.83	97.75	2.07	2.34	2.21
T_{12}	91.00	107.33	99.17	1.81	2.90	2.35
T_{13}	63.33	73.33	68.33	2.04	2.27	2.15
SEm(±)	**0.888**	**0.978**	**0.564**	**0.181**	**0.112**	**0.102**
CD(0.05)	**2.591**	**2.853**	**1.646**	**0.529**	**0.327**	**0.298**

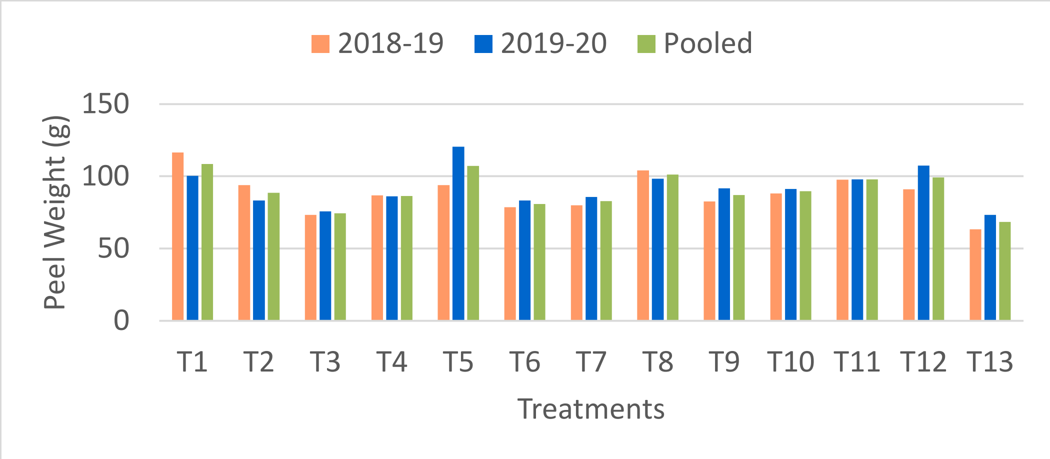


Fig. 4.1.14 Effect of integrated nutrient management treatments on peel weight of dragon fruits

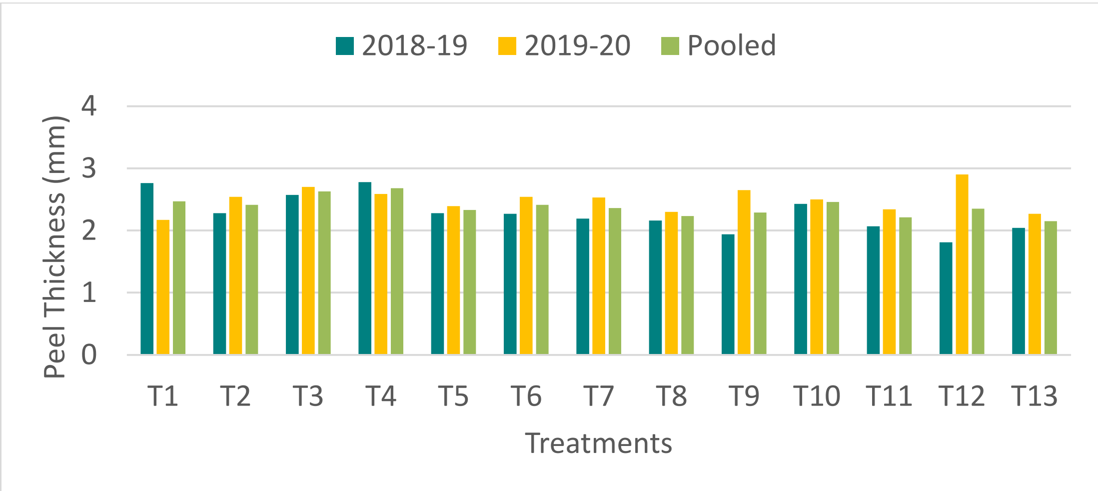


Fig. 4.1.15 Effect of integrated nutrient management treatments on peel thickness of dragon fruits

4.1.3.7. Peel thickness (mm)

From the data display on Table 4.1.17 and Fig. 4.1.15 it was evident that there was significant variation among the treatment related to the peel thickness and the highest peel thickness was observed in T_4 (Neem Cake (NC) to supply 50% K+ 50% RDF) (2.78mm) followed by T_1 (Recommended dose of fertilizer (RDF) as 100% inorganic) (2.76mm) in the first year of study 2018-2019 and in the second year

2019-2020 the highest was recorded in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) (2.90mm) followed by T_3 (Vermicompost (VC) to supply 50% K+ 50% RDF) (2.70 mm). Pooled data for both years showed that the highest peel thickness was recorded in T_4 (Neem Cake (NC) to supply 50% K+ 50% RDF) (2.68mm) and lowest (2.15mm) was observed in control (T_{13}).

4.1.3.8. Pulp weight (g)

Data of pulp weight presented at Table 4.1.16 showed significant variation among the different treatment. During the first year (2018-19) of study the highest pulp weight (269.67g) was observed in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) (238.33g) and in the second year (2019- 2020), the highest (255.34g) was recorded in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) followed by T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (252.84g). Pooled data for both years showed that the highest pulp weight was recorded in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (261.26g) and lowest pulp weight (159.50g) was recorded in control (T_{13}).

4.1.3.9. Pulp recovery (%)

Data presented in Table 4.1.16 and Fig. 4.1.16 showed that pulp recovery per cent of fruit varied significantly with different treatment. It was observed that the highest pulp recovery percentage (72.68% and 72.89%) was recorded under T_9 (FYM to supply 25% K + NC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) in both years during study. However, the second highest (72.37% and 72.81%) was recorded in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) in the first year (2018-2019) and with T_3 (Vermicompost (VC) to supply 50% K+ 50% RDF) in the second year (2019-2020). The pooled analysis data showed that the highest pulp recovery percent (72.79%) was observed in T_9 (FYM to supply 25% K + NC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) followed by T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (72.08%), while the lowest pulp recovery percent (64.64%) was recorded in control (T_{13}).

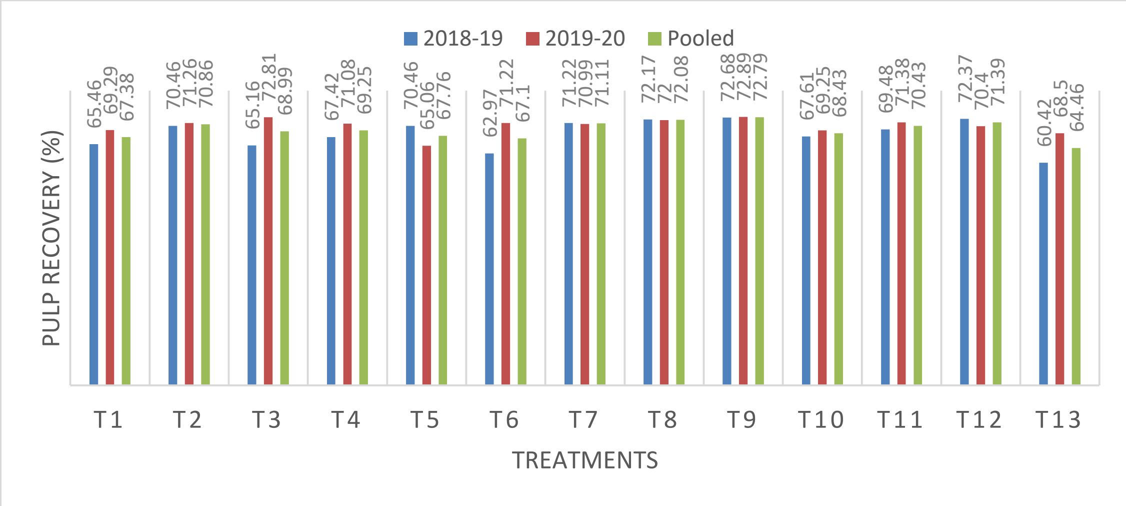


Fig. 4.1.16 Effect of integrated nutrient management treatments on pulp recovery percentage of dragon fruits

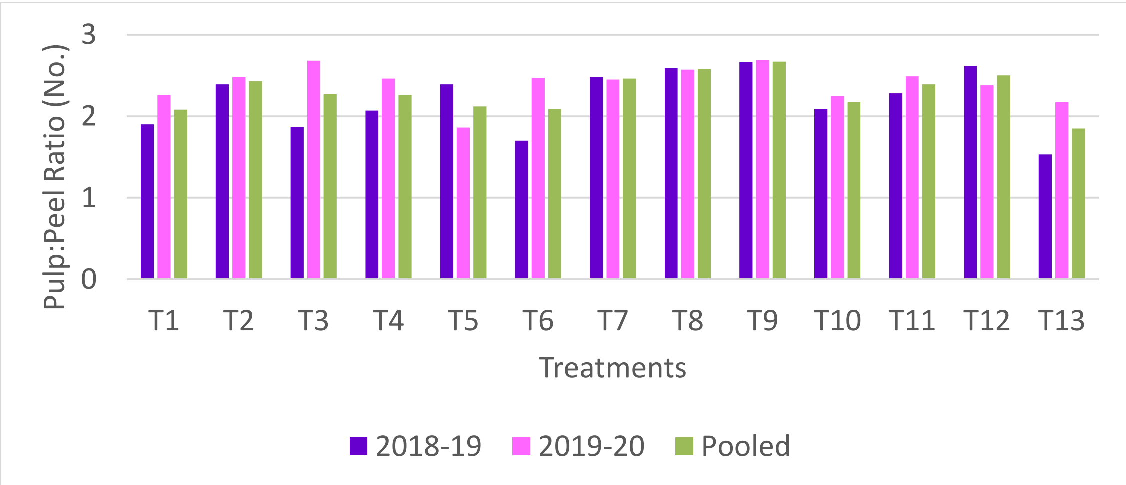


Fig. 4.1.17 Effect of integrated nutrient management treatments on pulp: peel ratio of dragon fruits

Table 4.1.18 : Effect of integrated nutrient management on specific gravity and pulp: peel ratio of dragon fruits

Treatments	Specific Gravity			Pulp:Peel Ratio		
	2018-19	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**
T_1	1.15	1.06	1.10	1.90	2.26	2.08
T_2	1.08	1.05	1.07	2.39	2.48	2.43
T_3	1.12	1.06	1.09	1.87	2.68	2.27
T_4	1.01	1.05	1.03	2.07	2.46	2.26
T_5	1.08	1.06	1.07	2.39	1.86	2.12
T_6	1.10	1.05	1.07	1.70	2.47	2.09
T_7	1.13	1.14	1.14	2.48	2.45	2.46
T_8	1.25	1.11	1.18	2.59	2.57	2.58
T_9	1.13	1.07	1.10	2.66	2.69	2.67
T_{10}	1.02	0.97	1.00	2.09	2.25	2.17
T_{11}	1.12	1.05	1.08	2.28	2.49	2.39
T_{12}	1.07	1.08	1.08	2.62	2.38	2.50
T_{13}	1.14	1.05	1.09	1.53	2.17	1.85
SEm(±)	**0.034**	**0.026**	**0.025**	**0.160**	**0.071**	**0.095**
CD(0.05)	**0.100**	**0.076**	**0.074**	**0.466**	**0.207**	**0.278**

4.1.3.10. Pulp:Peel ratio

Pulp: Peel ratio data observed in Table 4.1.18; Fig. 4.1.17 revealed that the highest pulp: peel ratio was found inT_9 (FYM to supply 25% K + NC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) which is (2.66 and 2.69) for both years followed by T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (2.59) during 2018-2019 and in the year 2019-2020, the highest value was recorded with T_3 (Vermicompost (VC) to supply 50% K+ 50% RDF) (2.68). From the pooled data the highest pulp: peel ration was found in T_9 (FYM to supply 25% K + NC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (2.67) followed by T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (2.58) while the lowest was observed in T_{13} (control) (1.85).

4.1.4. Bio- Chemical Parameter

4.1.4.1. Total soluble solid (^{0}Brix)

From the data presented at Table 4.1.19 and Fig. 4.1.18 found that various treatment had a significant influence on TSS content of the fruit. The highest TSS value (12.18 ^{0}Brix) was observed in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) followed by T_5 (Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB)) with a recorded value of (11.83^{0}Brix) in the first year 2018-2019 and T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) showed highest TSS value of (13.15 ^{0}Brix) during 2019-2020 which was followed by T_{12} (11.78 ^{0}Brix) and the lowest was observed with control (T_{13}) (8.87 and 8.80 ^{0}Brix) for two consecutive years.

. Pooled analysis data for both years showed the highest TSS value (12.45 ^{0}Brix) found under the treatment of T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) (11.98^{0}Brix) compared with the TSS value in treatment control (T_{13})(8.84^{0}Brix).

4.1.4.2. Titratable Acidity (%)

Data from the Table 4.1.19 showed that significant variation were observed in acidity of fruit during both the years. The presented data showed that the lowest acidity (0.21% and 0.18%) was recorded in T_6 (VC to supply 50% K + 50% RDF+AZ+PSB+ KSB) for two consecutive years and the highest (0.42% and 0.26%) was recorded in recommended dose of fertilizer (RDF) as 100% inorganic (T_1) in both years. Pooled analysis of data from both years showed that the titratable acidity percentage was lowest in VC to supply 50% K + 50% RDF+AZ+PSB+ KSB (T_6) (0.20%) and the highest (0.34%) was recorded in recommended dose of fertilizer (RDF) as 100% inorganic (T_1).

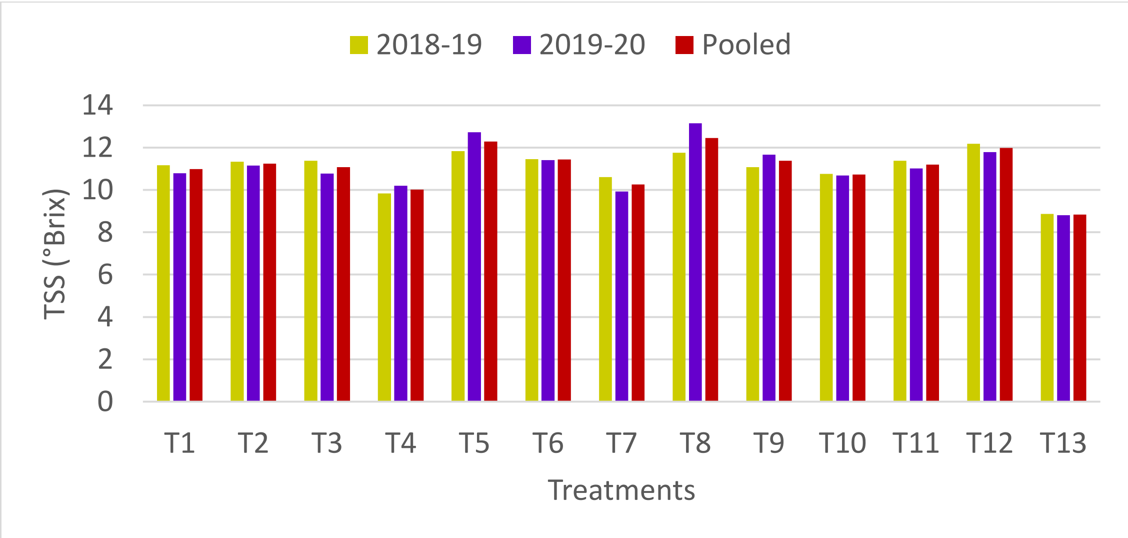


Fig. 4.1.18 Effect of integrated nutrient management treatments on TSS content of dragon fruits

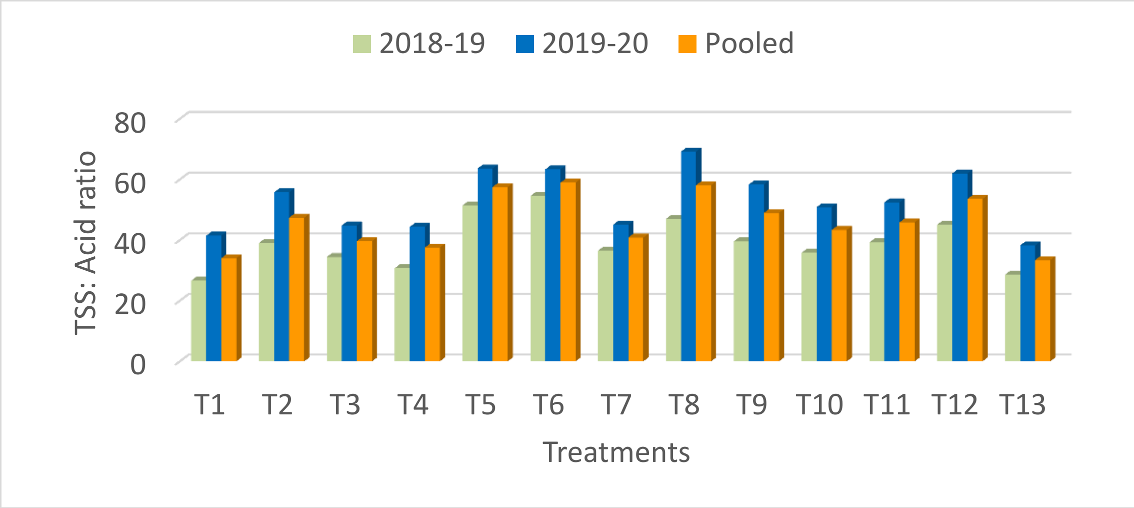


Fig. 4.1.19 Effect of integrated nutrient management treatments on TSS: acid ratio of dragon fruits

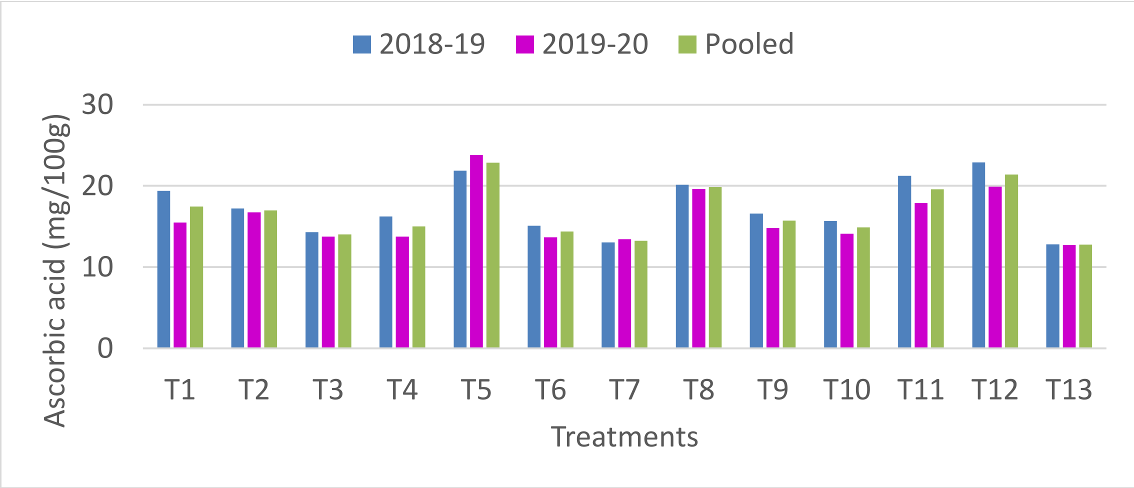


Fig. 4.1.20 Effect of integrated nutrient management treatments on ascorbic acid content of dragon fruits

4.1.4.3. TSS: acid ratio

Data displayed on Table 4.1.19 and Fig.4.1.19 manifested that TSS: acid ratio varied under each treatment due to different application of nutrients. During first year of experiment 2018-2019, maximum TSS/acid ratio (54.52) was obtained in T_6 (VC to supply 50% K + 50% RDF+AZ+PSB+ KSB) and in the second years 2019-2020, maximum TSS/acid ratio (69.21) was obtained in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB). However, T_5 (Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB)) recorded the second maximum TSS/acid ratio (51.43 and 63.60) in both years.

Pooled data from both years showed that maximum TSS/acid ratio (58.93) was obtained in T_6 (VC to supply 50% K + 50% RDF+AZ+PSB+ KSB) followed by FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) (58.11) and T_{13} (control) showed minimum TSS/acid ratio (33.44).

4.1.4.4. Total sugar (%)

Total sugar percentage of fruits showed significant variation under each treatment due to different application of nutrients. During first year of experiment i.e. 2018-2019, maximum total sugar percentage (9.24%) was obtained in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) followed by Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_5) (8.49%). During 2^{nd} years of experiment 2019-2020, maximum total sugar percentage (8.81%) was obtained in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) followed by T_5 (8.11%) (Table 4.1.20).

Pooled data from both years showed that maximum total sugar percentage (8.67%) was obtained in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) followed by FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) (8.34%). T_{13} (control) showed lowest total sugar percentage (5.05%).

4.1.4.5. Reducing sugar (%)

Data displayed on Table 4.1.20 revealed that reducing sugar percentage varied among the treatments during the experiment. During first year of experiment (2018-2019), maximum reducing sugar percentage (5.49%) was obtained in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+

KSB) followed by Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_5) (5.19%). During 2nd years of experiment (2019-2020), maximum reducing sugar percentage (6.98%) was obtained in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) followed by T_5 (6.54%) compared with control (T_{13}) (3.89% and 4.77%) in both years.

Pooled data from both years showed that maximum reducing sugar percentage (6.06%) was obtained in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) (5.91%). T_{13} (control) showed lowest reducing sugar percentage (4.33%).

4.1.4.6. Ascorbic acid (mg/100g)

Ascorbic acid content of the fruit as revealed from Table 4.1.20 and Fig. 4.1.20 showed significant variation among the treatments under study. Maximum ascorbic acid (22.88 mg/100g) was obtained in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) followed by Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_5) (23.88 mg/100g) during 2018-2019 and in the year 2019-2020, maximum ascorbic acid (23.81 mg/100g) was obtained in FYM to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_5) followed by T_{12} (19.90 mg/100g) compared with control (T_{13}) (12.81 and 12.72 mg/100g) in both years.

Pooled data showed that maximum ascorbic acid content (22.85 mg/100g) was obtained in FYM to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_5) followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) (21.39 mg/100g). T_{13} (control) showed lowest ascorbic acid (12.77 mg/100g) of fruits.

Table 4.1.19 : Effect of integrated nutrient management on Total Soluble Solids (TSS), titratable acidity and TSS: acid ration of dragon fruit

Treatments	TSS (°Brix)			Titratable Acidity (%)			TSS: Acid ratio		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	11.17	10.78	10.98	0.42	0.26	0.34	26.60	41.46	34.03
T_2	11.33	11.15	11.24	0.29	0.20	0.25	39.07	55.75	47.41
T_3	11.37	10.77	11.07	0.33	0.24	0.29	34.45	44.88	39.66
T_4	9.83	10.20	10.02	0.32	0.23	0.28	30.72	44.35	37.53
T_5	11.83	12.72	12.28	0.23	0.20	0.22	51.43	63.60	57.52
T_6	11.45	11.40	11.43	0.21	0.18	0.20	54.52	63.33	58.93
T_7	10.60	9.92	10.26	0.29	0.22	0.26	36.55	45.09	40.82
T_8	11.75	13.15	12.45	0.25	0.19	0.22	47.00	69.21	58.11
T_9	11.08	11.67	11.38	0.28	0.20	0.24	39.57	58.35	48.96
T_{10}	10.75	10.68	10.72	0.30	0.21	0.26	35.83	50.86	43.35
T_{11}	11.38	11.02	11.20	0.29	0.21	0.25	39.24	52.48	45.86
T_{12}	12.18	11.78	11.98	0.27	0.19	0.23	45.11	62.00	53.56
T_{13}	8.87	8.80	8.84	0.31	0.23	0.27	28.61	38.26	33.44
SEm(±)	**0.367**	**0.470**	**0.299**	**0.014**	**0.012**	**0.009**	**2.716**	**3.574**	**2.263**
CD(0.05)	**1.072**	**1.373**	**0.873**	**0.040**	**0.034**	**0.026**	**7.928**	**10.434**	**6.606**

Table 4.1.20 : Effect of integrated nutrient management on Total sugar, reducing sugar and ascorbic acid content of dragon fruit

Treatments	Total Sugar (%)			Reducing Sugar (%)			Ascorbic acid (mg/100g)		
	2018-19	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**
T_1	7.17	7.75	7.46	4.71	5.82	5.27	19.40	15.47	17.44
T_2	7.18	7.87	7.53	4.95	5.94	5.45	17.24	16.75	17.00
T_3	7.24	7.61	7.43	5.02	5.78	5.40	14.31	13.74	14.03
T_4	5.67	7.31	6.49	4.16	5.44	4.80	16.25	13.76	15.01
T_5	8.49	8.11	8.30	5.19	6.54	5.87	21.88	23.81	22.85
T_6	7.42	7.89	7.66	5.09	6.13	5.61	15.10	13.67	14.39
T_7	6.67	7.04	6.86	4.55	5.17	4.86	13.05	13.46	13.26
T_8	7.87	8.81	8.34	5.14	6.98	6.06	20.13	19.63	19.88
T_9	7.15	8.11	7.63	4.62	6.32	5.47	16.58	14.83	15.71
T_{10}	6.84	7.48	7.16	4.59	5.56	5.08	15.67	14.13	14.90
T_{11}	7.40	7.81	7.61	5.07	5.86	5.47	21.25	17.88	19.57
T_{12}	9.24	8.09	8.67	5.42	6.40	5.91	22.88	19.90	21.39
T_{13}	4.42	5.67	5.05	3.89	4.77	4.33	12.81	12.72	12.77
SEm(±)	**0.375**	**0.364**	**0.295**	**0.278**	**0.145**	**0.169**	**0.585**	**0.552**	**0.400**
CD(0.05)	**1.094**	**1.063**	**0.862**	**0.812**	**0.424**	**0.493**	**1.707**	**1.610**	**1.168**

4.1.4.7. Anthocyanin content of peel (mg/100g)

Data showed in the Table 4.1.21 and Fig. 4.1.21 revealed that significant variation was found in anthocyanin content of peel during both the years. The presented data shown that the highest anthocyanin content of peel (6.40 and 3.58 mg/100g) was recorded in FYM to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_5) followed by T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (5.55 and 3.46 mg/100g) and the lowest (1.49 and 1.19 mg/100g) was recorded in control (T_{13}) for two consecutive years.

Pooled analysis of data from both years showed that the highest (4.99 mg/100g) anthocyanin content of peel was in T_5 [FYM to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB)] followed by T_8 (4.51 mg/100g) and the lowest (1.34 mg/100g) was recorded in control (T_{13}).

4.1.4.8. Anthocyanin content of pulp (mg/100g)

Anthocyanin content of pulp as described at Table 4.1.21 showed that significant variation was observed due to different treatment during both the years. The presented data showed that the highest anthocyanin content of pulp (15.08 mg/100g) was recorded in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) followed by T_{11}(FYM to supply 25% K + VC to supply 25% K+ NC to supply 25% K + 25% RDF) (14.72mg/100g) in the first year of study. During the second year, the highest (13.97 mg/100g) was recorded in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) followed by T_{11}(9.44mg/100g) and the lowest (5.28 and 4.39mg/100g) was recorded in control (T_{13}) for two consecutive years.

Pooled analysis data from both years showed that the highest (13.22mg/100g) anthocyanin content of pulp in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) followed by T_{12} (12.18mg/100g) and the lowest (4.84mg/100g) was recorded in control (T_{13}).

4.1.5. Soil Nutrients analysis

4.1.5.1 Soil pH

Soil pH of the experimental plot under each treatment shown in table 4.1.22 revealed that significant differences were observed under the study. The highest soil pH (6.19) was recorded in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) (6.02) in the first year of experimental study 2018-2019. During the second years 2019-2020 the highest soil pH (6.30) was observed in followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) followed by T_8 (6.28) as compared to control (T_{13}) (4.85 and 5.05, respectively) for both the years. Pooled data for both years showed that the highest soil pH (6.24) was recorded in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) and lowest pH (4.95) was recorded in control (T_{13}).

4.1.5.2. Organic Carbon (%)

From Table 4.1.22 showed significant variation among each treatment with respect to organic carbon content of soil during the experimental study. The highest organic carbon content (1.04% and 0.95%) was recorded in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) followed by FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) (1.01% and 0.92%) as compared with the lowest control (T_{13}) (0.28% and 0.25%) for both years of study. Pooled analysis data revealed that highest organic carbon percentage (1.00%) was recorded in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) followed by (T_{12})(0.97%) and lowest (0.27%) was recorded in control (T_{13}).

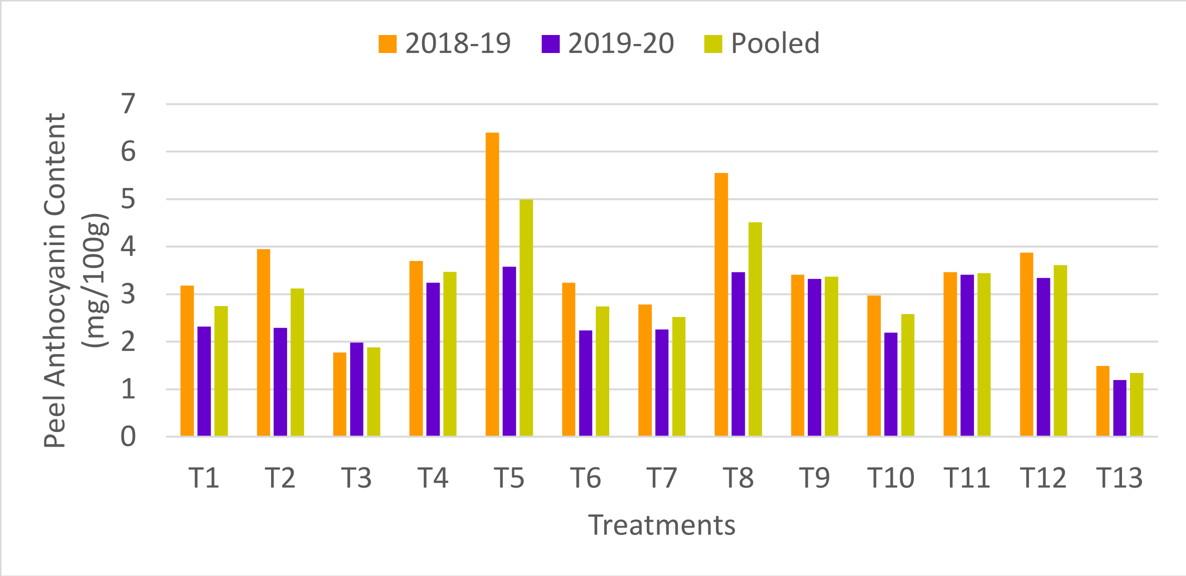


Fig. 4.1.21 Effect of integrated nutrient management treatments on peel anthocyanin content of dragon fruits

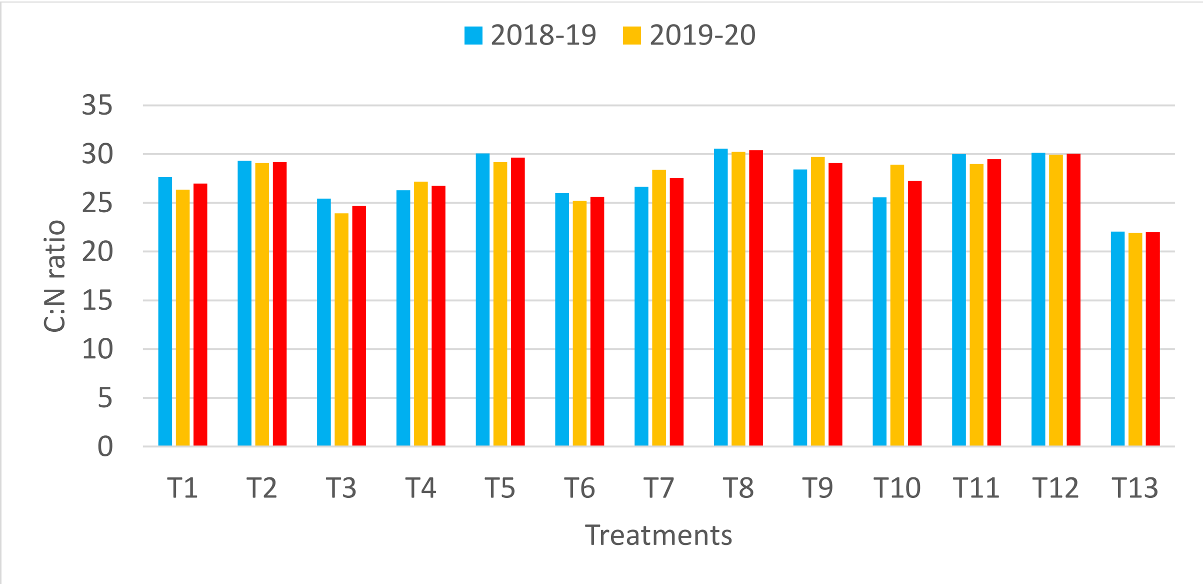


Fig. 4.1.22 Effect of integrated nutrient management treatments on C:N ratio of soil

Table 4.1.21 : Effect of integrated nutrient management on anthocyanin content of peel and pulp of dragon fruits

Treatments	Peel Anthocyanin Content (mg/100g)			Anthocyanin Content of Pulp (mg/100g)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	3.18	2.32	2.75	8.37	7.63	8.00
T_2	3.95	2.29	3.12	6.30	7.61	6.96
T_3	1.77	1.98	1.88	4.58	5.63	5.11
T_4	3.70	3.24	3.47	6.60	8.98	7.79
T_5	6.40	3.58	4.99	10.28	8.88	9.58
T_6	3.24	2.24	2.74	7.50	7.81	7.66
T_7	2.78	2.26	2.52	7.28	7.59	7.44
T_8	5.55	3.46	4.51	12.47	13.97	13.22
T_9	3.41	3.32	3.37	9.42	9.12	9.27
T_{10}	2.97	2.19	2.58	7.60	9.05	8.33
T_{11}	3.46	3.41	3.44	14.72	9.44	12.08
T_{12}	3.87	3.34	3.61	15.08	9.27	12.18
T_{13}	1.49	1.19	1.34	5.28	4.39	4.84
SEm(±)	**0.261**	**0.216**	**0.172**	**0.289**	**0.428**	**0.309**
CD(0.05)	**0.763**	**0.630**	**0.502**	**0.843**	**1.250**	**0.902**

Table 4.1.22 : Effect of integrated nutrient management on soil pH, organic carbon and C:N ratio of experimental soil of dragon fruit orchard

Treatments	Soil pH			Organic Carbon (%)			C:N ratio		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	4.95	5.28	5.12	0.82	0.59	0.71	27.63	26.34	26.98
T_2	5.34	5.72	5.53	0.92	0.78	0.85	29.30	29.07	29.18
T_3	5.02	5.15	5.09	0.65	0.52	0.59	25.42	23.93	24.67
T_4	5.28	5.45	5.37	0.76	0.62	0.69	26.29	27.16	26.73
T_5	5.97	6.21	6.09	1.00	0.84	0.92	30.05	29.18	29.62
T_6	5.16	5.21	5.19	0.69	0.56	0.63	26.00	25.21	25.60
T_7	5.30	5.51	5.41	0.78	0.69	0.74	26.66	28.38	27.52
T_8	6.19	6.28	6.24	1.04	0.95	1.00	30.55	30.22	30.38
T_9	5.42	6.15	5.79	0.86	0.89	0.88	28.42	29.70	29.06
T_{10}	5.22	5.56	5.39	0.72	0.76	0.74	25.55	28.91	27.23
T_{11}	5.32	5.75	5.54	0.98	0.80	0.89	30.00	28.97	29.48
T_{12}	6.02	6.30	6.16	1.01	0.92	0.97	30.13	29.92	30.03
T_{13}	4.85	5.05	4.95	0.28	0.25	0.27	22.04	21.92	21.98
SEm(±)	**0.064**	**0.117**	**0.072**	**0.014**	**0.012**	**0.011**	**0.763**	**0.804**	**0.730**
CD(0.05)	**0.185**	**0.341**	**0.210**	**0.041**	**0.035**	**0.031**	**2.227**	**2.346**	**2.129**

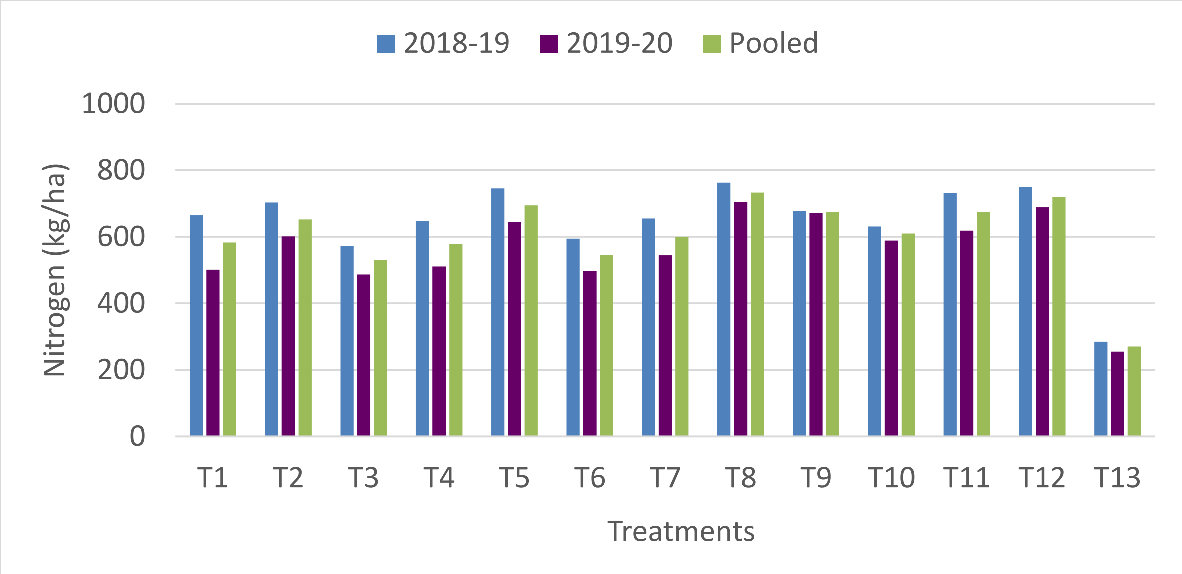


Fig. 4.1.23 Effect of integrated nutrient management treatments on nitrogen content of soil

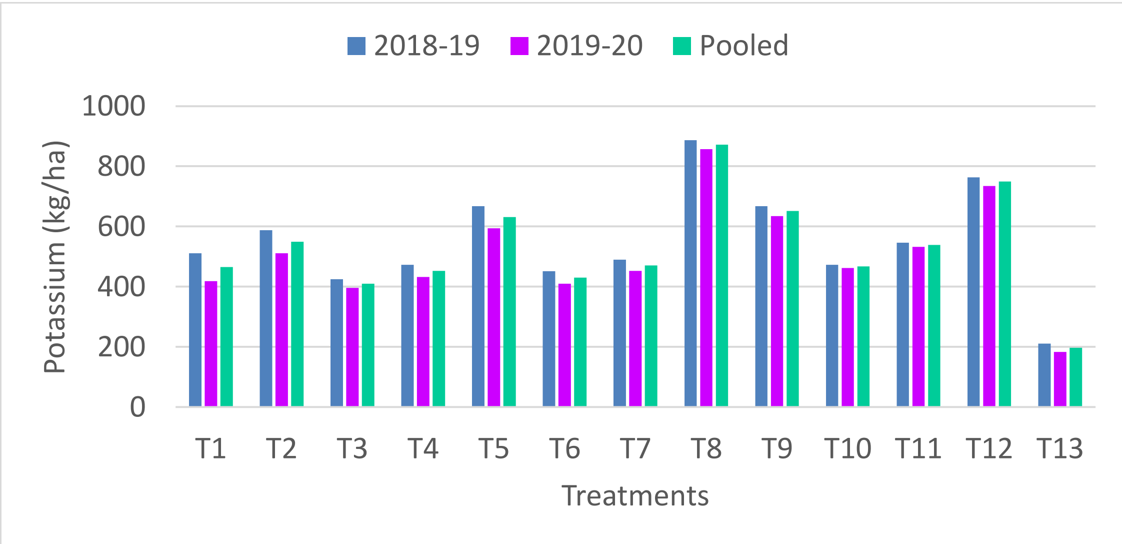


Fig. 4.1.24 Effect of integrated nutrient management treatments on potassium content of soil

4.1.5.3 C: N ratio

C: N ratio as appeared on Table 4.1.22 and Fig. 4.1.22 showed significant influence by various treatments during the study. The highest C: N ratio was recorded in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (30.55 and 30.22) followed by FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) (30.13 and 29.92) as compared with the lowest at control (T_{13}) (22.04 and 21.92) for both years of study. Pooled analysis data revealed that highest C: N ratio (30.38) was recorded in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) followed by T_{12} (30.03) and the lowest C: N ratio (21.98) was recorded in T_{13} (control).

4.1.5.4. Total nitrogen (kg/ha)

Total nitrogen content of the soil presented in Table 4.1.23 and Fig. 4.1.23 showed that applied integrated nutrients provided had a significant influenced on each treatment. The highest total nitrogen available in the soil (762.52kg/ha and 704.28 kg/ha) was recorded with FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB(T_8) followed by FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) (750.82 and 688.78 kg/ha) during both years of study and the least was recorded in control (T_{13}) (284.56 and 255.48 kg/ha).The pooled analysis from two years showed that the highest available nitrogen (733.28kg/ha) was observed in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) followed by (T_{12}) (719.80 kg/ha), while the lowest (270.02kg/ha) was observed in treatment control (T_{13}).

4.1.5.5. Phosphorus (kg/ha)

The available phosphorus content of experimental soil displayed in Table 4.1.23 showed that different nutrients had a significant influenced on each treatment during the study. The highest phosphorus (92.74kg/ha) was recorded in T_5 (Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB)) followed by FYM to supply 25% K + VC to supply 25% K+ 50% RDF+ AZ+ PSB+ KSB (T_8)

(89.34kg/ha) and lowest was in control T_{13} (23.63kg/ha) during 2018-2019. Whereas, in 2019-2020 the highest phosphorus (88.64kg/ha) was recorded in FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) followed by (T_8) (82.67kg/ha) as compared with the lowest (19.38kg/ha) in control. However, the pooled data revealed that from both years of study, the highest phosphorus content in soil (86.01kg/ha) was observed in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8), while the lowest (21.51kg/ha) was observed in treatment control (T_{13}).

4.1.5.6. Potassium (kg/ha)

Potassium content of experimental soil presented at Table 4.1.23 and Fig. 4.1.24 varied significantly due to different nutrients application. The highest potassium content in the soil (886.97 kg/ha and 856.47 kg/ha) was recorded with FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) followed by FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) (763.45 and 734.65 kg/ha) during both years of study and the least was recorded in control (T_{13}) (211.25 and 182.79 kg/ha).

The pooled analysis from two years showed that the highest available potassium in the experimental soil (871.72kg/ha) was observed in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) followed by (T_{12}) (749.05 kg/ha), while the lowest (197.02kg/ha) was observed in treatment control (T_{13}).

4.1.5.7. Manganese (mg/kg)

Data presented at Table 4.1.24 showed that manganese content in the soil varied significantly among each treatment due to different nutrients application. The highest manganese content in the soil (49.18mg/kg and 58.78mg/kg) was recorded with control (T_{13}) which was followed by T_3 (Vermicompost (VC) to supply 50% K+ 50% RDF) (46.76mg/kg and 57.65 mg/kg) during both year of study. However, during 2018-2019 the lowest manganese content of soil was found in FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12})

(13.45mg/kg) while in 2019-2020 lowest (18.92mg/kg) was observed in T_5 (Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB)).

The pooled analysis from two years data showed that the highest available manganese in the experimental soil (53.93mg/kg) was observed in control (T_{13}) followed by (T_3) (52.22 mg/kg), while the lowest (18.52mg/kg) was observed in FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}).

4.1.5.8. Iron (mg/kg)

Significant variation was observed among treatment with respect to available iron content in the experimental soil showed in Table 4.1.24 and Fig. 4.1.25. During 2018-2019, the maximum Iron content in the soil (154.10mg/kg) was recorded with FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) while in 2019-2020, it was found highest (230.50mg/kg) in T_5 (Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB)) while the second highest for both year was observed under FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) (148.00 mg/kg and 216.40mg/kg).The pooled analysis from two years showed that the highest available Iron in the experimental soil (188.20mg/kg) was observed in T_5 (Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB)) followed by (T_8) (182.20mg/kg), while the lowest (76.44mg/kg) was observed in treatment control (T_{13}).

Table 4.1.23 : Effect of integrated nutrient management on nitrogen, phosphorus and potassium content of experimental soil of dragon fruit orchard

Treatments	Nitrogen (kg/ha)			Phosphorus (kg/ha)			Potassium (kg/ha)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	664.78	501.78	583.28	70.28	58.35	64.32	511.28	418.68	464.98
T_2	703.45	601.02	652.24	75.37	65.48	70.43	587.87	511.04	549.46
T_3	572.87	486.72	529.80	58.73	45.78	52.26	424.67	395.62	410.15
T_4	647.61	511.27	579.44	65.43	49.74	57.59	472.38	431.98	452.18
T_5	745.32	644.78	695.05	92.74	72.53	82.64	667.82	594.35	631.09
T_6	594.36	497.67	546.02	60.56	52.91	56.74	451.29	409.72	430.51
T_7	655.47	544.67	600.07	68.72	61.29	65.01	489.72	452.39	471.06
T_8	762.52	704.28	733.40	89.34	82.67	86.01	886.97	856.47	871.72
T_9	677.78	671.27	674.53	79.67	76.78	78.23	667.82	634.98	651.40
T_{10}	631.29	588.78	610.04	62.18	59.78	60.98	472.39	462.38	467.39
T_{11}	731.82	618.56	675.19	72.54	69.72	71.13	545.78	532.46	539.12
T_{12}	750.82	688.78	719.80	82.35	88.64	85.50	763.45	734.65	749.05
T_{13}	284.56	255.48	270.02	23.63	19.38	21.51	211.25	182.79	197.02
SEm(±)	**1.354**	**1.036**	**0.862**	**0.844**	**0.664**	**0.566**	**1.960**	**1.335**	**1.342**
CD(0.05)	**3.951**	**3.023**	**2.515**	**2.464**	**1.938**	**1.651**	**5.721**	**3.897**	**3.918**

Table 4.1.24 : Effect of integrated nutrient management on iron and manganese content of experimental soil of dragon fruit orchard

Treatments	Fe (mg/Kg)			Mn (mg/Kg)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	107.30	150.70	129.00	29.99	42.76	36.38
T_2	138.30	159.40	148.85	23.63	31.30	27.47
T_3	68.82	98.40	83.61	46.78	57.65	52.22
T_4	90.96	155.90	123.43	39.96	49.32	44.64
T_5	145.90	230.50	188.20	18.81	18.92	18.87
T_6	82.61	112.50	97.56	44.48	54.32	49.40
T_7	86.30	151.50	118.90	34.19	48.67	41.43
T_8	148.00	216.40	182.20	16.75	20.31	18.53
T_9	132.00	212.50	172.25	23.28	28.24	25.76
T_{10}	83.24	162.30	122.77	42.98	50.80	46.89
T_{11}	124.00	188.50	156.25	25.91	29.69	27.80
T_{12}	154.10	194.50	174.30	13.45	23.58	18.52
T_{13}	65.13	87.74	76.44	49.18	58.78	53.98
SEm(±)	**0.763**	**0.964**	**0.575**	**0.677**	**0.695**	**0.482**
CD(0.05)	**2.226**	**2.814**	**1.679**	**1.977**	**2.029**	**1.408**

Table 4.1.25 : Effect of integrated nutrient management on copper and zinc content of experimental soil of dragon fruit orchard

Treatments	Cu (mg/Kg)			Zn (mg/kg)		
	2018-19	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**
T_1	1.78	2.75	2.27	13.31	14.23	13.77
T_2	1.56	2.17	1.87	13.52	17.84	15.68
T_3	2.41	2.95	2.68	6.94	10.61	8.78
T_4	1.97	2.68	2.33	12.93	14.92	13.93
T_5	1.35	2.09	1.72	14.67	21.71	18.19
T_6	2.18	2.84	2.51	9.18	12.34	10.76
T_7	1.86	2.56	2.21	10.70	16.34	13.52
T_8	1.24	1.85	1.55	28.25	31.40	29.83
T_9	1.47	1.76	1.62	14.53	19.78	17.16
T_{10}	2.32	2.41	2.37	8.75	15.73	12.24
T_{11}	1.63	2.29	1.96	13.45	18.40	15.93
T_{12}	1.28	1.96	1.62	21.05	27.56	24.31
T_{13}	2.55	3.03	2.79	5.38	6.41	5.90
SEm(±)	**0.087**	**0.170**	**0.090**	**0.974**	**0.527**	**0.635**
CD(0.05)	**0.255**	**0.497**	**0.261**	**2.844**	**1.538**	**1.852**

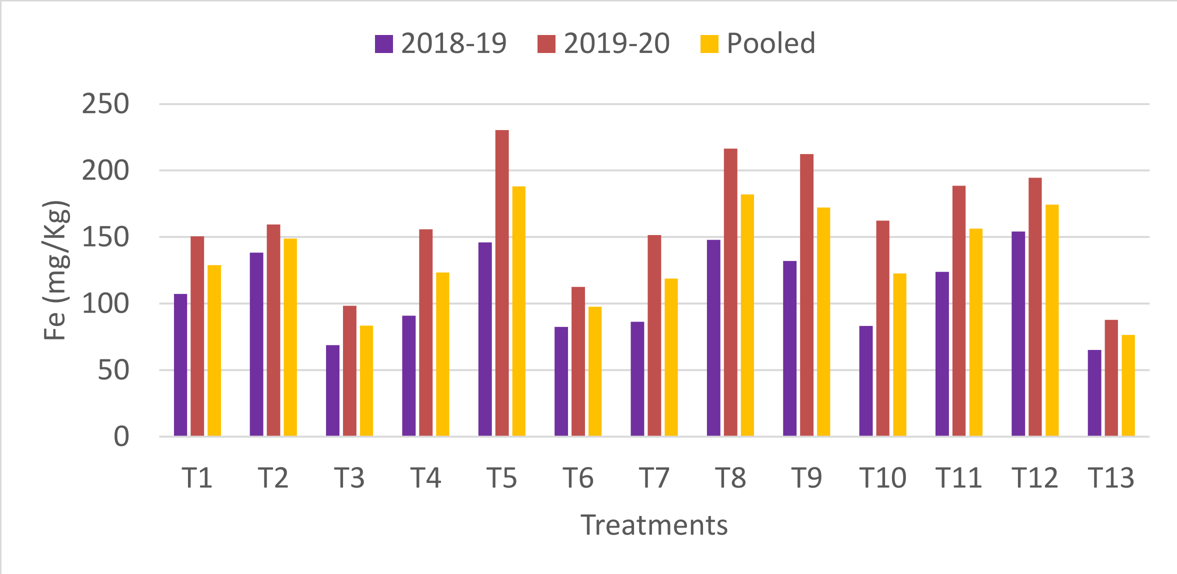


Fig. 4.1.25 Effect of integrated nutrient management treatments on iron content of soil

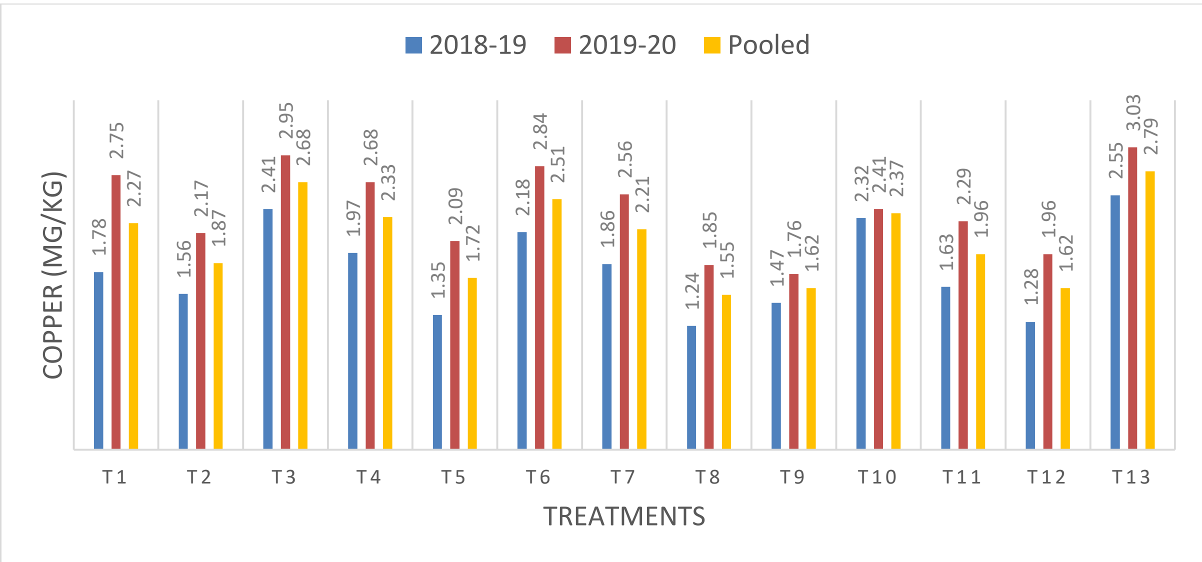


Fig. 4.1.26 Effect of integrated nutrient management treatments on copper content of soil

4.1.5.9. Copper (mg/kg)

It is clearly shown in Table 4.1.25, Fig. 4.1.26 that copper content in the soil varied significantly among each treatment due to different nutrients application. The highest magnesium content in the soil (2.55 mg/kg and 3.03mg/kg) was recorded with treatment control (T_{13}) which was followed by T_3 (Vermicompost (VC) to supply 50% K+ 50% RDF) (2.41mg/kg and 2.95 mg/kg) during both year of study. However, during 2018-2019 the lowest (1.24mg/kg) copper content of soil was found in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) while in 2019-2020 lowest (1.76mg/kg) was observed in T_9 (FYM to supply 25% K + NC to supply 25% K+ 50% RDF+AZ+PSB+ KSB). The pooled analysis from two years data showed that the highest available copper in the experimental soil (2.79 mg/kg) was observed in treatment control (T_{13}) followed by (T_3) (2.68mg/kg), while the lowest (1.55mg/kg) was observed in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8).

4.1.5.10. Zinc (mg/kg)

The available zinc content of experimental soil at Table 4.1.25 showed significant variation due to different nutrients application. The highest zinc content in the soil (28.25mg/kg and 31.40mg/kg) was recorded with FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) followed by FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) (21.05mg/kg and 27.56mg/kg) during both years of study and the least was recorded in control (T_{13}) (5.38mg/kg and 6.41mg/kg).The pooled analysis from two years showed that the highest available potassium in the experimental soil was (29.83mg/kg) was observed in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) followed by (T_{12}) (24.31mg/kg), while the lowest (5.90mg/kg) was observed in treatment control (T_{13}).

4.1.6. Soil microbial analysis

4.1.6.1. *Azotobacter* count

It was clear from the data presented in Table 4.1.26 that the highest *Azotobacter* count of experimental soil was observed in FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) (31.52 x 10^6 cfu g^{-1}) followed by FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) (29.56 x 10^6 cfu g^{-1}) during 2018-2019. In the second year 2019-2020, the maximum count was recorded in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) (82.76 x 10^6 cfu g^{-1}) followed by FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) (76.98 x 10^6 cfu g^{-1}). The pooled analysis from two years data showed that the maximum soil *Azotobacter* count was recorded in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) (56.16 x 10^6 cfu g^{-1}) followed by (T_{12}) (54.25 x 10^6 cfu g^{-1}) while the minimum population (4.98, 6.87 and 5.93 x 10^6 cfu g^{-1}) was observed in treatment control (T_{13}) in both the years of study and in pooled analysis.

4.1.6.2. Phosphorus Solubilizing Bacteria (PSB) count

Data of Phosphorus solubilising bacteria (PSB) count presented in Table 4.1.26 showed significant variation across treatment. During 2018-2019, the highest phosphorus solubilising bacteria count of experimental soil (29.52 x 10^6 cfu g^{-1}) was observed in T_5 [Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB)] followed by FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) (27.68 x 10^6 cfu g^{-1}). In the second year 2019-2020, the maximum PSB population count was recorded in FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) (85.432x 10^6 cfu g^{-1}) followed by (T_8) (71.56 x 10^6 cfu g^{-1}). The pooled analysis from two years data showed that the maximum soil phosphorus solubilising bacteria count was recorded in FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) (55.43 x 10^6 cfu g^{-1}) followed by (T_8) (49.62 x 10^6

cfu g^{-1}). However, the minimum population count (9.43, 11.68 and 10.53 x 10^6 cfu g^{-1}) was observed in treatment control (T_{13}) in both the years of study and in pooled data.

4.1.6.3. Potassium Solubilising Bacteria (KSB) Count

Data presented in Table 4.1.26 showed significant variation of KSB content in soil across treatments. During 2018-19 and 2019-20, the highest potassium solubilising bacteria (KSB) count (48.32 x10^6 cfu g^{-1} and 96.53 x10^6 cfu g^{-1}) was observed FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) followed by FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) (46.59 x10^6 cfu g^{-1} and 90.38 x 10^6 cfu g^1) and the lowest potassium solubilising bacteria (KSB) count (10.56 x10^6 cfu g^{-1} and 14.48 X 10^6 cfu g^{-1}) was observed in treatment control (T_{13}) The pooled analysis of two years data showed that the maximum soil potassium solubilising bacteria count was recorded in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) (72.43 x 10^6 cfu g^{-1}) followed by (T_{12}) (68.49 x 10^6 cfu g^{-1}). However, the minimum KSB count (12.52 x 10^6 cfu g^{-1}) was observed in treatment control (T_{13}).

4.1.7. Cladode analysis

4.1.7.1. Cladode Nitrogen (%)

It is clear from the data presented in Table 4.1.27 that significant variation in cladode nitrogen content was observed across treatments. The highest cladode nitrogen (2.56% and 3.12%) was recorded with FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) followed by FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) (2.45% and 2.24%) during both years of study and the least was recorded in control (T_{13}) (1.21% and 1.34%). The pooled analysis presented that cladode nitrogen was highest (3.28%) in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) followed by (T_{12}) (2.35%), while the lowest (1.28%) was observed in treatment control (T_{13}).

4.1.7.2. Cladode Phosphorus (%)

Table 4.1.27 revealed that available cladode phosphorus varied significantly among different treatment. During 2018-2019, T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) and T_6 (VC to supply 50% K + 50% RDF+AZ+PSB+ KSB) recorded the maximum cladode phosphorus percentage (0.28%) followed by FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) (0.26%). In the second years 2019-2020, cladode phosphorus was highest at T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) (0.36%) followed by FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) (0.32%), while control recorded the minimum cladode phosphorus percentage (0.13% and 0.15%) in both years of experimental study.

The pooled analysis presented that cladode phosphorus percentage as highest (0.32%) as observed in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) followed by (T_8) (0.29%), while the lowest (0.14%) was observed in treatment control (T_{13}).

4.1.7.3. Cladode Potassium (%)

From the data presented in Table 4.1.27 and Fig. 4.127 showed that significant influenced was observed across treatments. The maximum record for cladode potassium content (2.86% and 3.37%) was observed with FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) followed by FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+ PSB+ KSB (T_{12}) (2.81% and 3.21%) during both years of study and the least was recorded in control (T_{13}) (1.28% and 1.58%). The pooled analysis presented that cladode potassium content was the highest (3.12%) in case of the plants manured with FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) followed by (T_{12}) (3.01%), while the lowest (1.43%) was observed in treatment control (T_{13}).

Table 4.1.26 : Effect of integrated nutrient management on Azotobacter(AZ), Phosphate Solubilizing Bacteria (PSB), Potash Solubilizing Bacteria (KSB) count of experimental soil of dragon fruit orchard

Treatments	AZ count X 10^6cfu g^{-1}			PSB count X 10^6cfu g^{-1}			KSB count X 10^6cfu g^{-1}		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	5.67	7.95	6.81	13.24	17.98	15.61	15.48	17.49	16.49
T_2	14.95	28.92	21.94	18.65	25.72	22.19	23.72	39.76	31.74
T_3	7.98	11.93	9.96	10.37	14.38	12.38	18.39	22.58	20.49
T_4	12.62	24.87	18.75	17.58	31.38	24.48	20.43	34.82	27.63
T_5	26.47	68.54	47.51	29.52	62.18	45.85	44.18	74.82	59.50
T_6	18.27	32.47	25.37	21.47	39.84	30.66	25.91	45.39	35.65
T_7	24.58	42.38	33.48	23.12	45.73	34.43	32.19	51.28	41.74
T_8	29.56	82.76	56.16	27.68	71.56	49.62	48.32	96.53	72.43
T_9	21.67	57.32	39.50	24.67	67.53	46.10	39.87	83.72	61.80
T_{10}	20.48	46.59	33.54	22.85	51.18	37.02	28.69	56.34	42.52
T_{11}	17.38	38.27	27.83	23.37	56.43	39.90	37.42	65.38	51.40
T_{12}	31.52	76.98	54.25	25.43	85.42	55.43	46.59	90.38	68.49
T_{13}	4.98	6.87	5.93	9.43	11.68	10.56	10.56	14.48	12.52
SEm(±)	**0.760**	**1.879**	**1.191**	**0.912**	**1.384**	**0.789**	**1.969**	**1.555**	**0.995**
CD(0.05)	**2.219**	**5.486**	**3.476**	**2.661**	**4.041**	**2.302**	**5.748**	**4.540**	**2.905**

Table 4.1.27 : Effect of integrated nutrient management on cladode nitrogen, phosphorus and potassium content of dragon fruit plants

Treatments	Cladode Nitrogen (%)			Cladode Phosphorus (%)			Cladode Potassium (%)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	1.92	1.75	1.84	0.24	0.22	0.23	2.24	2.39	2.32
T_2	1.83	1.92	1.88	0.21	0.27	0.24	2.32	2.99	2.66
T_3	1.53	1.68	1.61	0.18	0.20	0.19	2.04	2.18	2.11
T_4	1.63	1.79	1.71	0.20	0.23	0.22	2.21	2.35	2.28
T_5	2.21	2.03	2.12	0.25	0.28	0.27	2.43	3.08	2.76
T_6	2.16	1.83	2.00	0.28	0.25	0.27	2.10	2.36	2.23
T_7	1.84	1.82	1.83	0.21	0.22	0.22	2.19	2.42	2.31
T_8	2.56	3.12	3.28	0.26	0.32	0.29	2.86	3.37	3.12
T_9	2.35	2.10	2.23	0.25	0.30	0.28	2.52	3.01	2.77
T_{10}	1.96	1.89	1.93	0.22	0.26	0.24	2.12	2.57	2.35
T_{11}	2.17	1.96	2.07	0.23	0.29	0.26	2.25	2.91	2.58
T_{12}	2.45	2.24	2.35	0.28	0.36	0.32	2.81	3.21	3.01
T_{13}	1.21	1.34	1.28	0.13	0.15	0.14	1.28	1.58	1.43
SEm(±)	**0.086**	**0.110**	**0.153**	**0.017**	**0.013**	**0.011**	**0.175**	**0.158**	**0.111**
CD(0.05)	**0.250**	**0.321**	**0.446**	**0.049**	**0.038**	**0.031**	**0.511**	**0.461**	**0.323**

Table 4.1.28 : Effect of integrated nutrient management on iron and manganese content of cladode of dragon fruit plants

Treatments	Cladode Fe (ppm)			Cladode Mn (ppm)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	174.72	176.37	175.55	501.40	723.50	612.45
T_2	186.21	187.24	186.73	554.40	765.30	659.85
T_3	134.82	137.93	136.38	374.40	550.40	462.40
T_4	171.94	185.46	178.70	485.00	689.40	587.20
T_5	194.38	249.56	221.97	637.40	822.30	729.85
T_6	145.59	154.82	150.21	425.40	609.70	517.55
T_7	156.38	163.48	159.93	463.80	760.50	612.15
T_8	221.54	235.67	228.61	653.50	819.50	736.50
T_9	182.54	229.48	206.01	584.40	795.60	690.00
T_{10}	164.32	194.83	179.58	454.40	612.10	533.25
T_{11}	176.53	217.35	196.94	546.30	787.40	666.85
T_{12}	230.73	234.78	232.76	706.80	792.40	749.60
T_{13}	104.58	117.13	110.86	108.00	116.10	112.05
SEm(±)	**1.740**	**0.736**	**0.880**	**5.041**	**7.920**	**4.740**
CD(0.05)	**5.079**	**2.149**	**2.568**	**14.713**	**23.118**	**13.836**

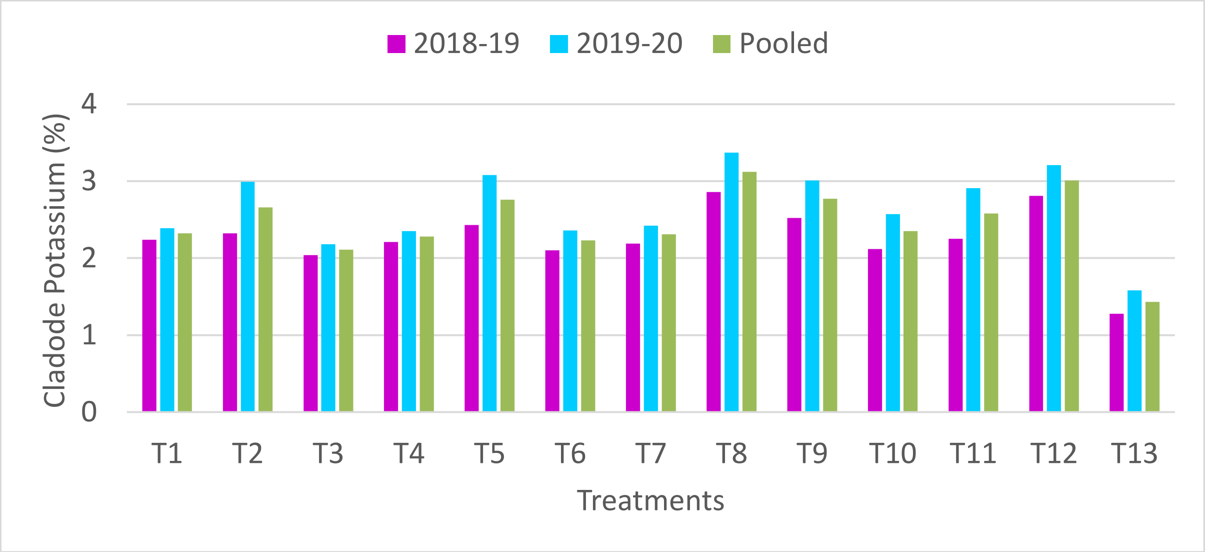


Fig. 4.1.27 Effect of integrated nutrient management treatments on potassium content of cladode

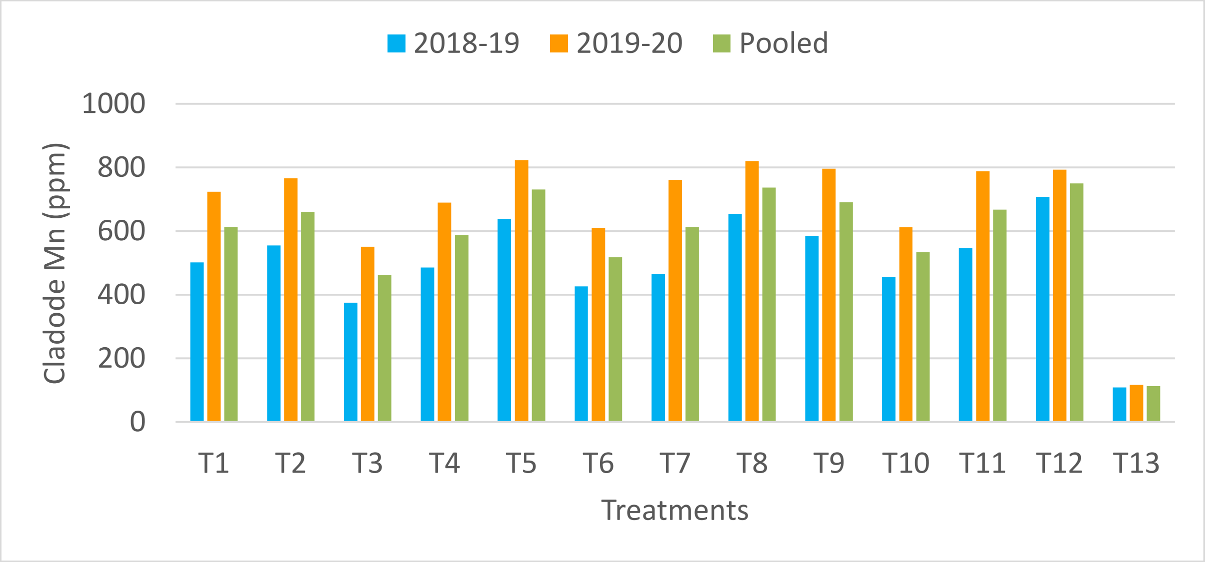


Fig. 4.1.28 Effect of integrated nutrient management treatments on manganese content of cladode

4.1.7.4. Cladode Fe (ppm)

Table 4.1.28 manifested that significant influence in iron content of cladode was observed across treatments during the experimental study. The maximum records for cladode iron (Fe) content (230.73ppm) was observed with FYM to supply 25% K+

VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) followed by plants applied with FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) (221.54ppm) during the first year of experiment while in the second years the maximum record (249.56ppm) of cladode Fe content was observed under Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_5) followed by (T_8) (235.67ppm) and the least was recorded in control (T_{13}) (104.58 and 117.13 ppm) in both year during the experimental research.

The pooled analysis presented that cladode iron (Fe) content was highest (232.76ppm) for the plants manured with FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) followed by (T_8) (228.61ppm), while the lowest (110.86ppm) was observed in control (T_{13}).

4.1.7.5. Cladode Manganese (ppm)

From the data shown in Table 4.1.28 and Fig. 4.1.28, it is evident that there was significant variation in manganese content of the cladode across treatments during the experimental study. The maximum records for cladode manganese content (706.80 ppm) was observed with FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) followed by plants applied with FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) (653.50ppm) during the first year of experiment while in the second years the maximum record (822.30ppm) of cladode manganese content was observed under Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_5) followed by (T_8) (819.50ppm) and the least was recorded in control (T_{13}) (108 and 116.10 ppm) in both year of the experimental research.

The pooled analysis presented that cladode manganese (Mn) content was the highest (749.60 ppm) for the plants applied with FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}) followed by (T_8) (736.50 ppm), while the lowest (112.05 ppm) was observed in treatment control (T_{13}).

4.1.7.6. Cladode Copper (ppm)

From the Table 4.1.29 it is clear that significant variation in cladode copper content across treatments under the current study. The maximum records for cladode copper content (8.18 ppm and 8.85 ppm) was recorded in control (T_{13}) which was followed by T_3 [Vermicompost (VC) to supply 50% K+ 50% RDF] (7.84 ppm and 8.06 ppm) and the minimum records for cladode copper content (3.44 ppm and 6.26 ppm) was recorded in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) for two consecutive years.

The pooled analysis presented that cladode copper content was highest (8.52 ppm) at control (T_{13}) followed by (T_3) (7.95 ppm), and the lowest cladode copper content was recorded in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) (4.85 ppm).

4.1.7.7. Cladode Zinc (ppm)

Significant variation in cladode zinc content was observed due to different treatments during the present study (Table 4.1.29 and Fig. 4.1.29). The maximum records for cladode zinc content (61.25 ppm and 69.50 ppm) was found in case of the plants applied with FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) which was followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) (56.72 ppm and 64.72 ppm) and minimum cladode zinc content was recorded at control (22.24 ppm and 34.62 ppm) for two consecutive years.

The pooled analysis presented that cladode zinc content was highest (65.38ppm) under T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) followed by (T_{12}) (60.72ppm), and the lowest cladode zinc content was recorded in control T_{13} (28.54 ppm).

Table 4.1.29 : Effect of integrated nutrient management on copper and zinc content of cladode of dragon fruit plants

Treatments	Cladode Cu (ppm)			Cladode Zn (ppm)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	6.44	7.78	7.11	46.40	56.72	51.56
T_2	6.13	7.10	6.62	48.64	63.78	56.21
T_3	7.84	8.06	7.95	43.47	54.27	48.87
T_4	6.98	7.48	7.23	45.26	58.07	51.67
T_5	5.48	6.42	5.95	51.34	61.45	56.40
T_6	7.33	8.04	7.69	44.21	54.44	49.33
T_7	6.63	7.34	6.99	45.06	56.31	50.69
T_8	3.44	6.26	4.85	61.25	69.50	65.38
T_9	5.74	5.83	5.79	50.23	59.74	54.99
T_{10}	7.66	7.14	7.40	43.64	58.18	50.91
T_{11}	6.34	6.90	6.62	49.24	58.85	54.05
T_{12}	5.15	6.41	5.78	56.72	64.72	60.72
T_{13}	8.18	8.85	8.52	22.45	34.62	28.54
SEm(±)	**0.221**	**0.207**	**0.171**	**0.974**	**0.484**	**0.504**
CD(0.05)	**0.646**	**0.604**	**0.500**	**2.843**	**1.413**	**1.472**

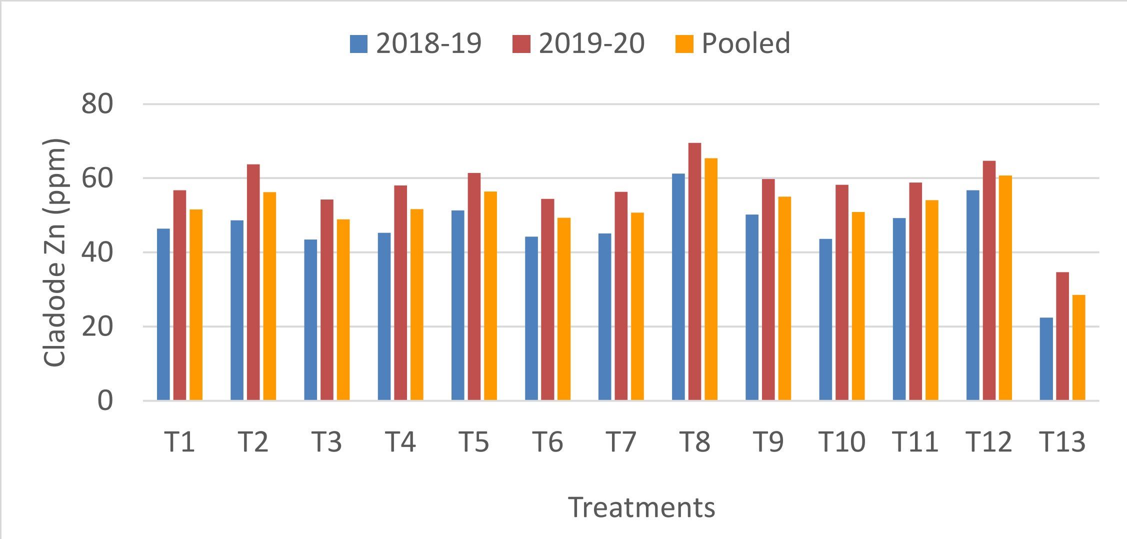


Fig. 4.1.29 Effect of integrated nutrient management treatments on zinc content of cladode

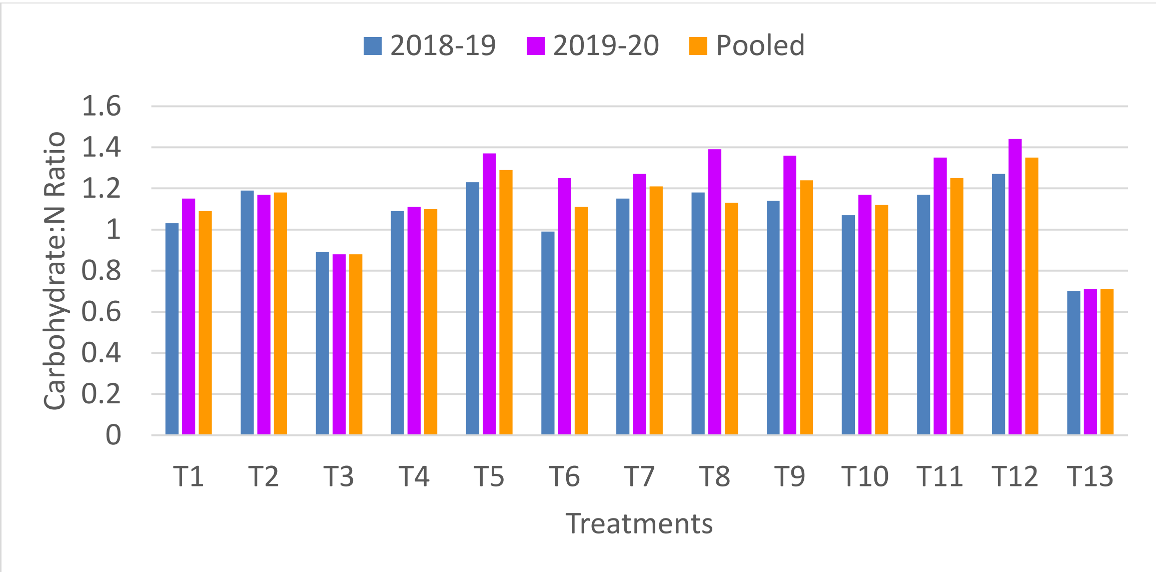


Fig. 4.1.30 Effect of integrated nutrient management treatments on carbohydrate : nitrogen ratio of cladode

4.1.7.8. Cladode carbohydrate (%)

Results of the impact of different treatments on dragon fruits shown in table 4.1.30 revealed that the highest cladode carbohydrate content (3.12%) was observed with T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB + KSB) followed by FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) (3.02%) in the year 2018-2019. Whereas, in the second year of study (2019-20), the maximum percentage was recorded with FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) (4.35%) followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) (3.23%) and the lowest cladode carbohydrate percentage was recorded in control (0.85% and 0.95%) for both the years of study.

The pooled data analysis presented that cladode carbohydrate percentage from two years showed that the highest (3.69%) was observed under FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) followed by (T_{12}) (3.18%), and the lowest cladode carbohydrate percentage content was recorded in (T_{13}) control (0.90 %).

4.1.7.9. Cladode Carbohydrate: Nitrogen (C: N) ratio

Carbohydrate: Nitrogen (C: N) ratio of cladode of dragon fruit showed significant variation among each treatments shown in Table 4.1.30 and Fig.4.1.30. It revealed that the highest cladode C: N ratio (1.27) was observed in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) followed by T_5 [(Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB)] (1.23) in the year 2018-2019. Whereas, in the second year of study, the maximum C:N ratio was recorded in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) (1.44) followed by (T_8) (3.23%) and the lowest cladode carbohydrate: nitrogen ratio content was recorded in control (0.70% and 0.71%) in both years of experimental study.

The pooled data analysis presented that cladode carbohydrate: nitrogen ratio was highest (1.35) under T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) followed by (T_5) (1.29) and the lowest cladode carbohydrate: nitrogen ratio content was recorded in control (0.71%).

4.1.7.10 Cost Benefit analysis

Perusal of the data presented in table 4.1.31 showed that the highest Gross Expenditure was obtained with T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) (Rs 987044.65) followed by T_{11} (FYM to supply 25% K + VC to supply 25% K+ NC to supply 25% K + 25% RDF) (Rs 925169.65) and the lowest gross expenditure was in control (T_{13}) (Rs 342760.00). Whereas, the highest gross income was observed in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (Rs 2545000.00) followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB)(Rs 2240000.00) and the lowest gross income was in control (T_{13}) (Rs 192500.00). Therefore, the highest net income was obtained with T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) (Rs 1686489.46) followed by (T_{12}) (Rs 1252955.35) and the lowest net income was in control (T_{13}) (Rs -150260.00). Among all the treatment, the highest benefit to cost ratio was obtained in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB)(1.96) followed by T_1 (Recommended dose of fertilizer (RDF) as 100% inorganic) (1.86) and the lowest benefit to cost ratio was observed in control (T_{13}) (-0.44).

Table 4.1.30 : Effect of integrated nutrient management on carbohydrate and carbohydrate: nitrogen (C:N) ratio of cladode of dragon fruit plants

Treatments	Carbohydrate (%)			Carbohydrate:N Ratio		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	1.98	2.01	2.00	1.03	1.15	1.09
T_2	2.18	2.25	2.22	1.19	1.17	1.18
T_3	1.36	1.48	1.42	0.89	0.88	0.88
T_4	1.78	1.98	1.88	1.09	1.11	1.10
T_5	2.71	2.78	2.75	1.23	1.37	1.29
T_6	2.13	2.28	2.21	0.99	1.25	1.11
T_7	2.12	2.32	2.22	1.15	1.27	1.21
T_8	3.02	4.35	3.69	1.18	1.39	1.13
T_9	2.68	2.86	2.77	1.14	1.36	1.24
T_{10}	2.09	2.21	2.15	1.07	1.17	1.12
T_{11}	2.54	2.64	2.59	1.17	1.35	1.25
T_{12}	3.12	3.23	3.18	1.27	1.44	1.35
T_{13}	0.85	0.95	0.90	0.70	0.71	0.71
SEm(±)	**0.078**	**0.128**	**0.073**	**0.035**	**0.038**	**0.053**
CD(0.05)	**0.228**	**0.375**	**0.212**	**0.103**	**0.110**	**0.153**

Table 4.1.31 : Effect of integrated nutrient management on Cost: Benefit Ratio of dragon fruit cultivation

Treatment	Gross expenditure (Rs)	Gross income (Rs)	Net income (Rs)	B:C ratio
T_1	530698.59	1520000.00	989301.41	1.86
T_2	735035.54	1687500.00	952464.46	1.30
T_3	858510.54	1042500.00	183989.46	0.21
T_4	788179.29	1400000.00	611820.71	0.78
T_5	796910.54	2020000.00	1223089.46	1.53
T_6	920385.54	1150000.00	229614.46	0.25
T_7	850054.29	1480000.00	629945.71	0.74
T_8	858510.54	2545000.00	1686489.46	1.96
T_9	823241.79	1907500.00	1084258.21	1.32
T_{10}	884910.54	1427500.00	542589.46	0.61
T_{11}	925169.65	1812500.00	887330.35	0.96
T_{12}	987044.65	2240000.00	1252955.35	1.27
T_{13}	342760.00	192500.00	-150260.00	-0.44

* Calculated based on one hectare land .

Experiment 2: Organic nutrient management of dragon fruit

4.2 Results

4.2.1 Plant growth and development

4.2.1.1. Cladode length (cm)

From the data presented in Table 4.2.1 and Fig. 4.2.1, it is evident that cladode length had significantly variation under different treatments during the period of study. Plants at T_{10} (NC +AZ+PSB+ KSB) had highest cladode length at 3 MAP (98.67 cm), 6 MAP (108.33 cm) and 9 MAP (143.00 cm), contrasting with the control (69.78 cm at 3 MAP, 79.98 cm at 6MAP and 96.89cm at 9MAP, respectively). After 12 months of planting, plants manured with FYM +AZ+PSB+ KSB (T_8) had maximum cladode length (175.33 cm) against control (118.67 cm). At 15 MAP, cladode length was recorded maximum in T_8 (212.78 cm) followed by T_{11} (200.56 cm) and T_{10} (194.33 cm) compared with control (142.78 cm). Percentage promotion of cladode length over initial revealed that plants at T_8 had highest growth (132.12%) followed by T_{11} (119.05%) compared with T_6 [Phosphate Solubilizing Bacteria (PSB)] where it was found lowest (81.20%) (Table 4.2.2).

After 18 months of planting, it was found that plants manured with FYM +AZ+PSB+ KSB (T_8) had maximum cladode length (218.11 cm) compared with control (165.33 cm) (Table 4.2.3). At 21 MAP, highest cladode length (248.56 cm) was recorded in T_{11} (PM +AZ+PSB+ KSB) compared with control (179.11 cm), whereas, at 24 MAP (255.22 cm), 27 MAP (277.67 cm) and finally at 30 MAP (297.44 cm); T_8 had the highest cladode length. At 30 MAP, cladode length of T_8 is followed by T_{11} (292.56 cm) and T_{10} (285.78 cm), whereas lowest length of cladode was recorded in control (214.11 cm). Percentage promotion of cladode length was recorded maximum (58.03%) in case of T_6 followed by T_2 (57.51%) compared with T_{11} (45.87%) at 30 MAP (Table 4.2.4; Fig. 4.2.2).

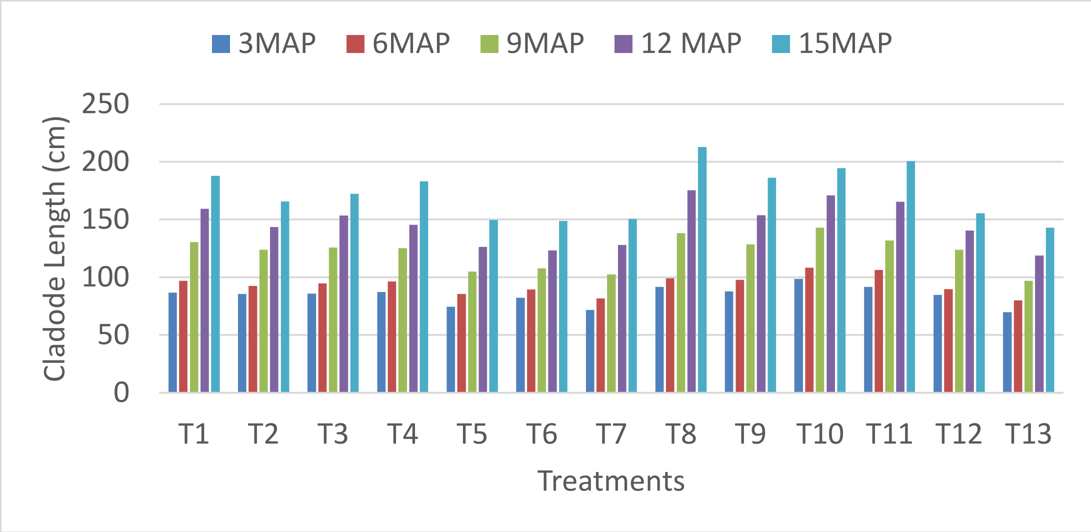


Fig. 4.2.1 Effect of organic nutrient management treatments on cladode length (2018-19)

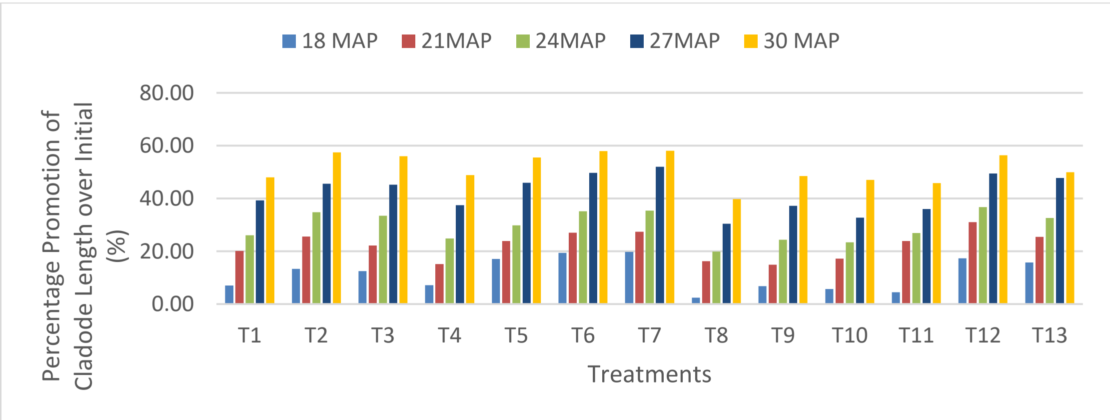


Fig. 4.2.2 Effect of organic nutrient management treatments on percentage promotion of cladode length over initial (2019-20)

Table 4.2.1 : Effect of organic nutrient management on cladode length of dragon fruit plants (2018-19)

Treatments	Cladode Length (cm)				
	2018-19				
	3MAP	6MAP	9MAP	12 MAP	15MAP
T_1	86.56	96.89	130.44	159.22	187.67
T_2	85.56	92.44	123.89	143.44	165.56
T_3	85.78	94.56	125.67	153.33	172.33
T_4	87.11	96.44	125.22	145.44	183.22
T_5	74.56	85.44	104.89	126.22	149.67
T_6	82.11	89.56	107.67	123.33	148.78
T_7	71.67	81.67	102.44	128.00	150.44
T_8	91.67	99.11	138.33	175.33	212.78
T_9	87.89	97.78	128.44	153.78	186.22
T_{10}	98.67	108.33	143.00	171.00	194.33
T_{11}	91.56	106.33	131.78	165.22	200.56
T_{12}	84.67	89.76	123.89	140.33	155.44
T_{13}	69.78	79.98	96.89	118.67	142.78
SEm(±)	**1.561**	**1.549**	**2.806**	**2.093**	**1.893**
CD(0.05)	**4.557**	**4.522**	**8.192**	**6.109**	**5.526**

*MAP= months after planting

Table 4.2.2 : Effect of organic nutrient management on percentage promotion of cladode length over initial (2018-19)

Treatments	Percentage Promotion of Cladode Length over Initial (%)				
	2018-19				
	3MAP	6MAP	9MAP	12 MAP	15MAP
T_1	0	11.93	50.69	83.94	116.81
T_2	0	8.04	44.80	67.65	93.50
T_3	0	10.24	46.50	78.75	100.90
T_4	0	10.71	43.75	66.96	110.33
T_5	0	14.59	40.68	69.29	100.74
T_6	0	9.07	31.13	50.20	81.20
T_7	0	13.95	42.93	78.60	109.91
T_8	0	8.12	50.90	91.26	132.12
T_9	0	11.25	46.14	74.97	111.88
T_{10}	0	9.79	44.93	73.30	96.95
T_{11}	0	16.13	43.93	80.45	119.05
T_{12}	0	6.01	46.32	65.74	83.58
T_{13}	0	14.62	38.85	70.06	104.61
SEm(±)	-	**0.534**	**1.904**	**2.780**	**3.315**
CD(0.05)	-	**1.558**	**5.557**	**8.113**	**9.675**

*MAP= months after planting

Table 4.2.3 : Effect of organic nutrient management on cladode length of dragon fruit plants (2019-20)

Treatments	**Cladode Length (cm)**				
	2019-20				
	18MAP	**21MAP**	**24MAP**	**27MAP**	**30 MAP**
T_1	201.00	225.56	236.67	261.56	277.89
T_2	187.67	208.00	223.22	241.00	260.78
T_3	193.89	210.67	230.00	250.33	268.89
T_4	196.33	211.00	228.78	251.89	272.78
T_5	175.33	185.56	194.33	218.44	232.78
T_6	177.78	189.11	201.22	222.78	235.11
T_7	180.33	191.67	203.67	228.67	237.89
T_8	211.11	247.44	255.22	277.67	297.44
T_9	198.89	214.00	231.67	255.67	276.56
T_{10}	205.44	227.78	240.00	258.11	285.78
T_{11}	209.67	248.56	254.56	272.89	292.56
T_{12}	182.44	203.78	212.67	232.33	243.11
T_{13}	165.33	179.11	189.33	211.11	214.11
SEm(±)	**2.686**	**1.291**	**1.168**	**1.635**	**0.883**
CD(0.05)	**7.841**	**3.767**	**3.409**	**4.772**	**2.578**

*MAP= months after planting

Table 4.2.4: Effect of organic nutrient management on percentage promotion of cladode length over initial (2019-20)

Treatments	Percentage Promotion of Cladode Length over Initial (%)				
	2019-20				
	18MAP	**21MAP**	**24MAP**	**27MAP**	**30 MAP**
T_1	7.10	20.19	26.11	39.37	48.07
T_2	13.35	25.63	34.83	45.57	57.51
T_3	12.51	22.25	33.46	45.26	56.03
T_4	7.16	15.16	24.87	37.48	48.88
T_5	17.14	23.98	29.84	45.95	55.53
T_6	19.49	27.11	35.25	49.74	58.03
T_7	19.87	27.41	35.38	52.00	58.13
T_8	2.50	16.29	19.95	30.50	39.79
T_9	6.80	14.92	24.41	37.29	48.51
T_{10}	5.72	17.21	23.50	32.82	47.06
T_{11}	4.54	23.93	26.92	36.06	45.87
T_{12}	17.37	31.10	36.82	49.47	56.40
T_{13}	15.79	25.44	32.60	47.86	49.96
SEm(±)	**1.013**	**1.425**	**1.320**	**1.002**	**1.551**
CD(0.05)	**2.114**	**4.159**	**3.854**	**2.924**	**4.528**

*MAP= months after planting

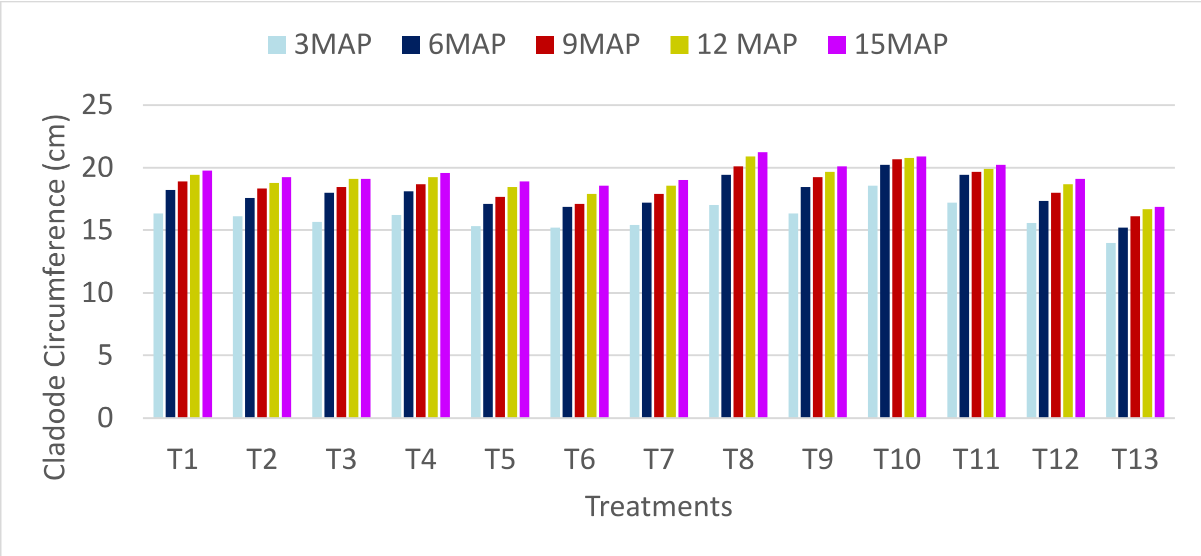


Fig. 4.2.3 Effect of organic nutrient management treatments on cladode circumference (2018-19)

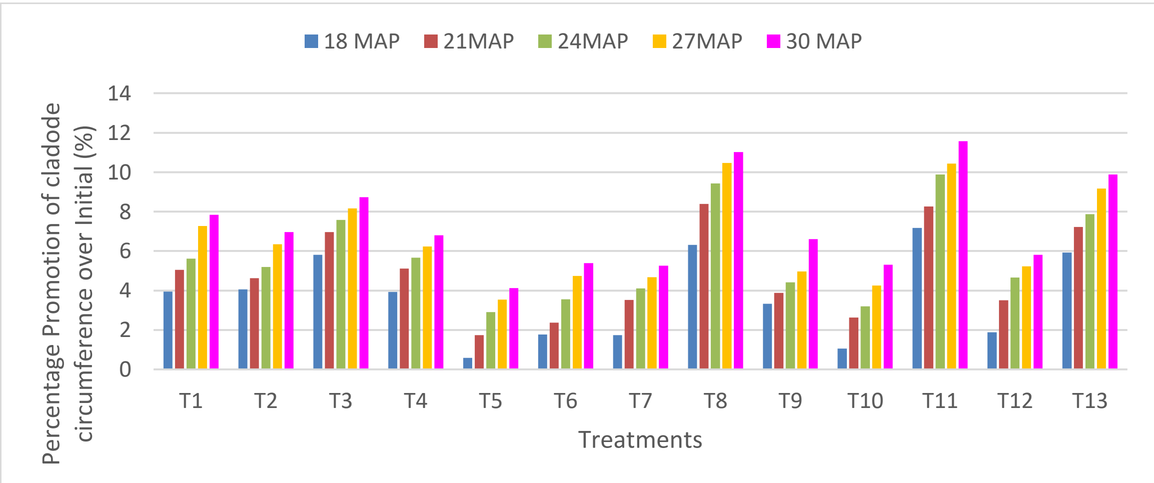


Fig. 4.2.4 Effect of organic nutrient management treatments on percentage promotion of cladode circumference over initial (2019-20)

4.2.1.2. Cladode circumference (cm)

Perusal of the data presented at Table 4.2.5 and Fig. 4.2.3 it is manifested that circumference of the cladode of dragon fruit plants was recorded highest at T_{10} (NC +AZ+PSB+ KSB) at 3MAP (18.56 cm), 6 MAP (20.22 cm) and 9MAP (20.67 cm) whereas, it was lowest under control (14.00 cm at 3MAP, 15.22 cm at 6MAP and 16.11 cm at 9MAP, respectively.). At 12 MAP, cladode circumference was recorded maximum (20.89 cm) at T_8 whereas, it was recorded lowest (16.67 cm) at control (T_{13}). Likewise, after 15 months of planting, highest cladode circumference (21.22 cm) was recorded in T_8 followed by T_{10} (20.89 cm) compared with control (16.89 cm). Percentage promotion of cladode circumference was recorded maximum (24.82%) at T_8 followed by T_5 and T_6, which were statistically at par (23.22%) compared with T_{10} where it was lowest (12.55%) at 15 MAP (Table 4.2.6).

In second year trial (2019-20), cladode circumference was consistently high in T_8 (FYM +AZ+PSB+ KSB) and recorded maximum at 18 MAP (22.56 cm), 21 MAP (23.00 cm), 24 MAP (23.22 cm), 27 MAP (23.44 cm) and finally at 30 MAP (23.56 cm), (Table 4.2.7); whereas, it was remained lowest in control (17.89 cm at 18 MAP, 18.11 cm at 21 MAP, 18.22 cm at 24 MAP, 18.44 cm at 27 MAP and 18.56 cm at 30 MAP). Percentage promotion analysis of cladode circumference revealed that it was found highest (11.57%) in T_{11} followed by T_8 (11.03%), whereas it was recorded lowest (4.13%) under T_5 at 30 MAP (Table 4.2.8; Fig. 4.2.4).

4.2.1.3 Number of Cladode per plant (No.)

It is evident from Table 4.2.9 that, number of cladodes per plant was not significantly varied among the treatments at 3 MAP. After 6 months of planting, it was found that plants at T_{10} (NC +AZ+PSB+ KSB) had highest number of cladodes (3.00) compared with control (1.67). At 9 MAP, maximum number of cladodes per plant (6.67) was recorded in T_{11} (PM +AZ+PSB+ KSB), whereas, it was minimum at control (2.22). At 12 and 15 MAP, number of cladodes per plants was found highest (8.22 and 8.56) in T_8 (FYM +AZ+PSB+ KSB) compared with control (2.56 at 12 MAP and 2.67 at 15 MAP).

Data presented at Table 4.2.10 and Fig. 4.2.5 manifested that plants under T_8 had maximum number of cladodes per plants at 18 MAP (9.22) and 21 MAP (9.56) compared with control (4.11 at 18 MAP and 5.22 at 21 MAP). At 24 MAP, number of cladodes per plant was maximum (16.67) at T_{11}, whereas, it was minimum (7.00)

Table 4.2.5 : Effect of organic nutrient management on cladode circumference of dragon fruit plants (2018-19)

Treatments	**Cladode Circumference (cm)**				
	2018-19				
	3MAP	**6MAP**	**9MAP**	**12 MAP**	**15MAP**
T_1	16.33	18.22	18.89	19.44	19.78
T_2	16.11	17.56	18.33	18.78	19.22
T_3	15.67	18.00	18.44	19.11	19.11
T_4	16.22	18.11	18.67	19.22	19.56
T_5	15.33	17.11	17.67	18.44	18.89
T_6	15.22	16.89	17.11	17.89	18.56
T_7	15.42	17.22	17.89	18.56	19.00
T_8	17.00	19.44	20.11	20.89	21.22
T_9	16.33	18.44	19.22	19.67	20.11
T_{10}	18.56	20.22	20.67	20.78	20.89
T_{11}	17.22	19.44	19.67	19.89	20.22
T_{12}	15.57	17.33	18.00	18.67	19.11
T_{13}	14.00	15.22	16.11	16.67	16.89
SEm(±)	**0.116**	**0.137**	**0.249**	**0.195**	**0.305**
CD(0.05)	**0.340**	**0.400**	**0.726**	**0.569**	**0.890**

*MAP= months after planting

Table 4.2.6 : Effect of organic nutrient management on percentage promotion of cladode circumference over initial (2018-19)

Treatments	Percentage Promotion of Cladode Circumference over Initial (%)				
	2018-19				
	3MAP	6MAP	9MAP	12 MAP	15MAP
T_1	0.00	11.57	15.68	19.04	21.13
T_2	0.00	9.00	13.78	16.57	19.30
T_3	0.00	14.87	17.68	21.95	21.95
T_4	0.00	11.65	15.10	18.50	20.59
T_5	0.00	11.61	15.26	20.29	23.22
T_6	0.00	10.97	12.42	17.54	21.94
T_7	0.00	11.67	16.02	20.36	23.22
T_8	0.00	14.35	18.29	22.88	24.82
T_9	0.00	12.92	17.70	20.45	23.15
T_{10}	0.00	8.94	11.37	11.96	12.55
T_{11}	0.00	12.89	14.23	15.51	17.42
T_{12}	0.00	11.30	15.61	19.91	22.74
T_{13}	0.00	8.71	15.07	19.07	20.64
SEm(±)	-	**1.040**	**0.698**	**0.485**	**0.767**
CD(0.05)	-	**3.036**	**2.039**	**1.415**	**2.238**

*MAP= months after planting

Table 4.2.7 : Effect of organic nutrient management on cladode circumference of dragon fruit plants (2019-20)

Treatments	Cladode Circumference (cm)				
	2019-20				
	18MAP	21MAP	24MAP	27MAP	30 MAP
T_1	20.56	20.78	20.89	21.22	21.33
T_2	20.00	20.11	20.22	20.44	20.56
T_3	20.22	20.44	20.56	20.67	20.78
T_4	20.33	20.56	20.67	20.78	20.89
T_5	19.00	19.22	19.44	19.56	19.67
T_6	18.89	19.00	19.22	19.44	19.56
T_7	19.33	19.67	19.78	19.89	20.00
T_8	22.56	23.00	23.22	23.44	23.56
T_9	20.78	20.89	21.00	21.11	21.44
T_{10}	21.11	21.44	21.56	21.78	22.00
T_{11}	21.67	21.89	22.22	22.33	22.56
T_{12}	19.47	19.78	20.00	20.11	20.22
T_{13}	17.89	18.11	18.22	18.44	18.56
SEm(±)	**0.311**	**0.288**	**0.199**	**0.304**	**0.295**
CD(0.05)	**0.909**	**0.840**	**0.582**	**0.888**	**0.861**

*MAP= months after planting

Table 4.2.8: Effect of organic nutrient management on percentage promotion of cladode circumference over initial (2019-20)

Treatments	Percentage Promotion of cladode circumference over Initial (%)				
	2019-20				
	18MAP	21MAP	24MAP	27MAP	30 MAP
T_1	3.94	5.06	5.61	7.28	7.84
T_2	4.06	4.63	5.20	6.35	6.97
T_3	5.81	6.96	7.59	8.16	8.74
T_4	3.94	5.11	5.67	6.24	6.80
T_5	0.58	1.75	2.91	3.55	4.13
T_6	1.78	2.37	3.56	4.74	5.39
T_7	1.74	3.53	4.11	4.68	5.26
T_8	6.31	8.39	9.43	10.46	11.03
T_9	3.33	3.88	4.43	4.97	6.61
T_{10}	1.05	2.63	3.21	4.26	5.31
T_{11}	7.17	8.26	9.89	10.44	11.57
T_{12}	1.88	3.51	4.66	5.23	5.81
T_{13}	5.92	7.22	7.87	9.18	9.89
SEm(±)	**0.134**	**0.109**	**0.186**	**0.239**	**0.250**
CD(0.05)	**0.412**	**0.320**	**0.543**	**0.697**	**0.729**

*MAP= months after planting

Table 4.2.9 : Effect of organic nutrient management on number of cladode per dragon fruit plants (2018-19)

Treatments	Number of Cladode per Plant (No.) 2018-19				
	3MAP	**6MAP**	**9MAP**	**12 MAP**	**15MAP**
T_1	1.11	2.56	5.00	6.22	6.78
T_2	1.00	2.33	4.00	4.56	5.89
T_3	1.00	2.44	4.56	5.22	6.00
T_4	1.00	2.44	4.89	5.56	6.11
T_5	1.00	1.89	3.11	3.78	4.11
T_6	1.00	1.78	2.78	3.22	3.78
T_7	1.00	2.11	3.33	4.33	4.44
T_8	1.11	2.67	6.56	8.22	8.56
T_9	1.11	2.67	5.22	6.67	7.11
T_{10}	1.22	3.00	5.78	7.22	7.78
T_{11}	1.11	2.78	6.67	7.78	8.11
T_{12}	1.00	2.22	3.89	4.44	4.56
T_{13}	1.00	1.67	2.22	2.56	2.67
SEm(±)	**0.225#**	**0.253**	**0.285**	**0.238**	**0.255**
CD(0.05)	**0.657#**	**0.737**	**0.830**	**0.694**	**0.746**

*MAP= months after planting, #= data are not significant

Table 4.2.10 : Effect of organic nutrient management on number of cladode per dragon fruit plants (2019-20)

Treatments	Number of Cladode per Plant (No.)				
	2019-20				
	18MAP	21MAP	24MAP	27MAP	30 MAP
T_1	7.11	8.44	15.89	20.33	22.56
T_2	6.78	7.56	15.11	19.44	21.89
T_3	6.89	7.89	15.67	19.67	22.22
T_4	7.00	8.22	15.56	19.78	22.11
T_5	5.22	7.33	14.11	17.33	18.78
T_6	5.67	7.22	13.89	16.89	19.11
T_7	5.89	7.33	14.33	19.11	20.56
T_8	9.22	9.56	16.33	21.78	24.44
T_9	7.33	8.56	16.11	19.89	22.44
T_{10}	7.89	8.67	16.22	20.56	22.78
T_{11}	8.56	8.89	16.67	21.33	24.33
T_{12}	6.56	7.44	14.67	18.89	20.67
T_{13}	4.11	5.22	7.00	8.11	9.22
SEm(±)	**0.191**	**0.209**	**0.478**	**0.485**	**0.436**
CD(0.05)	**0.557**	**0.610**	**1.396**	**1.415**	**1.272**

*MAP= months after planting

at T_{13}. At 30 months after planting, number of cladodes per plant was recorded maximum at T_8 (24.44) followed by T_{11} (24.33) and T_{10} (22.78) compared with control (9.22).

4.2.2 Fruit growth and development

4.2.2.1. Number of flower per pillar

Data presented in Table 4.2.11 clearly showed that there was significant variation in number of flowers due to various treatments. Maximum number of flower per pillar (15.33 and 20.00) was observed in FYM +AZ+PSB+ KSB (T_8) in both year of the experimental study which was followed by NC +AZ+PSB+ KSB (T_{10}) (12.00) in 2018-2019 and PM +AZ+PSB+ KSB (T_{11}) (17.67) in 2019-2020. However, pooled analysis data showed that the highest number of flower per pillar was observed in FYM +AZ+PSB+ KSB (T_8) (17.67) followed by NC +AZ+PSB+ KSB (T_{10}) (14.50). The minimum number of flower per pillar (4.67, 6.00 and 5.34) was observed in control (T_{13}) in both the experimental years and in pooled analysis.

4.2.2.2. Number of fruits per pillar

Number of fruits per pillar was presented in Table 4.2.11 clearly showed that there was significant variation in number of fruits per pillar due to various treatment. Maximum number of fruit per pillar (14.33 and 18.67) was recorded in treatment FYM +AZ+PSB+ KSB (T_8) and the second highest was found in NC +AZ+PSB+ KSB (T_{10}) (10.33 and 15.33) in both the years of experimental study. The minimum (2.00 and 3.00) number of fruit per pillar was obtained in plant under control (T_{13}).

The pooled analysis showed highest number of fruit per pillar (16.50) in plants manured with FYM +AZ+PSB+ KSB (T_8) which was at par with treatment T_{10} (12.83). The lowest recorded number of fruits per pillar was in control treatment T_{13} (2.50).

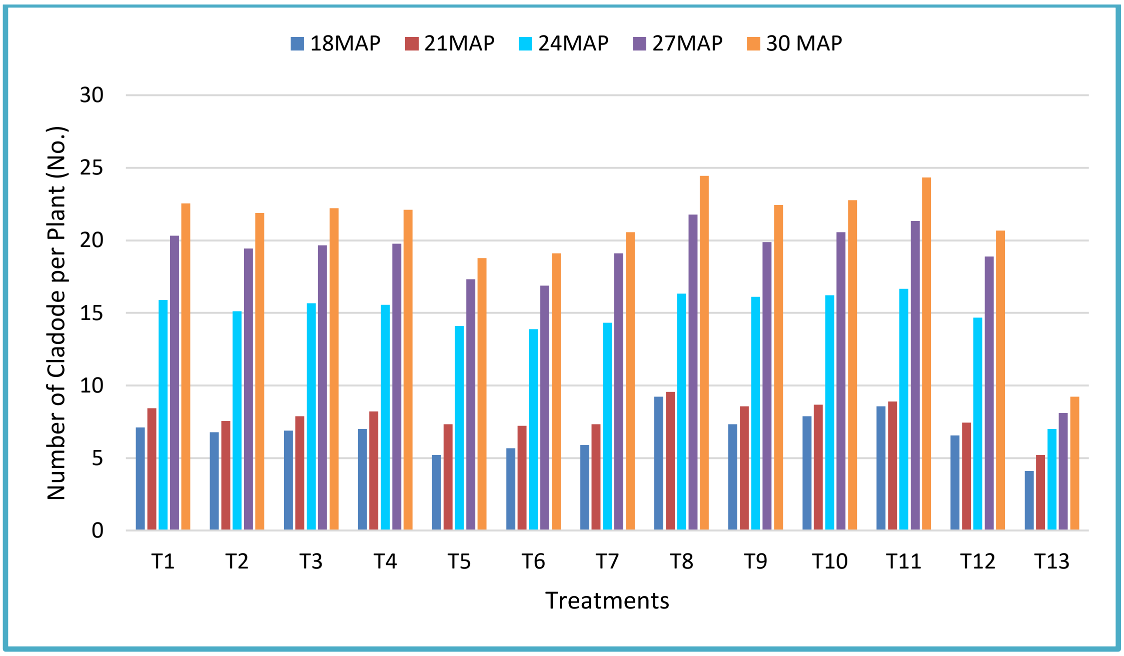


Fig. 4.2.5 Effect of organic nutrient management treatments on number of cladode per plant (2019-20)

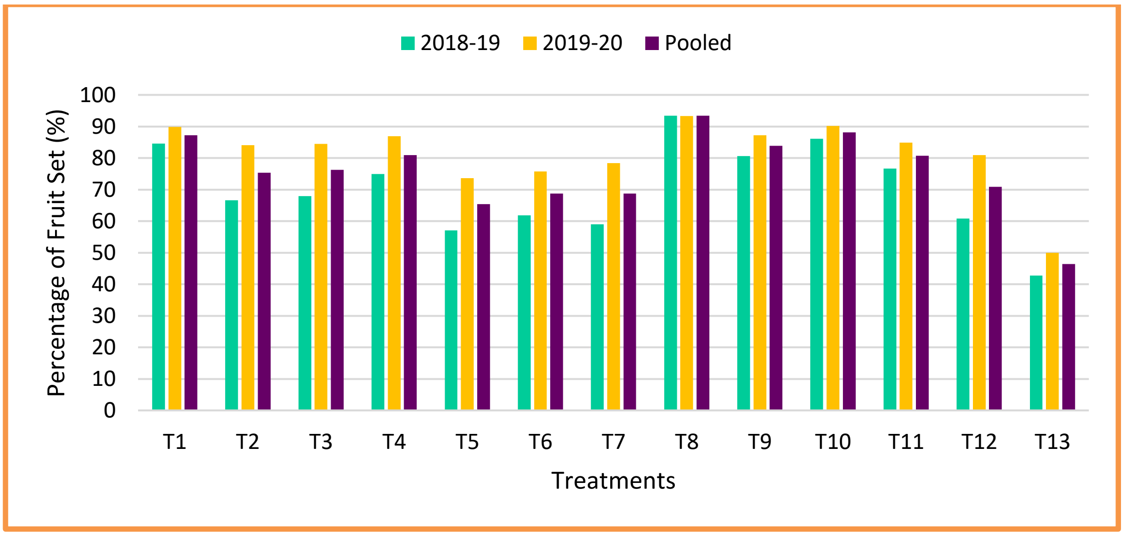


Fig. 4.2.6 Effect of organic nutrient management treatments on fruit set percentage of dragon fruits

4.2.2.3. Fruit set (%)

From the data demonstrated at Table 4.2.12 and Fig. 4.2.6 showed that fruit set percentage significantly varied under different treatment which range between 42.83% to 93.49% in 2018-2019 and 50.00% to 93.35 % in 2019-2020. Plant treated with FYM +AZ+PSB+ KSB (T_8) recorded highest fruit set percentage i.e. (93.48% and 93.35 %) which was followed by NC +AZ+PSB+ KSB (T_{10}) (86.08% and 90.18%) while, control recorded the lowest (42.83%, 50%) in two consecutive years.

The pooled data showed that maximum fruit set percentage (93.41%) was in case of the plants applied with FYM +AZ+PSB+ KSB (T_8) which was followed by the plants manured with NC +AZ+PSB+ KSB (T_{10}) (88.13%). However, plants at control recorded the lowest fruit set (46.41%).

4.2.2.4. Flower bud drop (%)

Data for flower bud drop percentage for different treatment are presented in Table 4.2.12 and Fig. 4.2.7. From the table it is evident that the lowest flower bud drop 6.52% and 6.65% was observed with FYM +AZ+PSB+ KSB (T_8) which was followed by (13.92% and 9.82%) under NC +AZ+PSB+ KSB (T_{10}) in both years of study. However, the highest (57.17% and 50.00%) was recorded under control (T_{13}) for two consecutive years.

The pooled data showed that the lowest flower bud drop percentage (6.59%) was observed in FYM +AZ+PSB+ KSB (T_8) and the highest (53.59%) was recorded in (T_{13}) control.

Table 4.2.11 : Effect of organic nutrient management on number of flower and fruits per pillar in dragon fruit plants

Treatments	Number of Flower per Pillar (No.)			Number of Fruits per Pillar (No.)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	8.66	16.33	12.50	7.33	14.67	11.00
T_2	8.00	14.67	11.34	5.33	12.33	8.83
T_3	8.34	15.00	11.67	5.67	12.67	9.17
T_4	8.00	15.33	11.67	6.00	13.33	9.67
T_5	7.00	12.67	9.84	4.00	9.33	6.67
T_6	7.00	11.00	9.00	4.33	8.33	6.33
T_7	7.33	12.33	9.83	4.33	9.67	7.00
T_8	15.33	20.00	17.67	14.33	18.67	16.50
T_9	10.33	15.67	13.00	8.33	13.67	11.00
T_{10}	12.00	17.00	14.50	10.33	15.33	12.83
T_{11}	10.00	17.67	13.84	7.67	15.00	11.34
T_{12}	7.67	14.00	10.84	4.67	11.33	8.00
T_{13}	4.67	6.00	5.34	2.00	3.00	2.50
SEm(±)	**0.703**	**1.224**	**0.764**	**0.613**	**0.560**	**0.333**
CD(0.05)	**2.053**	**3.573**	**2.230**	**1.790**	**1.635**	**0.973**

Table 4.2.12 : Effect of organic nutrient management on percentage of fruit set and flower bud drop in dragon fruit plants

Treatments	Percentage of Fruit Set (%)			Percentage of Flower Bud Drop (%)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	84.64	89.83	87.24	15.36	10.17	12.76
T_2	66.63	84.05	75.34	33.38	15.95	24.66
T_3	67.99	84.47	76.23	32.01	15.53	23.77
T_4	75.00	86.95	80.98	25.00	13.05	19.02
T_5	57.14	73.64	65.39	42.86	26.36	34.61
T_6	61.86	75.73	68.79	38.14	24.27	31.21
T_7	59.07	78.43	68.75	40.93	21.57	31.25
T_8	93.48	93.35	93.41	6.52	6.65	6.59
T_9	80.64	87.24	83.94	19.36	12.76	16.06
T_{10}	86.08	90.18	88.13	13.92	9.82	11.87
T_{11}	76.70	84.89	80.79	23.30	15.11	19.21
T_{12}	60.89	80.93	70.91	39.11	19.07	29.09
T_{13}	42.83	50.00	46.41	57.17	50.00	53.59
SEm(±)	**8.039**	**7.190**	**6.074**	**7.140**	**5.608**	**5.211**
CD(0.05)	**23.467**	**20.988**	**17.730**	**20.841**	**16.370**	**15.211**

Table 4.2.13 : Effect of organic nutrient management on yield and days from fruit set to maturity in dragon fruit plants

Treatments	Yield per Pillar (Kg)			Yield per Hectare (Tons/Hectare)			Days from Fruit Set to Maturity (Days)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	2.12	5.41	3.76	2.65	6.76	4.70	34.33	42.17	38.25
T_2	1.49	3.83	2.66	1.86	4.79	3.32	34.50	39.33	36.92
T_3	1.59	4.33	2.96	1.99	5.41	3.70	34.17	39.17	36.67
T_4	1.71	4.19	2.95	2.14	5.24	3.69	33.67	38.83	36.25
T_5	0.83	2.51	1.67	1.04	3.14	2.09	32.83	38.17	35.50
T_6	1.02	2.41	1.72	1.28	3.01	2.15	33.17	37.50	35.34
T_7	1.18	2.97	2.07	1.48	3.71	2.59	33.83	41.33	37.58
T_8	4.80	8.02	6.41	6.00	10.02	8.01	35.67	42.50	39.09
T_9	2.43	5.12	3.78	3.04	6.40	4.72	35.17	43.33	39.25
T_{10}	3.25	5.87	4.56	4.07	7.34	5.70	36.17	40.83	38.50
T_{11}	2.44	6.16	4.30	3.05	7.70	5.38	35.00	39.67	37.34
T_{12}	1.24	3.38	2.31	1.55	4.23	2.89	33.33	41.17	37.25
T_{13}	0.33	0.72	0.52	0.41	0.90	0.65	31.67	36.33	34.00
SEm(±)	**0.292**	**0.426**	**0.257**	**0.365**	**0.533**	**0.321**	**0.474**	**0.768**	**0.418**
CD(0.05)	**0.852**	**1.244**	**0.749**	**1.065**	**1.554**	**0.936**	**1.384**	**2.241**	**1.221**

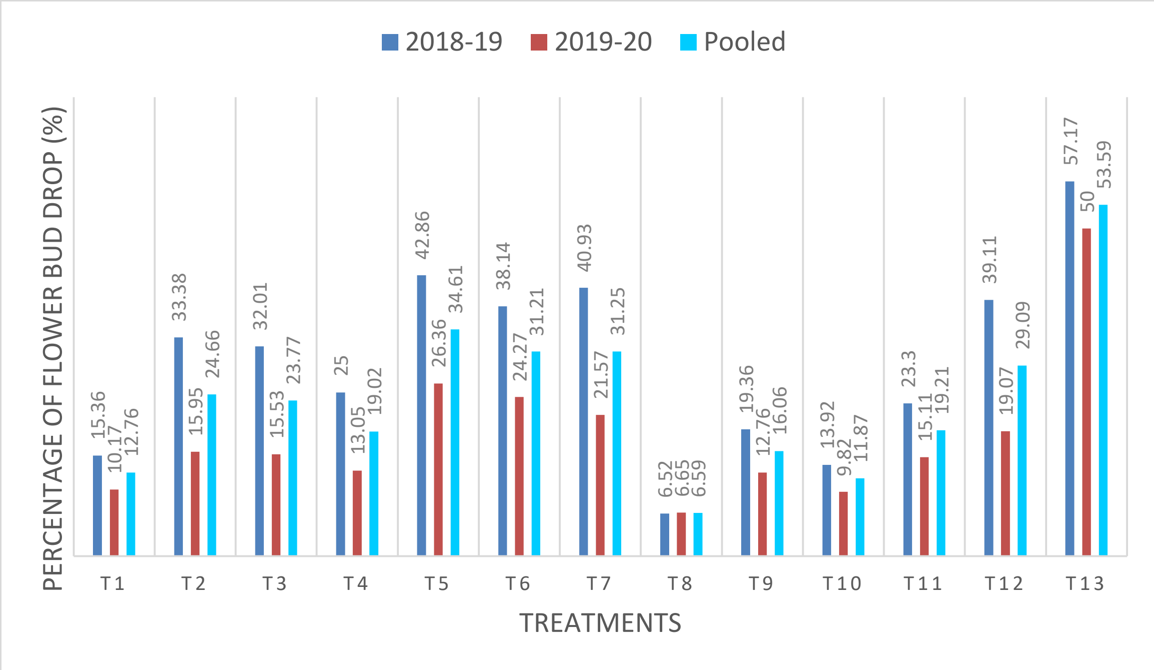


Fig. 4.2.7 Effect of organic nutrient management treatments on percentage of flower bud drop

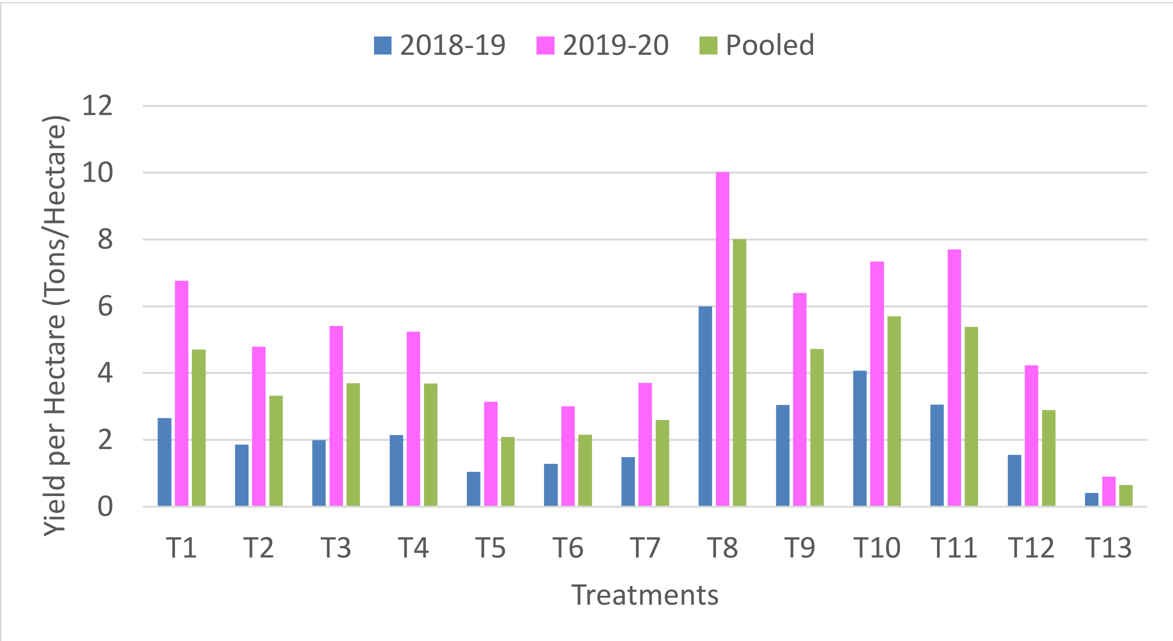


Fig. 4.2.8 Effect of organic nutrient management treatments on yield of dragon fruits

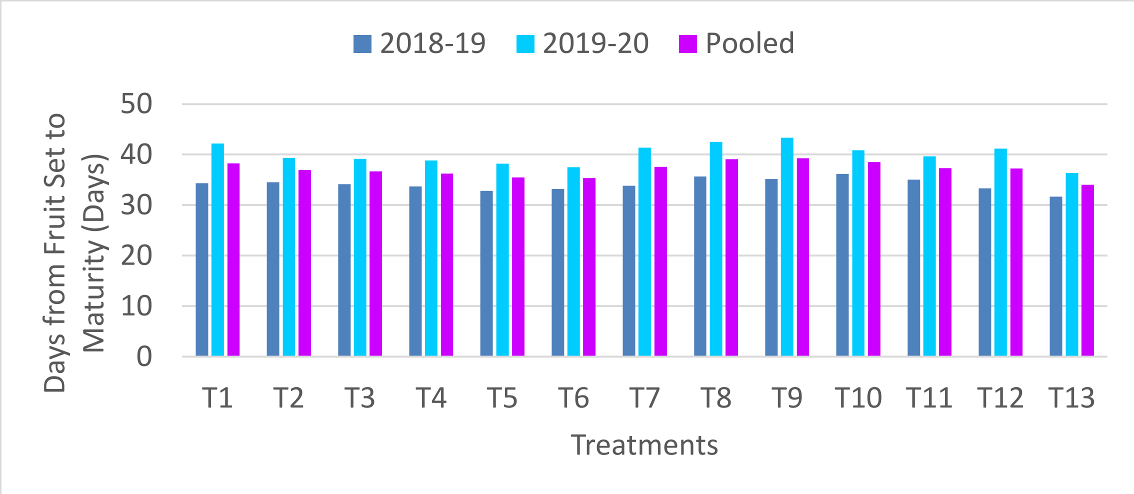


Fig. 4.2.9 Effect of organic nutrient management treatments on days from fruit set to maturity

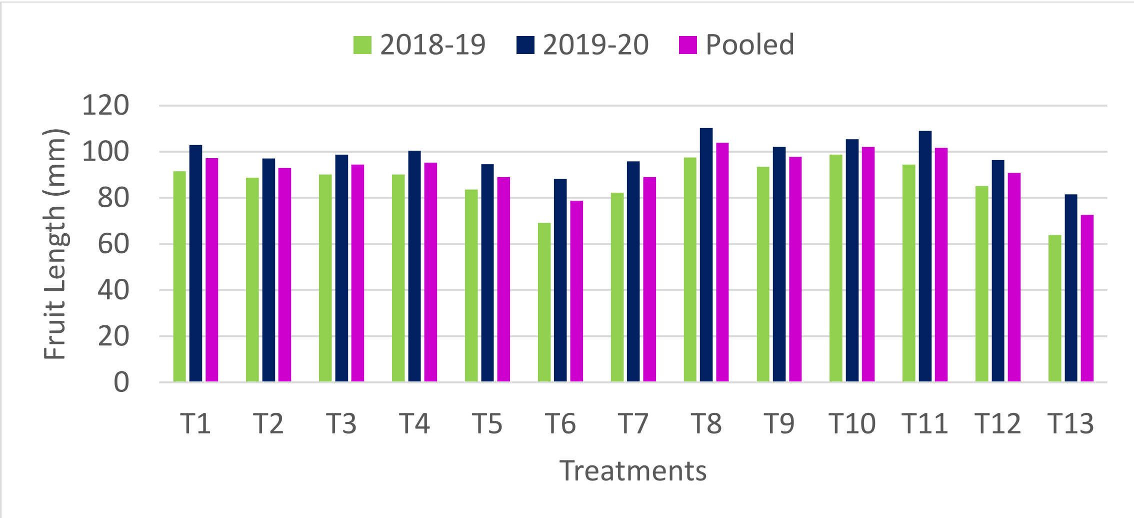


Fig. 4.2.10 Effect of organic nutrient management treatments on fruit length of dragon fruit

4.2.2.5. Days from fruit set to maturity

From table 4.2.13 and Fig. 4.2.9, it can be concluded that days required from fruit set to maturity varied significantly among the treatment. Maximum days (36.17 days) were observed in NC +AZ+PSB+ KSB (T_{10}) in 2018-2019 whereas longest days required (43.33 days) were recorded under treatment VC +AZ+PSB+ KSB (T_9) in 2019-2020, which was followed by FYM +AZ+PSB+ KSB (T_8) (35.67 and 42.50

days) in both years of experimental study. The shortest days required from fruit set to maturity was observed under control (T_{13}) (31.67 and 36.33 days) in both the years.

The pooled data showed that maximum day required from fruit set to maturity was recorded in VC +AZ+PSB+ KSB (T_9) (39.25 days) which was followed by NC +AZ+PSB+ KSB (T_{10}) (38.50 days). The shortest 34.00 days was observed under control treatment (T_{13}).

4.2.2.6. Yield

It is clear from the Table 4.2.13 and Fig. 4.2.8 that significant difference was obtained among the treatment with respect to yield. Yield varied from 0.33 kg per pillar or 0.41 t per ha to 4.80 kg per pillar or 6.00 t per ha in 2018-2019, whereas, it varied from 0.72 kg per pillar or 0.90 t per ha to 8.02kg per pillar or 10.02t per ha during 2019-2020. Highest yield was recorded with FYM +AZ+PSB+ KSB (T_8) (4.80 kg per pillar or 6.00 t per ha, in 2018-19 and 8.02 kg per pillar or 10.02 t per ha, in 2019-20,which was followed by NC +AZ+PSB+ KSB (T_{10}) (3.25kg per pillar or 4.07t /ha) in the year 2018-2019 and in the year 2019-2020, second highest yield (6.16 kg per pillar or 7.70 t/ha) was observed in T_{11}(PM +AZ+PSB+ KSB). However, the lowest yield was observed in control (T_{13}) (0.33 kg per pillar or 0.41t /ha and 0.72kg per pillar or 0.90t per ha) in both years of the experimental study.

From the pooled analysis it was concluded that FYM +AZ+PSB+ KSB (T_8) was recorded with maximum yield (6.41 kg per pillar or 8.01 t per ha) followed by NCAZ+PSB+ KSB (T_{10}) (4.56 kg per pillar or 5.70 tons/ ha), the lowest yield was recorded with control (0.52 kg per pillar or 0.65tons/ha).

4.2.3. Fruit physical parameter

4.2.3.1 Fruit length (mm)

Data presented at Table 4.2.14 and Fig. 4.2.10 revealed that the dragon fruit length was significantly increased under various treatments. Maximum fruit length was recorded in NC +AZ+PSB+ KSB (T_{10}) (98.71mm) which was followed by FYM +AZ+PSB+ KSB (T_8)(97.39 mm) during 2018-2019. Whereas, FYM +AZ+PSB+

KSB (T_8) was recorded maximum fruit length (110.17mm) in the year 2019-2020 followed by PM +AZ+PSB+ KSB (T_{11}) (109.00mm). The minimum fruit length was observed in control (T_{13}) (63.85mm and 81.50mm) in both the years.

The pooled data for two consecutive years had shown that maximum fruit length were recorded in FYM +AZ+PSB+ KSB (T_8) (103.78 mm) followed by NC +AZ+PSB+ KSB (T_{10}) (102.02mm) compared with control (72.68 mm).

4.2.3.2. Fruit Diameter (mm)

The data presented in Table 4.2.14 and Fig. 4.2.11 clearly showed that the highest fruit diameters (80.79 mm and 86.33mm) were observed in FYM +AZ+PSB+ KSB (T_8) for two consecutive years followed by NC +AZ+PSB+ KSB (T_{10}) having diameter of (79.5mm) during 2018-2019 and in 2019-2020 it was observed in PM +AZ+PSB+ KSB (T_{11}) (85.33mm). The minimum fruit diameter was found in control (T_{13}) (60.38mm and 67.17mm) in both the years of experimental study.

However, the pooled data for both the year shown that the highest fruit diameter was recorded in FYM +AZ+PSB+ KSB (T_8) (83.56mm) which was followed by PM +AZ+PSB+ KSB (T_{11}) (81.79mm), while the lowest (63.78mm) was recorded in control (T_{13}).

4.2.3.3. Fruit weight (g)

It is obvious from the data shown in Table 4.2.15 and Fig. 4.2.12 that the fruit weight was significantly influenced by the application of various treatment. The highest fruit weight (335.00g and 429.33g) was observed in FYM +AZ+PSB+ KSB (T_8) which was followed by PM +AZ+PSB+ KSB (T_{11}) (318.33g and 410.67g) while the least (163.33g and 239.83g) was in control (T_{13}) for two consecutive years.

The pooled data for both the years showed that the highest fruit weight (382.17g) was observed in FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11}) (364.50g) while the lowest (201.58g) was recorded in control (T_{13}).

Table 4.2.14 : Effect of organic nutrient management on fruit length and diameter of dragon fruits

Treatments	Fruit Length (mm)			Fruit Diameter (mm)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	91.42	102.83	97.13	73.38	82.00	77.69
T_2	88.76	97.00	92.88	69.58	79.00	74.29
T_3	90.06	98.67	94.37	71.46	80.17	75.82
T_4	90.16	100.33	95.25	72.20	79.67	75.94
T_5	83.51	94.50	89.01	63.02	70.17	66.60
T_6	69.17	88.17	78.67	65.32	75.33	70.33
T_7	82.14	95.83	88.99	66.05	74.67	70.36
T_8	97.39	110.17	103.78	80.79	86.33	83.56
T_9	93.48	102.00	97.74	76.38	81.17	78.78
T_{10}	98.71	105.33	102.02	79.50	82.33	80.92
T_{11}	94.36	109.00	101.68	78.25	85.33	81.79
T_{12}	85.13	96.33	90.73	66.22	78.67	72.45
T_{13}	63.85	81.50	72.68	60.38	67.17	63.78
SEm(±)	**0.459**	**0.895**	**0.539**	**0.625**	**0.661**	**0.500**
CD(0.05)	**1.340**	**2.614**	**1.574**	**1.825**	**1.930**	**1.460**

Table 4.2.15 : Effect of organic nutrient management on fruit weight and volume of dragon fruits

Treatments	Fruit Weight (g)			Fruit Volume (cc)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	289.33	368.50	328.92	279.67	353.00	316.34
T_2	278.67	310.50	294.59	261.67	300.17	280.92
T_3	280.67	341.67	311.17	272.33	332.00	302.17
T_4	285.83	314.50	300.17	276.00	303.33	289.67
T_5	208.00	268.83	238.42	195.33	252.00	223.67
T_6	236.67	289.50	263.09	227.67	280.00	253.84
T_7	272.83	306.83	289.83	254.00	289.00	271.50
T_8	335.00	429.33	382.17	305.33	408.00	356.67
T_9	292.00	374.67	333.34	281.67	365.33	323.50
T_{10}	315.00	382.83	348.92	291.67	380.83	336.25
T_{11}	318.33	410.67	364.50	302.67	406.17	354.42
T_{12}	264.67	298.67	281.67	256.33	293.83	275.08
T_{13}	163.33	239.83	201.58	152.67	229.33	191.00
SEm(±)	**7.354**	**6.798**	**4.487**	**7.096**	**3.880**	**3.940**
CD(0.05)	**21.466**	**19.842**	**13.097**	**20.713**	**11.324**	**11.500**

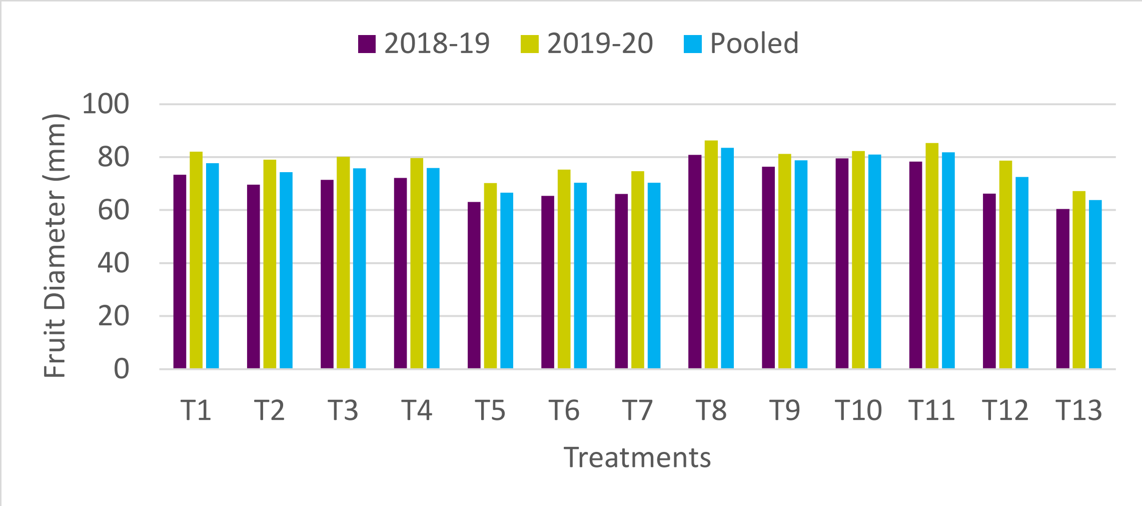


Fig. 4.2.11 Effect of organic nutrient management treatments on fruit diameter of dragon fruit

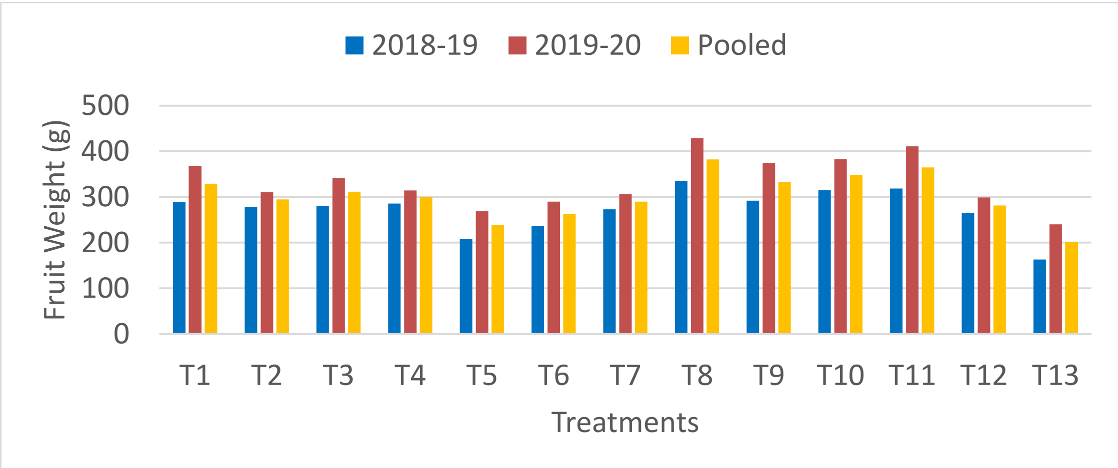


Fig. 4.2.12 Effect of organic nutrient management treatments on fruit weight of dragon fruit

4.2.3.4. Fruit volume (cc)

From the data shown in Table 4.2.15 and Fig. 4.2.13 the fruit volume showed a significant variation among various treatments. The highest fruit volume (305.33cc and 408.00 cc) was recorded in FYM +AZ+PSB+ KSB (T_8) which was followed by PM +AZ+PSB+ KSB (T_{11}) (302.67cc and 406.17 cc) while the lowest fruit volume (152.67cc and 229.33cc) was in control (T_{13}) for two consecutive years.

The pooled data showed that the highest was in FYM +AZ+PSB+ KSB (T_8) (356.67cc) followed by PM +AZ+PSB+ KSB (T_{11}) (354.42cc). However, the lowest value (191.00cc) was recorded in treatment control (T_{13}).

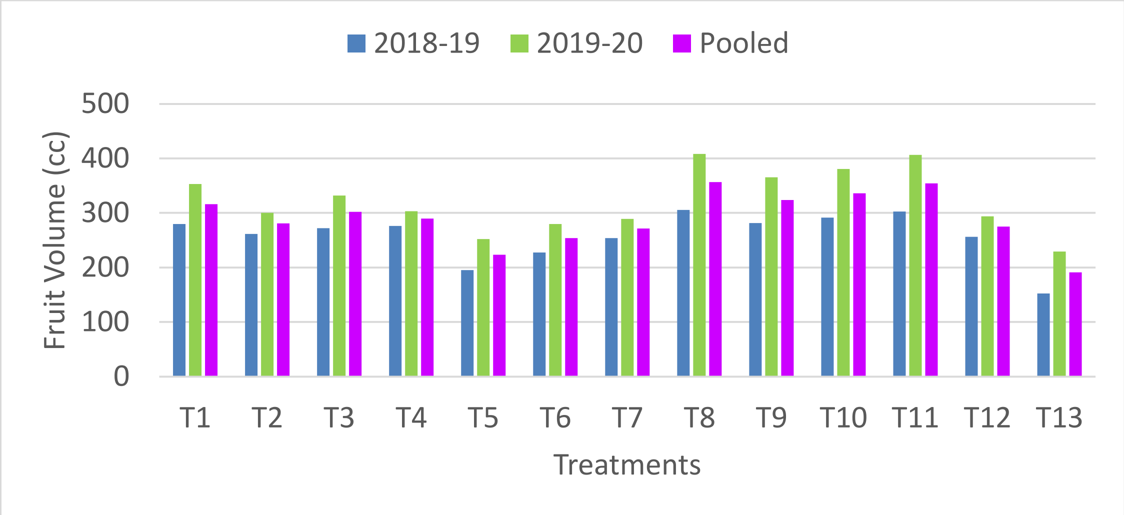


Fig. 4.2.13 Effect of organic nutrient management treatments on fruit volume of dragon fruit

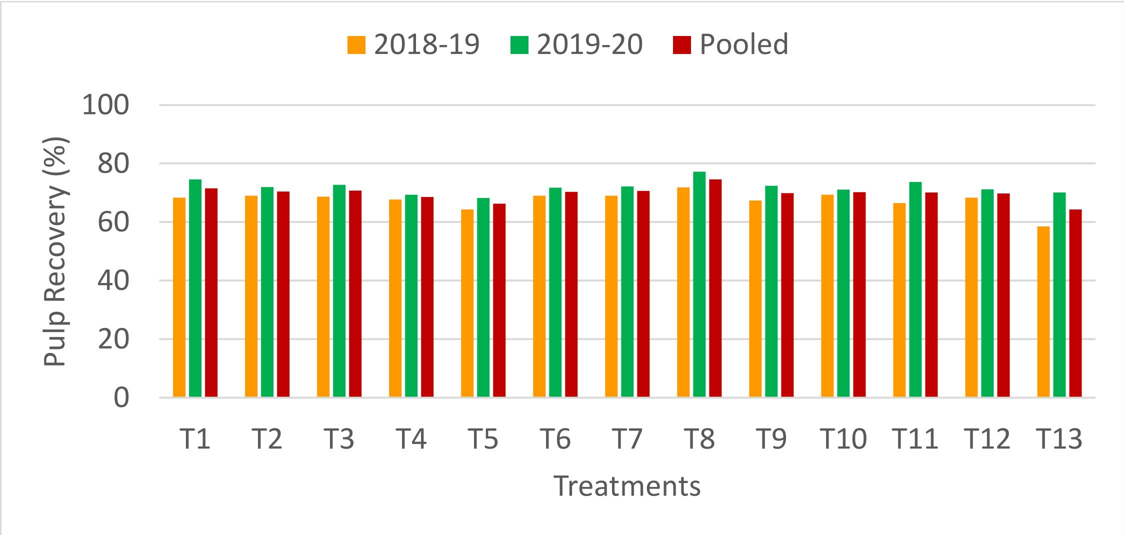


Fig. 4.2.14 Effect of organic nutrient management treatments on pulp recovery percentage of dragon fruit

4.2.3.5. Pulp weight (g)

Data of pulp weight presented on Table 4.2.16 showed that significant influence was observed in pulp weight among different treatments. During the first year of study (2018-2019), the highest pulp weight (240.83g) was observed in FYM +AZ+PSB+ KSB (T_8) followed by NC +AZ+PSB+ KSB (T_{10}) (218.50g) and in the second year (2019-2020), the highest pulp weight of dragon fruit (331.66g) was recorded in FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11}) (302.67g). However, the minimum pulp weight (95.50g and 168.16g) was recorded in control (T_{13}) for both years of study. From the pooled data it was revealed that the highest pulp weight was recorded in FYM +AZ+PSB+ KSB (T_8) (286.25g) followed by (T_{11}) (257.17g) and lowest pulp weight (131.83g) was recorded in control (T_{13}).

4.2.3.6. Pulp recovery (%)

Data presented in Table 4.2.16 and Fig. 4.2.14 showed that pulp recovery per cent of fruit varied significantly with different treatment. It was observed that the highest pulp recovery percentage (71.89% and 77.25%) was recorded under FYM +AZ+PSB+ KSB (T_8) in both years during study. Whereas, the second highest pulp recovery (69.37%) was recorded in NC +AZ+PSB+ KSB (T_{10}) in the year 2018-2019 while in 2019-2020 it was recorded in (T_1) Farm Yard Manure (FYM) (74.63%). However, the lowest pulp recovery percentage (58.47%) was recorded in control (T_{13}) in 2018-2019 but in the year 2019-2020 it was recorded lowest in Azotobacter (AZ) (T_5) (68.20%).

The pooled analysis data showed that the highest pulp recovery percent (74.57%) was observed in FYM +AZ+PSB+ KSB (T_8) followed by (T_1) Farm Yard Manure (FYM) (71.50%), while the lowest pulp recovery percent (64.29%) was recorded in control (T_{13}).

4.2.3.7. Peel weight

The data showed on Table 4.2.17 revealed that there was significant variation among treatment regarding the fruit peel weight. The highest peel weight (106.67g) were recorded in PM +AZ+PSB+ KSB (T_{11}) followed by NC +AZ+PSB+ KSB (T_{10})

Table 4.2.16 : Effect of organic nutrient management on pulp weight and pulp recovery percentage of dragon fruits

Treatments	Pulp Weight (g)			Pulp Recovery (%)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	197.83	275.00	236.42	68.38	74.63	71.50
T_2	192.34	223.33	207.84	69.02	71.93	70.47
T_3	192.84	248.50	220.67	68.71	72.73	70.72
T_4	193.66	218.17	205.92	67.75	69.37	68.56
T_5	133.83	183.33	158.58	64.34	68.20	66.27
T_6	163.34	207.67	185.51	69.02	71.73	70.37
T_7	188.26	221.50	204.88	69.00	72.19	70.60
T_8	240.83	331.66	286.25	71.89	77.25	74.57
T_9	196.67	271.17	233.92	67.35	72.38	69.86
T_{10}	218.50	272.00	245.25	69.37	71.05	70.21
T_{11}	211.66	302.67	257.17	66.49	73.70	70.10
T_{12}	181.00	212.67	196.84	68.39	71.21	69.80
T_{13}	95.50	168.16	131.83	58.47	70.12	64.29
SEm(±)	**7.770**	**6.694**	**4.411**	**1.242**	**0.558**	**0.568**
CD(0.05)	**22.681**	**19.539**	**12.874**	**3.625**	**1.630**	**1.657**

Table 4.2.17 : Effect of organic nutrient management on peel weight and peel thickness of dragon fruits

Treatments	Peel Weight (g)			Peel Thickness (mm)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	91.50	93.50	92.50	2.21	3.33	2.77
T_2	86.33	87.17	86.75	2.27	3.08	2.68
T_3	87.83	93.17	90.50	2.45	3.25	2.85
T_4	92.17	96.33	94.25	2.85	3.58	3.22
T_5	74.17	85.50	79.84	2.37	3.00	2.69
T_6	73.33	81.83	77.58	2.79	3.18	2.99
T_7	84.57	85.33	84.95	2.45	3.21	2.83
T_8	94.17	97.67	95.92	2.32	3.42	2.87
T_9	95.33	103.50	99.42	2.40	3.83	3.12
T_{10}	96.50	110.83	103.67	2.55	3.92	3.24
T_{11}	106.67	108.00	107.34	2.66	3.67	3.17
T_{12}	83.67	86.00	84.84	2.75	3.75	3.25
T_{13}	67.83	71.67	69.75	1.99	2.75	2.37
SEm(±)	**1.214**	**0.491**	**0.590**	**0.065**	**0.193**	**0.112**
CD(0.05)	**3.544**	**1.432**	**1.723**	**0.190**	**0.562**	**0.326**

Table 4.2.18 : Effect of organic nutrient management on specific gravity and pulp: peel ratio of dragon fruits

Treatments	Specific Gravity (No.)			Pulp:Peel Ratio (No.)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	1.03	1.04	1.04	2.16	2.94	2.55
T_2	1.06	1.03	1.05	2.23	2.56	2.39
T_3	1.03	1.03	1.03	2.20	2.67	2.43
T_4	1.04	1.04	1.04	2.10	2.26	2.18
T_5	1.06	1.07	1.07	1.80	2.14	1.97
T_6	1.04	1.03	1.04	2.23	2.54	2.38
T_7	1.07	1.06	1.07	2.23	2.60	2.41
T_8	1.10	1.05	1.07	2.56	3.40	2.98
T_9	1.04	1.03	1.03	2.06	2.62	2.34
T_{10}	1.08	1.01	1.04	2.26	2.45	2.36
T_{11}	1.05	1.01	1.03	1.98	2.80	2.39
T_{12}	1.03	1.02	1.02	2.16	2.47	2.32
T_{13}	1.07	1.05	1.06	1.41	2.35	1.88
SEm(±)	**0.013**	**0.008**	**0.009**	**0.105**	**0.070**	**0.053**
CD(0.05)	**0.037**	**0.023**	**0.027**	**0.307**	**0.204**	**0.155**

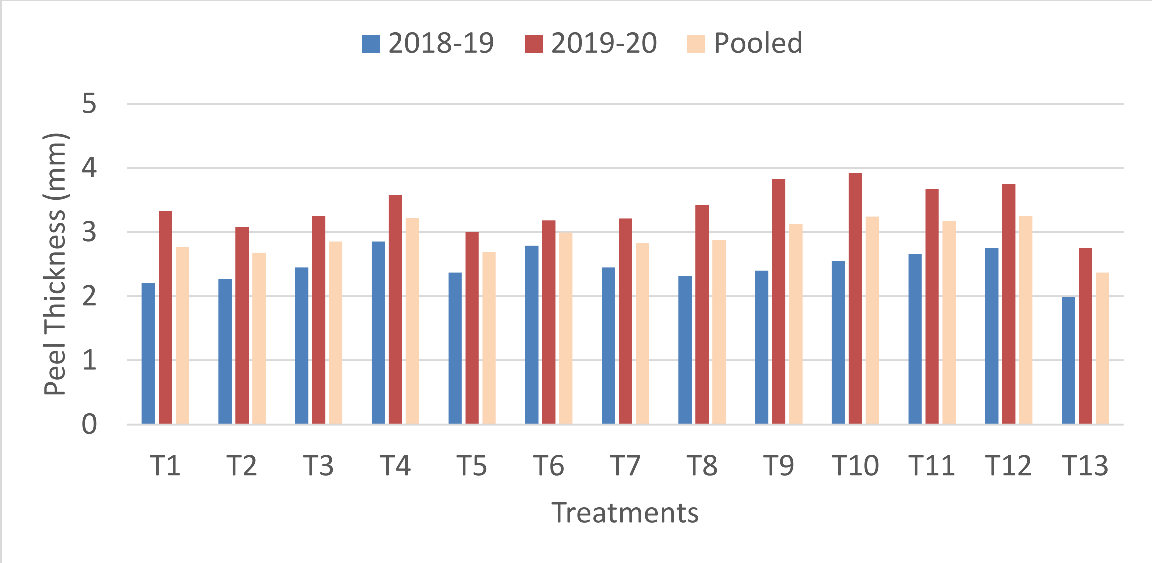


Fig. 4.2.15 Effect of organic nutrient management treatments on peel thickness of dragon fruit

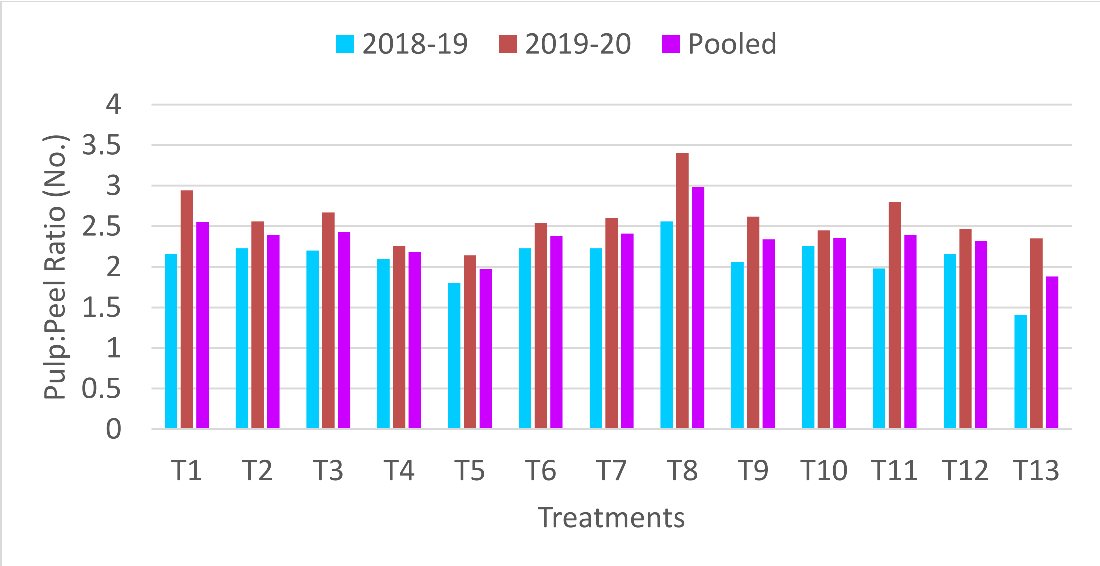


Fig. 4.2.16 Effect of organic nutrient management treatments on pulp:peel ratio of dragon fruit

(96.50g) during the first year 2018-2019. Whereas, in the second year (2019-2020), highest peel weight (110.83g) were observed in NC+AZ+PSB+ KSB (T_{10}). However, the minimum peel weight (67.83g and 71.67g) were observed in control (T_{13}) for both the years. From the pooled analysis it was found that the highest peel weight (107.34g) was observed in PM +AZ+PSB+ KSB (T_{11}) which was followed by (T_{10}) (103.67) and minimum peel weight (69.75g) was recorded in T_{13} (control).

4.2.3.8. Peel thickness (mm)

From the data display on Table 4.2.17 it was obvious that there was a significant variation among the treatment related to the peel thickness and was recorded that the highest peel thickness was observed in plant treated with Poultry Manure (PM) (T_4) (2.85mm) followed by Phosphate Solubilizing Bacteria (PSB) (T_6) (2.79mm) in the first year of study 2018-2019 and in the second year 2019-2020, the highest was recorded in NC +AZ+PSB+ KSB (T_{10}) (3.92mm) followed by AZ+PSB+ KSB (T_{12}) (3.75 mm). However the minimum peel thickness (1.99mm and 2.75mm) were observed in control (T_{13}).

Pooled data for both years showed that the highest peel thickness was recorded in AZ+PSB+ KSB (T_{12}) (3.25mm) followed by (T_{10}) (3.24mm) and minimum pulp thickness (2.37mm) was observed in control (T_{13}).

4.2.3.9. Specific gravity

The data presented in Table 4.2.18 and Fig. 4.2.15 showed that there was variation in specific gravity of dragon fruit among the different treatments, which ranged from 1.03 to 1.10 in the first year and 0.01 to 1.07 during second year of study. Maximum specific gravity (1.10) was found in FYM +AZ+PSB+ KSB (T_8) and second highest (1.08) were observed in NC +AZ+PSB+ KSB (T_{10}) and the lowest specific gravity (1.03) was observed in plant treated under three treatment i.e. (T_1) Farm Yard Manure (FYM), (T_3) Neem Cake (NC) and AZ+PSB+ KSB (T_{12}) during 2018-2019.Whereas, during the year 2019-2020, Azotobacter (AZ) (T_5) has a maximum specific gravity of fruit (1.07) followed by Potash Solubilizing Bacteria (KSB) (T_7) (1.06) while the minimum specific gravity of fruit (1.01) was observed in NC +AZ+PSB+ KSB (T_{10}) and PM +AZ+PSB+ KSB (T_{11}).

The pooled analysis showed that the highest (1.07) specific gravity of fruit was observed under Azotobacter (AZ) (T_5) and Potash Solubilizing Bacteria (KSB)

(T_7) which was followed by (T_{13}) Control (1.06) and the lowest is in AZ+PSB+ KSB (T_{12}) (1.02).

4.2.3.10. Pulp: Peel ratio

Pulp: Peel ratio of fruits were manifested in Table 4.2.18 and Fig. 4.2.16, which revealed that the highest pulp: peel ratio of fruit was found in FYM +AZ+PSB+ KSB (T_8) (2.56) which was followed by NC +AZ+PSB+ KSB (T_{10}) (2.26) and the lowest (1.41) was observed under (T_{13}) control (no fertilizer) during 2018-2019 and during 2019-2020, the highest value was recorded with FYM +AZ+PSB+ KSB (T_8) which is (3.40) followed by (T_1)Farm Yard Manure (FYM) (2.94) and the lowest (1.41) was observed under (T_{13}) control.

From the pooled data the highest pulp: peel ratio (2.98) was found in FYM +AZ+PSB+ KSB (T_8) which was followed by (T_1) Farm Yard Manure (FYM) (2.55) and the lowest (1.88) was observed under (T_{13}) control.

4.2.4. Bio- Chemical Parameter

4.2.4.1. Total soluble solid (^{0}Brix)

From the data presented at Table 4.2.19 showed that various treatment had a significant influence on TSS content of the fruit. The highest TSS value of fruits (12.97^{0}Brix) was observed in VC +AZ+PSB+ KSB (T_9) followed by FYM +AZ+PSB+ KSB (T_8) (11.83^{0}Brix) and the lowest (8.13^{0}Brix) were observed under treatment control (T_{13}) in the first year (2018-2019). However, FYM +AZ+PSB+ KSB (T_8) showed highest TSS value of (12.58^{0}Brix) and was followed by VC +AZ+PSB+ KSB (T_9) (10.78 ^{0}Brix) and the lowest (8.58^{0}Brix) was recorded under treatment control (T_{13}) during 2019-2020. Pooled analysis data showed that highest TSS value (12.21^{0}Brix) was found under the treatment of FYM +AZ+PSB+ KSB (T_8) followed by VC +AZ+PSB+ KSB (T_9) (11.88^{0}Brix) compared with the TSS value in control (T_{13}) (8.36^{0}Brix).

4.2.4.2. Titratable Acidity (%)

Data shown in the Table 4.2.19 revealed that significant variation was observed in acidity of fruit during both the years. The presented data showed that the lowest acidity (0.28% and 0.27%) was recorded in FYM +AZ+PSB+ KSB (T_8) for two consecutive years and the highest (0.47% and 0.52%) was recorded in control (T_{13}) which was followed by Azotobacter (AZ) (T_5) (0.45% and 0.475) in both years of the experimental study.

Pooled analysis of data from both years showed that the titratable acidity percentage was lowest in FYM +AZ+PSB+ KSB (T_8) (0.28%) and the highest (0.50%) was recorded in control (T_{13}) followed by plant treated with Azotobacter (AZ) (T_5) (0.46%).

4.2.4.3. TSS: acid ratio

Data presented on Table 4.1.19 and Fig. 4.2.17 manifested that TSS: acid ratio of fruit got significant variation under each treatment due to different application of nutrients. During first year of experiment (2018-2019), maximum TSS/acid ratio (44.72) was observed in VC +AZ+PSB+ KSB (T_9) followed by FYM +AZ+PSB+ KSB (T_8) (42.25) and the lowest (17.30) was recorded under treatment control (T_{13}). However, FYM +AZ+PSB+ KSB (T_8) showed highest TSS/acid ratio (46.59) and was followed by VC +AZ+PSB+ KSB (T_9) (35.93) during 2019-2020. While the minimum TSS/acid ratio (16.50) was observed under control (T_{13}) in the year 2019-2020.

Pooled analysis of data for both years showed the highest TSS/acid ratio (44.42) was found under the treatment of FYM +AZ+PSB+ KSB (T_8) followed by VC +AZ+PSB+ KSB (T_9) (40.33) compared with the TSS/acid ratio fruits at control (T_{13}) (16.90).

4.2.4.4. Total sugar (%)

Total sugar percentage showed significant variation under each treatment due to different application of nutrients. During first year of experimental study (2018-

2019) maximum total sugar percentage (8.39%) was obtained in VC +AZ+PSB+ KSB(T_9) followed by FYM +AZ+PSB+ KSB (T_8) (7.86%) and the lowest (4.56%) was under control (T_{13}). During 2nd years of experimental study (2019-2020), maximum total sugar percentage (9.24%) was obtained in FYM +AZ+PSB+ KSB (T_8) followed by T_9 (8.32%) and the lowest value (4.42%) was recorded under control (T_{13}) (Table 4.1.20).

Pooled data from both years shows that maximum total sugar percentage (8.55%) was obtained in FYM +AZ+PSB+ KSB (T_8) followed by VC +AZ+PSB+ KSB (T_9) (8.36%). T_{13} (control) showed lowest total sugar percentage (4.49%).

4.2.4.5. Reducing sugar (%)

Data displayed on Table 4.2.20 revealed that reducing sugar percentage varied from each treatment during the experiment. During first year of experimental study 2018-2019 maximum reducing sugar percentage (5.99%) was obtained in VC +AZ+PSB+ KSB(T_9) followed by FYM +AZ+PSB+ KSB (T_8) (5.79%) and the lowest (4.00%) was under control (T_{13}). During 2nd years of experiment (2019-2020), maximum reducing sugar percentage (6.22%) was obtained in FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11})(5.89%) compared with control (T_{13}) (3.98%).

Pooled data from both years showed that maximum reducing sugar percentage (6.01%) was obtained in FYM +AZ+PSB+ KSB (T_8) followed by VC+AZ+PSB+ KSB(T_9)(5.89%). T_{13} (control) showed lowest reducing sugar percentage (3.99%).

Table 4.2.19 : Effect of organic nutrient management on Total Soluble Solids (TSS), titratable acidity and TSS: acid ration of dragon fruit

Treatments	TSS (°Brix)			Titratable Acidity (%)			TSS: Acid ratio		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	11.17	10.62	10.90	0.32	0.34	0.33	34.91	31.24	33.07
T_2	10.83	10.57	10.70	0.34	0.40	0.37	31.85	26.43	29.14
T_3	10.75	10.53	10.64	0.36	0.38	0.37	29.86	27.71	28.79
T_4	10.77	10.22	10.50	0.38	0.42	0.40	28.34	24.33	26.34
T_5	9.83	9.33	9.58	0.45	0.47	0.46	21.84	19.85	20.85
T_6	10.18	9.58	9.88	0.44	0.38	0.41	23.14	25.21	24.17
T_7	10.43	10.03	10.23	0.39	0.42	0.41	26.74	23.88	25.31
T_8	11.83	12.58	12.21	0.28	0.27	0.28	42.25	46.59	44.42
T_9	12.97	10.78	11.88	0.29	0.30	0.30	44.72	35.93	40.33
T_{10}	11.08	10.58	10.83	0.34	0.33	0.34	32.59	32.06	32.32
T_{11}	11.58	10.7	11.14	0.31	0.32	0.32	37.35	33.44	35.40
T_{12}	10.40	9.62	10.01	0.42	0.44	0.43	24.76	21.86	23.31
T_{13}	8.13	8.58	8.36	0.47	0.52	0.50	17.30	16.50	16.90
SEm(±)	**0.443**	**0.206**	**0.227**	**0.009**	**0.017**	**0.011**	**1.643**	**1.261**	**1.063**
CD(0.05)	**1.293**	**0.600**	**0.664**	**0.026**	**0.051**	**0.032**	**4.797**	**3.681**	**3.102**

Table 4.2.20 : Effect of organic nutrient management on Total sugar, reducing sugar and ascorbic acid content of dragon fruit

Treatments	Total Sugar (%)			Reducing Sugar (%)			Ascorbic acid (mg/100g)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	7.23	7.42	7.33	5.63	5.78	5.71	16.79	18.61	17.70
T_2	6.92	7.24	7.08	5.50	5.50	5.50	14.27	17.05	15.66
T_3	6.62	7.18	6.90	5.36	5.15	5.26	16.12	17.12	16.62
T_4	6.86	7.15	7.01	5.09	5.08	5.09	14.85	17.58	16.22
T_5	5.72	6.32	6.02	4.78	4.36	4.57	11.68	15.76	13.72
T_6	5.87	6.67	6.27	4.85	4.49	4.67	11.05	13.12	12.09
T_7	6.61	7.09	6.85	5.02	5.05	5.04	12.72	16.18	14.45
T_8	7.86	9.24	8.55	5.79	6.22	6.01	20.94	21.42	21.18
T_9	8.39	8.32	8.36	5.99	5.79	5.89	17.68	18.37	18.03
T_{10}	6.93	7.40	7.17	5.56	5.72	5.64	20.84	19.03	19.94
T_{11}	7.58	7.61	7.60	5.65	5.89	5.77	17.89	21.92	19.91
T_{12}	6.28	6.84	6.56	4.96	4.76	4.86	13.05	16.39	14.72
T_{13}	4.56	4.42	4.49	4.00	3.98	3.99	10.79	12.90	11.85
SEm(±)	**0.241**	**0.257**	**0.173**	**0.258**	**0.268**	**0.187**	**0.297**	**0.364**	**0.262**
CD(0.05)	**0.703**	**0.751**	**0.505**	**0.754**	**0.782**	**0.547**	**0.868**	**1.062**	**0.766**

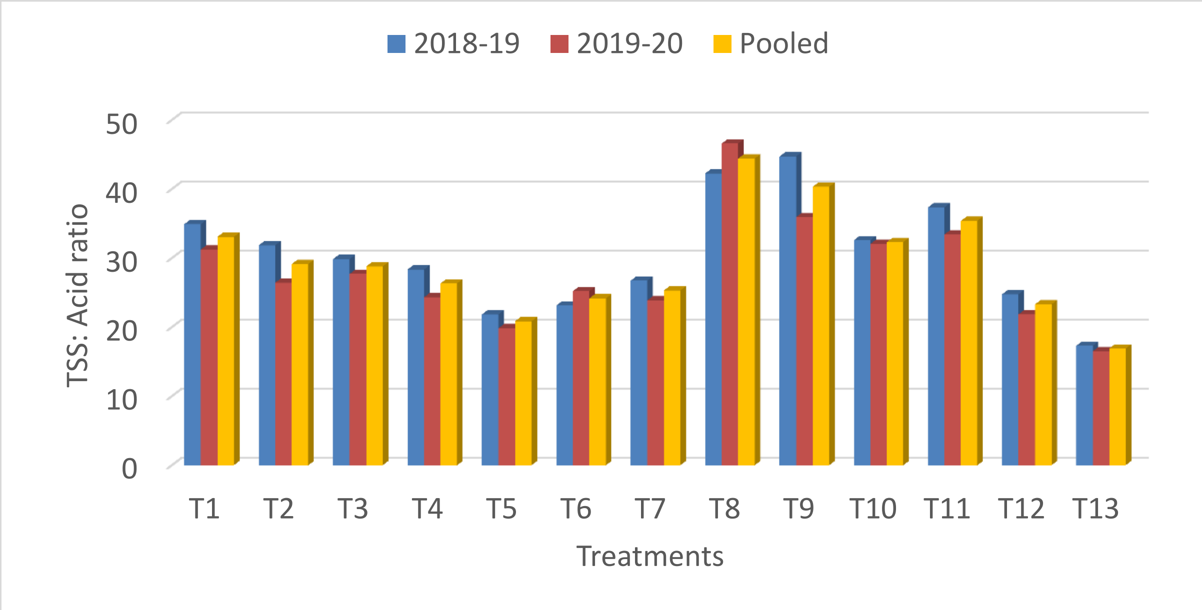


Fig. 4.2.17 Effect of organic nutrient management treatments on TSS:acid ratio of dragon fruit

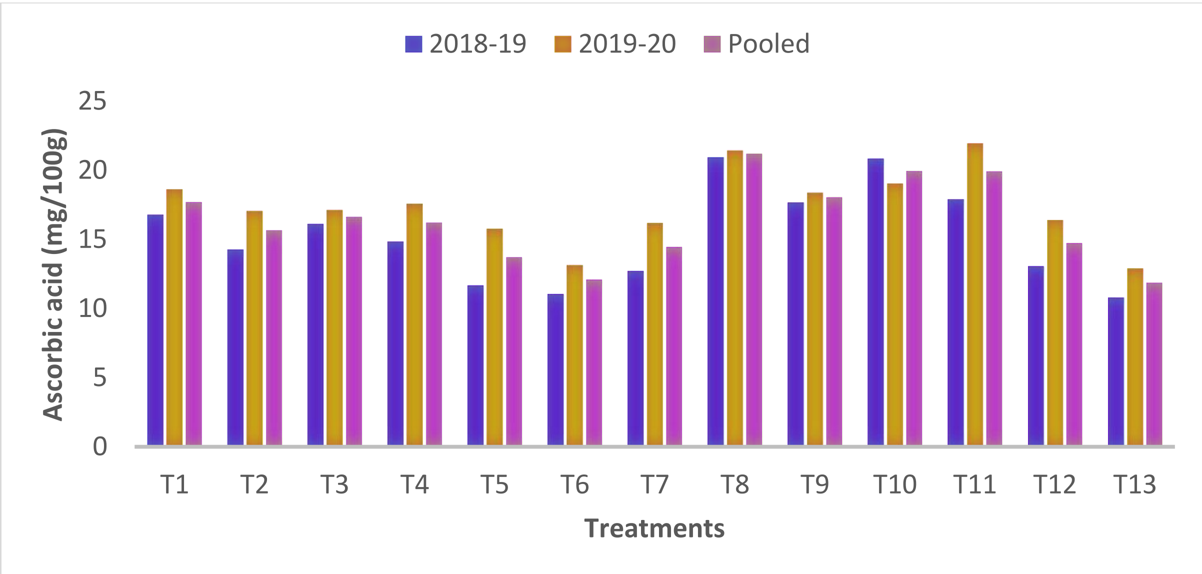


Fig. 4.2.18 Effect of organic nutrient management treatments on ascorbic acid content of dragon fruit

4.2.4.6. Ascorbic acid (mg/100g)

Ascorbic acid content of the fruit as revealed from the Table 4.1.20 and Fig. 4.2.18 showed significant variation among treatment. Maximum ascorbic acid (20.94 mg/100g) was obtained in FYM +AZ+PSB+ KSB (T_8) followed by NC +AZ+PSB+ KSB (T_{10}) (20.84 mg/100g) as compared with control (T_{13}) (10.78 mg/100g) during 2018-2019 and in the year 2019-2020, maximum ascorbic acid (21.92 mg/100g) was obtained in PM +AZ+PSB+ KSB (T_{11}) followed by T_8(21.42 mg/100g) compared with control (T_{13}) (12.90 mg/100g).

Pooled data showed that maximum ascorbic acid (21.18 mg/100g) was obtained in T_8 (FYM +AZ+PSB+ KSB) followed by plants treated with NC +AZ+PSB+ KSB (T_{10}) ((19.94 mg/100g) and T_{13} (control) showed lowest ascorbic acid content (11.85 mg/100g).

4.2.4.7. Anthocyanin content of peel (mg/100g)

Data showed in the Table 4.2.21 and Fig. 4.2.19 revealed significant variation in anthocyanin content of peel during both the years. The presented data had shown that the highest anthocyanin content of peel (7.31 mg/100g) was recorded in VC +AZ+PSB+ KSB (T_9) followed by PM +AZ+PSB+ KSB (T_{11}) (7.18 mg/100g) and the lowest (1.85 mg/100g) was recorded in control (T_{13}) during 2018-2019. However, FYM +AZ+PSB+ KSB (T_8) showed maximum anthocyanin content of peel (5.36 mg/100g) followed by (T_1) Farm Yard Manure (FYM) (4.14 mg/100g) compared with control (T_{13}) (1.56 mg/100g) in 2019-2020.

Pooled analysis data from both years showed the highest (5.45mg/100g) anthocyanin content of peel was found in VC +AZ+PSB+ KSB (T_9) followed by PM +AZ+PSB+ KSB (T_{11}) (5.13mg/100g) and the lowest (1.71mg/100g) was recorded in control (T_{13}).

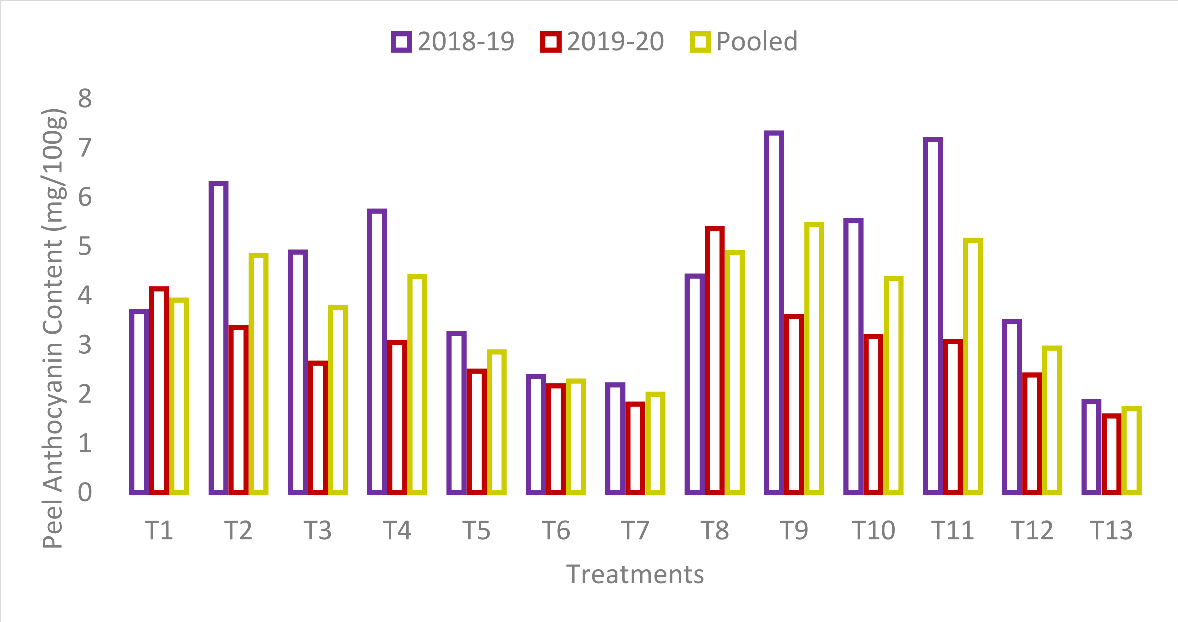


Fig. 4.2.19 Effect of organic nutrient management treatments on peel anthocyanin content of dragon fruit

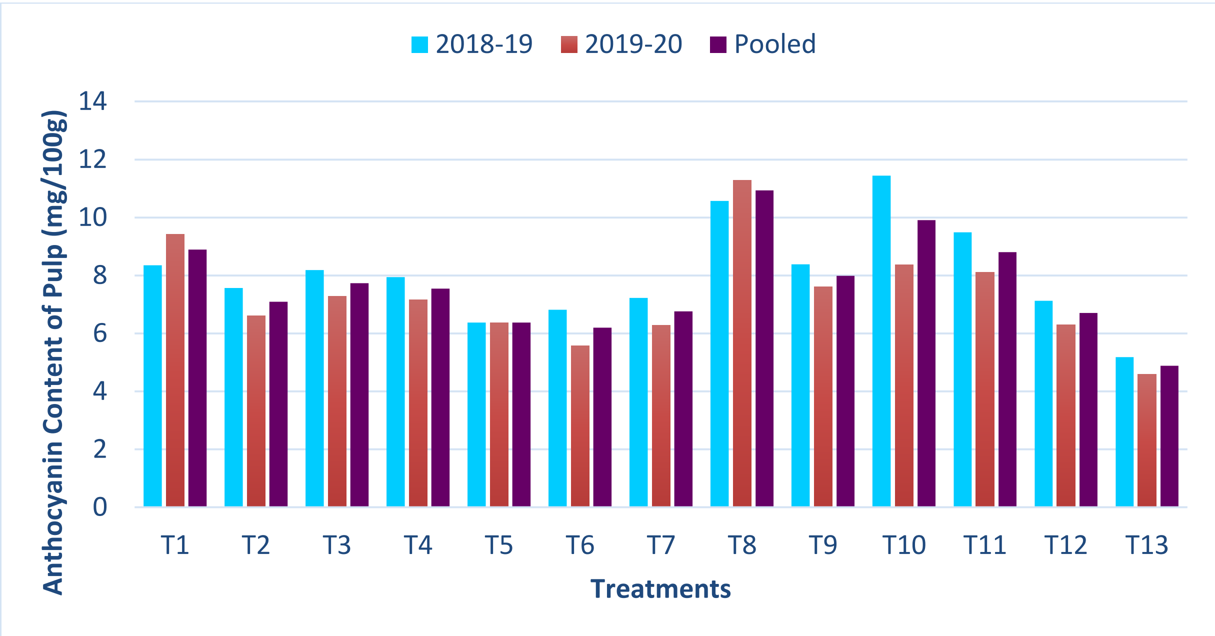


Fig. 4.2.20 Effect of organic nutrient management treatments on pulp anthocyanin content of dragon fruit

Table 4.2.21 : Effect of organic nutrient management on anthocyanin content of peel and pulp of dragon fruits

Treatments	Peel Anthocyanin Content (mg/100g)			Anthocyanin Content of Pulp (mg/100g)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	3.68	4.14	3.91	8.35	9.42	8.89
T_2	6.28	3.36	4.82	7.57	6.60	7.09
T_3	4.89	2.63	3.76	8.18	7.28	7.73
T_4	5.72	3.05	4.39	7.94	7.16	7.55
T_5	3.24	2.47	2.86	6.37	6.37	6.37
T_6	2.36	2.17	2.27	6.82	5.57	6.20
T_7	2.19	1.80	2.00	7.23	6.28	6.76
T_8	4.40	5.36	4.88	10.57	11.28	10.93
T_9	7.31	3.58	5.45	8.38	7.60	7.99
T_{10}	5.53	3.17	4.35	11.44	8.37	9.91
T_{11}	7.18	3.07	5.13	9.49	8.11	8.80
T_{12}	3.48	2.39	2.94	7.12	6.30	6.71
T_{13}	1.85	1.56	1.71	5.18	4.58	4.88
SEm(±)	**0.215**	**0.188**	**0.146**	**0.449**	**0.174**	**0.262**
CD(0.05)	**0.627**	**0.549**	**0.426**	**1.310**	**0.509**	**0.765**

Table 4.2.22 : Effect of organic nutrient management on soil pH, organic carbon and C:N ratio of experimental soil of dragon fruit orchard

Treatments	Soil pH			Organic Carbon (%)			C:N ratio		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	6.38	6.40	6.39	0.94	0.82	0.88	33.22	30.49	31.86
T_2	6.23	6.25	6.24	0.79	0.65	0.72	30.10	28.48	29.29
T_3	6.30	6.30	6.30	0.83	0.72	0.78	30.60	29.02	29.81
T_4	6.32	6.27	6.30	0.87	0.69	0.78	31.38	28.79	30.09
T_5	6.02	6.07	6.05	0.62	0.52	0.57	27.70	25.75	26.72
T_6	5.96	5.74	5.85	0.67	0.49	0.58	28.70	25.78	27.24
T_7	6.15	5.94	6.05	0.73	0.58	0.66	28.95	27.38	28.16
T_8	6.43	6.63	6.53	1.09	0.96	1.03	34.30	32.73	33.51
T_9	6.38	6.39	6.39	0.97	0.76	0.87	32.70	29.02	30.86
T_{10}	6.42	6.42	6.42	1.04	0.89	0.97	34.19	31.98	33.08
T_{11}	6.39	6.53	6.46	1.02	0.92	0.97	33.98	32.10	33.04
T_{12}	6.22	6.25	6.24	0.76	0.62	0.69	29.46	27.91	28.69
T_{13}	4.98	5.12	5.05	0.30	0.28	0.29	24.11	25.05	24.58
SEm(±)	**0.162**	**0.065**	**0.080**	**0.019**	**0.022**	**0.015**	**0.907**	**1.195**	**0.826**
CD(0.05)	**0.474**	**0.188**	**0.233**	**0.057**	**0.063**	**0.043**	**2.648**	**3.489**	**2.412**

4.2.4.8. Anthocyanin content of pulp (mg/100g)

Anthocyanin content of pulp as showed in Table 4.2.21 and Fig. 4.2.20 revealed significant variation due to different treatment during both the years. The presented data shown that the highest anthocyanin content of pulp (11.44 mg/100g) was recorded in NC +AZ+PSB+ KSB (T_{10}) followed by FYM +AZ+PSB+ KSB (T_8) (10.57mg/100g) at par with the control (T_{13}) (5.18mg/100g) in the first year of study. During the second years of study, the highest (11.28 mg/100g) was recorded in FYM +AZ+PSB+ KSB (T_8) followed by T_1(9.42mg/100g) and the lowest (4.58mg/100g) was recorded in control (T_{13}).

Pooled analysis data from both years showed that the highest (10.93mg/100g) anthocyanin content of pulp was recorded in FYM +AZ+PSB+ KSB (T_8) followed by T_{10} (9.91mg/100g) and the lowest (4.88mg/100g) was recorded in control (T_{13}).

4.2.5. Soil Nutrients analysis

4.2.5.1 Soil pH

Soil pH of the experimental data shown in Table 4.2.22 revealed significant differences were observed among treatment under the study. During first years of study (2018-2019) the highest soil pH (6.43) was recorded in FYM +AZ+PSB+ KSB (T_8) followed by NC +AZ+PSB+ KSB (T_{10}) (6.42) as compared to control (T_{13}) (4.98). Whereas, during the second years 2019-2020 the highest soil pH(6.63) was recorded under FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11})(6.53) and the lowest soil pH were observed with control (T_{13}) (5.12).

Pooled data for both years showed that the highest soil pH (6.53) was recorded in FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11}) (6.46) and lowest (5.05) was recorded in control (T_{13}).

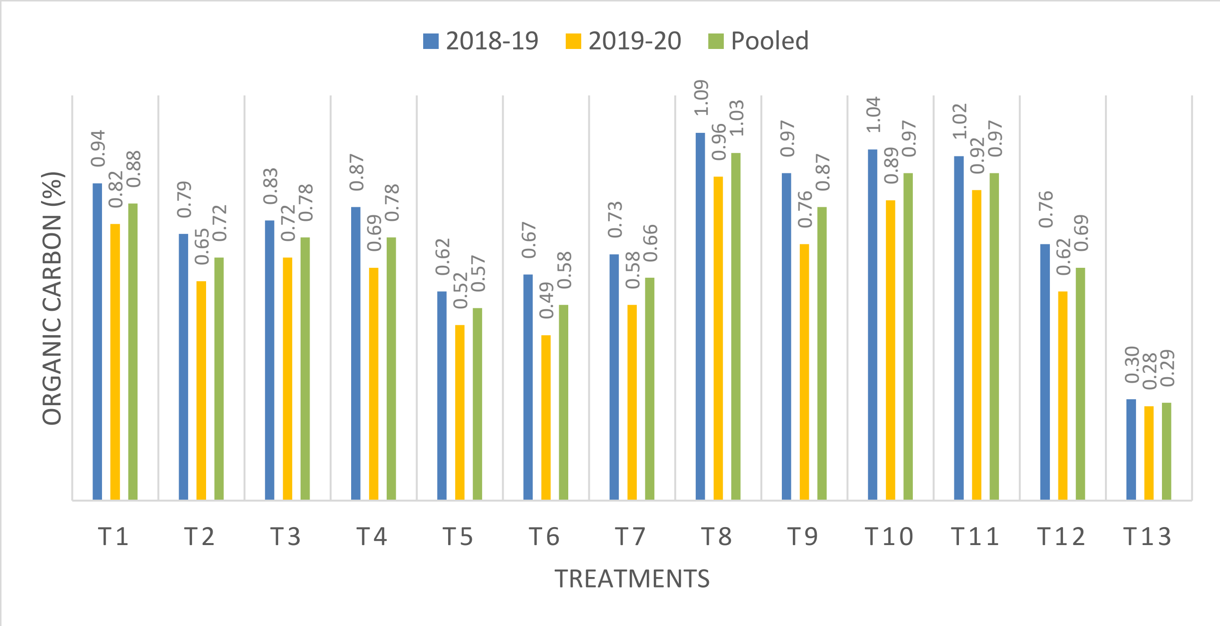


Fig. 4.2.21 Effect of organic nutrient management treatments on soil organic carbon content

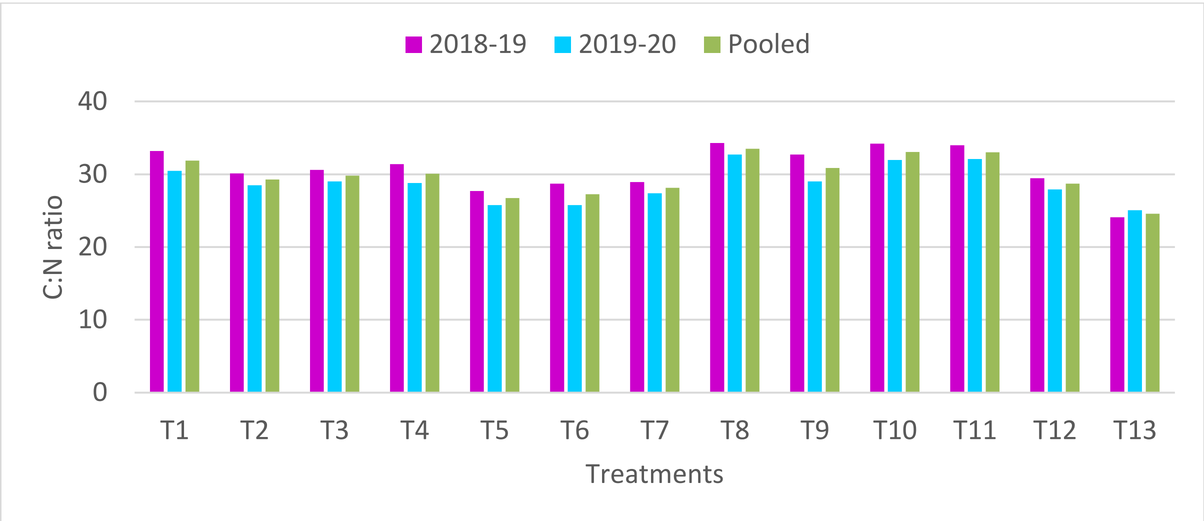


Fig. 4.2.22 Effect of organic nutrient management treatments on C:N ratio of soil

4.2.5.2. Organic Carbon (%)

Table 4.2.22 and Fig. 4.2.21 showed significant variation among treatment with respect to organic carbon percentage during the experimental study. During first years of study (2018-2019), the highest organic carbon content (1.09%) was recorded in FYM +AZ+PSB+ KSB (T_8) followed by NC +AZ+PSB+ KSB (T_{10}) (1.04%) as compared to control (T_{13}) (0.30%). Whereas, during the second years 2019-2020 the highest organic carbon content (0.96%) was recorded under FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11}) (0.92%) and the lowest organic carbon percentage was recorded with control (T_{13}) (0.28%).

Pooled data for both years showed that the highest organic carbon percentage (1.03%) was recorded in FYM +AZ+PSB+ KSB (T_8) followed by NC +AZ+PSB+ KSB (T_{10}) and PM +AZ+PSB+ KSB (T_{11}) with a value of (0.97%) and lowest organic carbon percentage (0.29%) was recorded in control (T_{13}).

4.2.5.3 C: N ratio

C: N ratio as appeared on Table 4.2.22 and Fig. 4.2.22 manifested that it got significantly influenced by various treatments during the study. The lowest C: N ratio was recorded in T_{13} control (24.11) while the highest C:N was recorded in FYM +AZ+PSB+ KSB (T_8) (34.30) followed by NC +AZ+PSB+ KSB (T_{10}) (34.19) in the year 2018- 2019. During 2019-2020, the lowestC:N ratio (25.05) was recorded under treatment control (T_{13}). However, the highest C:N ratio was recorded with FYM +AZ+PSB+ KSB (T_8) (32.73) followed by (T_{11})(32.10) in the second years of study.

Pooled analysis of data for both years revealed that highest C: N ratio (33.51) was recorded in FYM +AZ+PSB+ KSB (T_8) followed by (T_{10}) (33.08) and the lowest C: N ratio (24.58) was recorded in control (T_{13}).

4.2.5.3. Total nitrogen (kg/ha)

Total nitrogen content of the soil presented in Table 4.2.23 and Fig. 4.2.23 showed that organic nutrients treatments had a significant influenced on it. The highest total nitrogen available in the soil (711.87 kg/ha and 656.98 kg/ha) was

Table 4.2.23 : Effect of organic nutrient management on nitrogen, phosphorus and potassium content of experimental soil of dragon fruit orchard

Treatments	Nitrogen (kg/ha)			Phosphorus (kg/ha)			Potassium (kg/ha)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	633.78	602.34	618.06	62.34	58.24	60.29	712.36	645.38	678.87
T_2	587.89	511.26	549.58	72.18	44.98	58.58	656.82	545.36	601.09
T_3	607.56	555.78	581.67	65.87	51.28	58.58	578.98	572.38	575.68
T_4	620.98	536.87	578.93	48.78	49.87	49.33	611.64	512.82	562.23
T_5	501.35	452.39	476.87	43.52	42.38	42.95	398.78	378.76	388.77
T_6	522.87	425.78	474.33	59.78	62.37	61.08	435.76	346.81	391.29
T_7	564.89	474.59	519.74	40.56	39.67	40.12	512.38	436.78	474.58
T_8	711.87	656.98	684.43	70.56	71.09	70.83	842.34	812.36	827.35
T_9	664.56	586.67	625.62	82.13	68.57	75.35	832.78	785.45	809.12
T_{10}	681.28	623.48	652.38	51.28	54.78	53.03	809.67	681.28	745.48
T_{11}	672.39	641.98	657.19	79.56	65.82	72.69	767.89	724.98	746.44
T_{12}	577.78	497.56	537.67	56.62	47.56	52.09	487.59	484.62	486.11
T_{13}	278.67	250.38	264.53	21.56	17.82	19.69	208.67	178.53	193.60
SEm(±)	**0.865**	**1.077**	**0.728**	**0.511**	**0.491**	**0.371**	**1.370**	**1.522**	**1.258**
CD(0.05)	**2.524**	**3.143**	**2.125**	**1.491**	**1.433**	**1.082**	**3.999**	**4.442**	**3.672**

Table 4.2.24 : Effect of organic nutrient management on iron and manganese content of experimental soil of dragon fruit orchard

Treatments	Fe (mg/Kg)			Mn (mg/Kg)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	72.25	134.10	103.18	67.09	56.12	61.61
T_2	68.29	124.40	96.35	76.05	63.93	69.99
T_3	68.85	145.10	106.98	75.60	63.68	69.64
T_4	70.85	132.30	101.58	75.75	61.10	68.43
T_5	62.49	99.82	81.16	63.48	55.47	59.48
T_6	62.74	89.13	75.94	61.94	54.87	58.41
T_7	67.54	112.50	90.02	61.02	54.55	57.79
T_8	110.80	196.40	153.60	74.69	58.86	66.78
T_9	75.19	147.30	111.25	90.95	95.10	93.03
T_{10}	79.89	221.20	150.55	83.52	70.93	77.23
T_{11}	113.10	174.70	143.90	79.37	61.15	70.26
T_{12}	65.32	113.30	89.31	65.13	53.97	59.55
T_{13}	58.30	86.81	72.56	51.96	50.45	51.21
SEm(±)	**0.569**	**0.561**	**0.393**	**0.512**	**0.512**	**0.375**
CD(0.05)	**1.660**	**1.639**	**1.146**	**1.494**	**1.496**	**1.094**

Table 4.2.25 : Effect of organic nutrient management on copper and zinc content of experimental soil of dragon fruit orchard

Treatments	Cu (mg/Kg)			Zn (mg/kg)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	1.11	2.06	1.59	10.28	20.19	15.24
T_2	1.55	3.21	2.38	8.65	18.40	13.53
T_3	1.54	3.37	2.46	9.18	19.89	14.54
T_4	1.45	4.20	2.83	9.29	28.00	18.65
T_5	0.99	1.85	1.42	5.72	17.31	11.52
T_6	1.07	1.52	1.30	6.55	16.54	11.55
T_7	1.13	2.00	1.57	5.90	17.38	11.64
T_8	1.14	3.14	2.14	21.03	30.77	25.90
T_9	1.99	5.90	3.95	12.42	20.77	16.60
T_{10}	2.17	5.10	3.64	15.17	26.95	21.06
T_{11}	1.72	4.24	2.98	13.58	28.99	21.29
T_{12}	1.01	1.59	1.30	7.13	18.14	12.64
T_{13}	1.98	2.15	2.07	4.69	6.32	5.51
SEm(±)	**0.112**	**0.071**	**0.082**	**0.237**	**0.507**	**0.293**
CD(0.05)	**0.328**	**0.207**	**0.239**	**0.691**	**1.481**	**0.855**

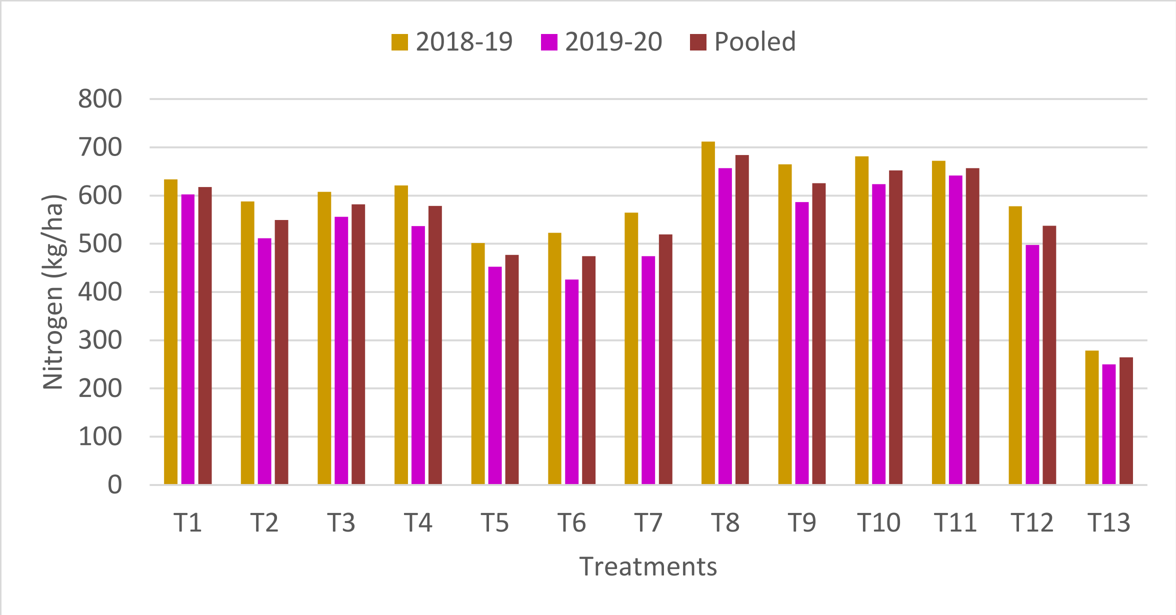


Fig. 4.2.23 Effect of organic nutrient management treatments on nitrogen content of soil

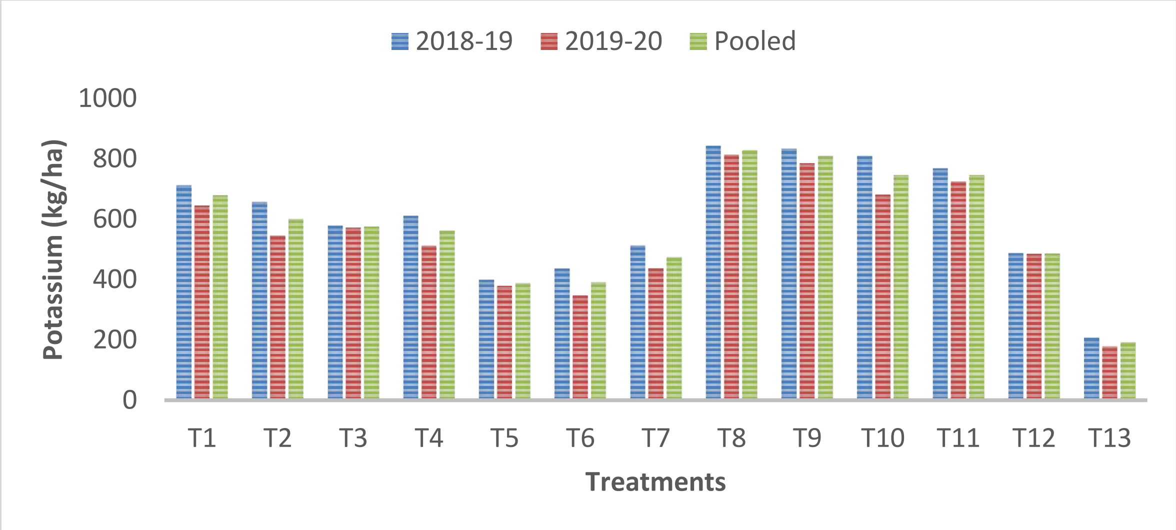


Fig. 4.2.24 Effect of organic nutrient management treatments on potassium content of soil

recorded with FYM +AZ+PSB+ KSB(T_8) for two consecutive years followed by NC +AZ+PSB+ KSB (T_{10}) (681.28 kg/ha) during the first year of study and PM +AZ+PSB+ KSB (T_{11}) showed the second highest (641.98kg/ha) during the second year of study. The minimum nitrogen available in the soil was recorded in control (T_{13}) (278.67 and 250.38 kg/ha) for both years of experimental study.

The pooled analysis from two years showed that the highest available nitrogen (684.43kg/ha) was observed in FYM +AZ+PSB+ KSB (T_8) followed by (T_{11}) (657.19 kg/ha), while the lowest available nitrogen (264.53kg/ha) was observed in control treatment (T_{13}).

4.2.5.4. Phosphorus (kg/ha)

The available phosphorus content of experimental soil as displayed in Table 4.2.23 showed that different nutrients had significant influence on each treatment during the study. The highest phosphorus content of soil (82.13 kg/ha) was recorded in VC +AZ+PSB+ KSB (T_9) followed by PM +AZ+PSB+ KSB (T_{11}) (79.56kg/ha) and the minimum nitrogen content of experimental soil was observed in control (T_{13}) (21.56kg/ha) during 2018-2019. Whereas, in 2019-2020 the highest phosphorus content (71.09kg/ha) was recorded in FYM +AZ+PSB+ KSB (T_8) followed by (T_9) (68.57kg/ha) as compared with the lowest phosphorus content of experimental soil was observed in control (T_{13}) (17.82kg/ha) during 2019-2020.

However, the pooled data revealed that from both years of study the highest soil phosphorus content (75.35kg/ha) was recorded in VC +AZ+PSB+ KSB (T_9) followed by (T_{11}) (72.69kg/ha) while the lowest (19.69kg/ha) was observed in control treatment (T_{13}).

4.2.5.5. Potassium (kg/ha)

Potassium content of experimental soil presented at Table 4.2.23 and Fig. 4.2.24 showed significant variation due to different treatments. The highest potassium content in the soil (842.34 kg/ha and 812.36 kg/ha) was recorded with FYM +AZ+PSB+ KSB (T_8) followed by VC +AZ+PSB+ KSB (T_9) (832.78 and 785.45 kg/ha) and the least was recorded in control (T_{13}) (208.67 and 178.53 kg/ha) during both years of study. The pooled analysis from two years showed that the highest available potassium in the experimental soil (827.35kg/ha) was observed in

FYM +AZ+PSB+ KSB (T_8) followed by (T_9) (809.12 kg/ha), while the lowest (193.60kg/ha) was observed in control treatment (T_{13}).

4.2.5.6. Manganese (mg/kg)

Data presented from Table 4.2.24 showed that manganese content in the soil varied significantly among each treatment due to different nutrients application. The highest manganese content in the soil (90.95mg/kg and 95.10 mg/kg) was recorded with VC +AZ+PSB+ KSB (T_9) which was followed by NC +AZ+PSB+ KSB (T_{10}) (83.52 mg/kg and 70.93mg/kg) and the minimum manganese content of experimental soil was observed in control (T_{13}) (51.96mg/Kg and 50.45mg/kg) during both years of experimental study.

The pooled analysis from two years data showed that the highest available manganese in the experimental soil (93.03mg/kg) was observed in VC +AZ+PSB+ KSB (T_9) followed by (T_{10}) (77.23 mg/kg), while the lowest manganese content of soil (51.21 mg/kg) was observed in control (T_{13}).

4.2.5.7. Iron (mg/kg)

Significant variation was observed among treatment with respect to available iron content in the experimental soil showed in Table 4.2.24. During 2018-2019, the maximum Iron content in the soil (113.10mg/kg) was recorded with PM +AZ+PSB+ KSB (T_{11}) which was followed by FYM +AZ+PSB+ KSB (T_8) (110.80mg/kg) and it was recorded lowest iron content of experimental soil in T($_{13}$) (58.30 mg/kg). Whereas, in the year 2019-2020, the highest soil iron (221.20mg/kg) was recorded in NC +AZ+PSB+ KSB (T_{10}) followed by FYM +AZ+PSB+ KSB (T_8) (196.40 mg/kg) and the lowest iron content of soil (86.81) was observed in control (T_{13}).

However, the pooled analysis from two years showed that the highest available iron in the experimental soil (153.60mg/kg) was observed in FYM +AZ+PSB+ KSB (T_8) followed by (T_{11}) (150.55mg/kg), while the lowest (72.56 mg/kg) was observed in control treatment (T_{13}).

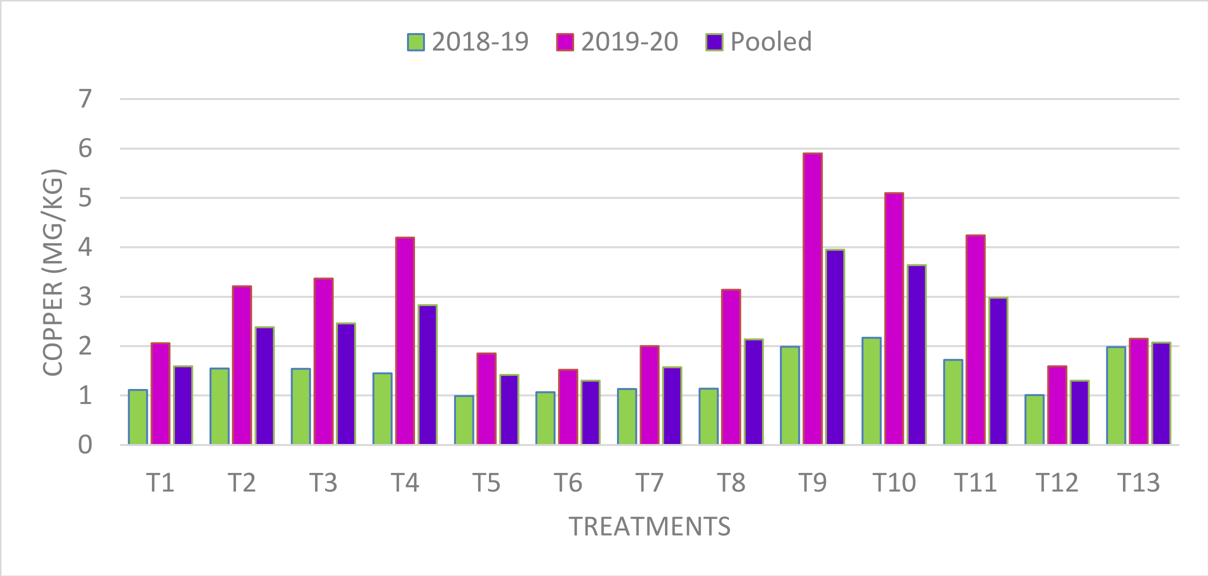


Fig. 4.2.25 Effect of organic nutrient management treatments on copper content of soil

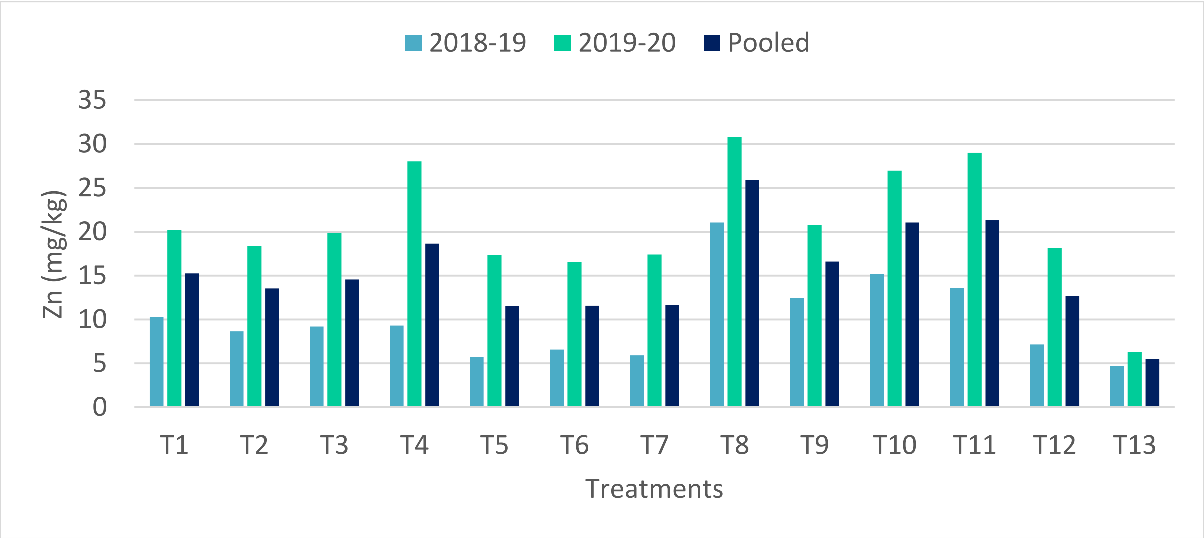


Fig. 4.2.26 Effect of organic nutrient management treatments on zinc content of soil

4.2.5.8. Copper (mg/kg)

It is clearly shown in Table 4.2.25 and Fig. 4.2.25 that copper content in the soil varied significantly among each treatment due to different nutrients application. The highest copper content in the soil (2.17 mg/kg) was recorded with NC +AZ+PSB+

KSB (T_{10}) followed by VC +AZ+PSB+ KSB (T_9) (1.99mg/kg) and the minimum available copper content of experimental soil was found in Azotobacter (AZ) (T_5) (0.99mg/kg) in the first year of study (2018-2019). During the second year (2019-2020), the highest copper content in the soil (5.90mg/kg) was recorded with VC +AZ+PSB+ KSB (T_9) followed by NC +AZ+PSB+ KSB (T_{10}) (5.10mg/kg) and the minimum available copper content of experimental soil was found in Phosphate Solubilizing Bacteria (PSB) (T_6) (1.52mg/kg).

The pooled analysis from two years data showed that the highest available copper in the experimental soil (3.95mg/kg) was observed in VC +AZ+PSB+ KSB (T_9) followed by NC +AZ+PSB+ KSB (T_{10})(3.64mg/kg), while the lowest (1.30mg/kg) was observed commonly under both the treatment of (T_{12}) AZ+PSB+ KSB and Phosphate Solubilizing Bacteria (PSB) (T_6).

4.2.5.9. Zinc (mg/kg)

The available zinc content of experimental soil (Table 4.2.25, Fig. 4.2.26) showed significant variation due to different treatments. The highest zinc content in the soil (21.03mg/kg) was recorded with FYM +AZ+PSB+ KSB (T_8) followed by NC +AZ+PSB+ KSB (T_{10}) (15.17mg/kg) and the lowest was recorded in control (T_{13}) (4.69mg/kg) during the year 2018-2019. Whereas, during the second year of study 2019-2020, the highest zinc content in the soil (30.77mg/kg) was recorded with FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11}) (28.99mg/kg) and the lowest was recorded in control (T_{13}) (6.32mg/kg).

The pooled analysis from two years showed that the highest available zinc in the experimental soil (25.90mg/kg) was observed in FYM +AZ+PSB+ KSB (T_8) followed by (T_{11}) (21.29mg/kg) while the lowest (5.51mg/kg) was observed in control treatment (T_{13}).

4.2.6. Soil microbial analysis

4.2.6.1. *Azotobacter* count

It was clear from the data presented in Table 4.2.26 that for two consecutive years of study, the highest *Azotobacter* count of experimental soil was observed in NC +AZ+PSB+ KSB (T_{10}) (34.78 x 10^6 cfu g^{-1}) followed by FYM +AZ+PSB+ KSB (T_8) (32.46 x 10^6 cfu g^{-1}) and the lowest count was observed in control (T_{13})(5.12 x 10^6 cfu g^{-1}) during 2018-2019. In the second year 2019-2020, the maximum count was recorded in FYM +AZ+PSB+ KSB (T_8) (89.64 x 10^6 cfu g^{-1}) followed by PM +AZ+PSB+ KSB (T_{11}) (79.46 x 10^6 cfu g^{-1}) and the lowest count was observed in control (T_{13})(6.13 x 10^6 cfu g^{-1}).

The pooled analysis from two years data showed that the maximum soil *Azotobacter* count was recorded in FYM +AZ+PSB+ KSB (T_8) (61.05 x 10^6 cfu g^{-1}) followed by (T_{11}) (54.82 x 10^6 cfu g^{-1}) while the minimum population count (5.63x 10^6 cfu g^{-1}) was observed in treatment control (T_{13}).

4.2.6.2. Phosphorus Solubilizing Bacteria (PSB)count

Phosphorus solubilising bacteria (PSB) count data presented in Table 4.2.26 showed significant variation across the treatments. During 2018-2019, the highest Phosphorus solubilising bacteria count of experimental soil (27.89 x 10^6 cfu g^{-1}) was observed in VC +AZ+PSB+ KSB (T_9) followed by PM +AZ+PSB+ KSB (T_{11}) (24.32 x 10^6 cfu g^{-1}) and the lowest population count was observed in control (T_{13}) (8.86 x 10^6 cfu g^{-1}). In the second year (2019-2020), the maximum PSB population count was recorded in FYM +AZ+PSB+ KSB (T_8) (62.93 x 10^6 cfu g^{-1}) followed by (T_9) (58.76 x 10^6 cfu g^{-1}) and the lowest population count was observed in control (T_{13}) (10.86 x 10^6 cfu g^{-1}).

The pooled analysis from two years data showed that the maximum soil phosphorus solubilising bacteria count was recorded in VC +AZ+PSB+ KSB (T_9) (43.33 x 10^6 cfu g^{-1}) followed by FYM +AZ+PSB+ KSB (T_8) (42.06 x 10^6 cfu g^{-1}) while the minimum population count (9.86 x 10^6 cfu g^{-1}) was recorded in treatment control (T_{13}).

4.2.6.3. Potassium Solubilising Bacteria (KSB) Count

Data presented in Table 4.2.26 showed significant variation in KSB count across treatments. During 2018-2019, the highest Potassium solubilising bacteria (KSB) count (42.87 x10^6 cfu g^{-1} and 92.38 x10^6 cfu g^{-1}) was recorded in FYM +AZ+PSB+ KSB (T_8) followed by VC +AZ+PSB+ KSB (T_9) (38.65 x 10^6 cfu $g^{-1}$and 89.23 x 10^6 cfu g^{-1}) and the lowest population count was observed in control (T_{13}) (12.32 x 10^6 cfu $g^{-1}$and 14.98 x 10^6 cfu g^{-1}).

The pooled analysis of data showed that the highest potassium solubilising bacteria (KSB) count (67.63 x10^6 cfu g^{-1}) was observed in FYM +AZ+PSB+ KSB (T_8) followed by VC +AZ+PSB+ KSB (T_9) (63.94 x 10^6 cfu g^{-1}) and the lowest population count was observed in control (T_{13}) (13.65x 10^6 cfu g^{-1}).

4.2.7. Cladode analysis

4.2.7.1. Cladode Nitrogen (%)

It is clear from the data presented in Table 4.2.27 and Fig. 4.2.27 that significant influence was observed across treatments. The highest cladode nitrogen (2.24%) was recorded with FYM +AZ+PSB+ KSB (T_8) followed by NC +AZ+PSB+ KSB (T_{10}) (2.17%) and the minimum cladode nitrogen percentage was recorded in control (T_{13}) (1.23%) in the year 2018-2019. However, in the year 2019-2020, the highest cladode nitrogen (2.27%) was recorded with FYM +AZ+PSB+ KSB (T_8) followed by PM+AZ+PSB+ KSB (T_{11}) (2.17%) and the minimum cladode nitrogen percentage was recorded in control (T_{13}) (1.36%)

The pooled analysis data presented that cladode nitrogen from two years data showed that the highest (2.26%) was observed in FYM +AZ+PSB+ KSB (T_8) followed by (T_{10}) (2.14%), while the lowest (1.30%) was observed in control treatment (T_{13}).

4.2.7.2. Cladode Phosphorus (%)

Table 4.2.27 revealed that available cladode phosphorus varied significantly among different treatment. During 2018-2019, the highest cladode phosphorus

Table 4.2.26 : Effect of organic nutrient management on Azotobacter(AZ), Phosphate Solubilizing Bacteria (PSB), Potash Solubilizing Bacteria (KSB) count of experimental soil of dragon fruit orchard

Treatments	AZ count X 10^6cfu g^{-1}			PSB count X 10^6cfu g^{-1}			KSB count X 10^6cfu g^{-1}		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	9.56	14.12	11.84	14.32	26.51	20.42	19.11	29.54	24.33
T_2	6.72	8.38	7.55	12.54	17.92	15.23	18.98	28.92	23.95
T_3	6.57	9.27	7.92	13.19	22.34	17.77	18.92	26.85	22.89
T_4	7.32	10.54	8.93	13.87	19.78	16.83	17.85	27.56	22.71
T_5	18.79	29.46	24.13	9.87	12.67	11.27	14.82	22.12	18.47
T_6	7.18	10.12	8.65	15.98	45.78	30.88	16.47	24.87	20.67
T_7	9.32	12.48	10.90	10.69	15.73	13.21	25.87	49.87	37.87
T_8	32.46	89.64	61.05	21.18	62.93	42.06	42.87	92.38	67.63
T_9	28.97	65.32	47.15	27.89	58.76	43.33	38.65	89.23	63.94
T_{10}	34.78	72.19	53.49	12.54	42.38	27.46	34.98	72.36	53.67
T_{11}	30.18	79.46	54.82	24.32	52.39	38.36	31.84	78.48	55.16
T_{12}	22.67	34.71	28.69	17.78	38.92	28.35	24.56	52.36	38.46
T_{13}	5.12	6.13	5.63	8.86	10.86	9.86	12.32	14.98	13.65
SEm(±)	**0.634**	**1.312**	**0.578**	**0.536**	**1.179**	**0.781**	**0.602**	**1.072**	**0.594**
CD(0.05)	**1.852**	**3.829**	**1.687**	**1.566**	**3.442**	**2.280**	**1.758**	**3.130**	**1.734**

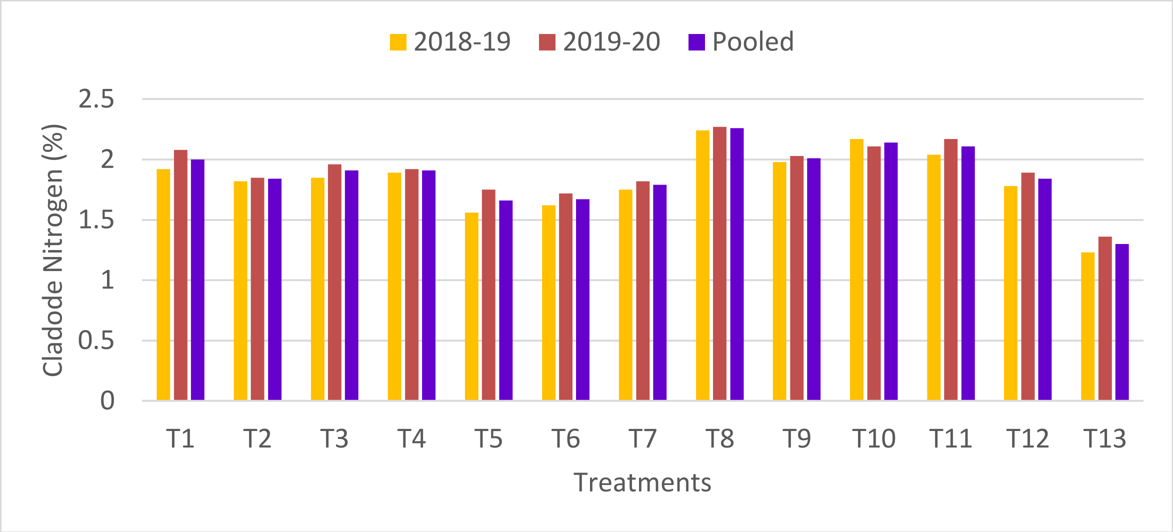


Fig. 4.2.27 Effect of organic nutrient management treatments on cladode nitrogen content

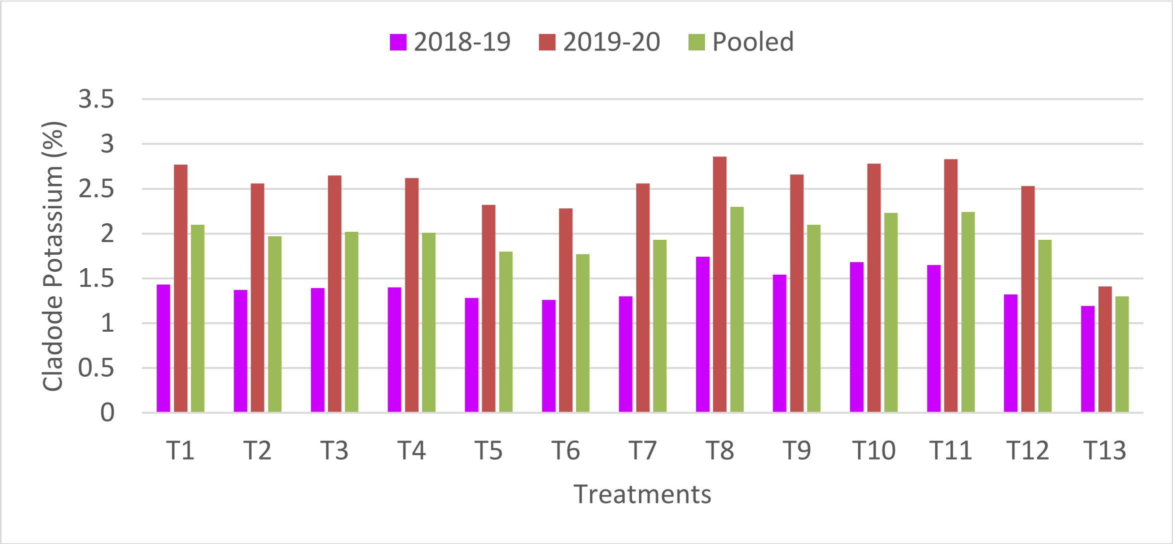


Fig. 4.2.28 Effect of organic nutrient management treatments on cladode potassium content

(0.25%) was recorded with FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11}) (0.23%)and the minimum cladode phosphorus percentage was recorded in control (T_{13}) (0.12%). During the second years of study 2019-2020, the highest cladode phosphorus (0.51%) was recorded with PM +AZ+PSB+ KSB (T_{11}) followed by FYM

+AZ+PSB+ KSB (T_8)(0.47%) and the minimum cladode phosphorus percentage was recorded in control (T_{13}) (0.19%).

The pooled analysis presented that cladode phosphorus percentage from two years data showed that the highest (0.37%) was observed in PM +AZ+PSB+ KSB (T_{11}) followed by FYM +AZ+PSB+ KSB (T_8)(0.36%), while the lowest (0.16%) was observed in control treatment (T_{13}).

4.2.7.3. Cladode Potassium (%)

From the data presented in Table 4.2.27 and Fig. 4.2.28 revealed that significant influence was observed across treatments for cladode potassium content. The maximum record for cladode potassium percentage (1.74%) was observed with FYM +AZ+PSB+ KSB (T_8) followed by NC +AZ+PSB+ KSB (T_{10}) (1.68%) and the lowest was recorded in control (T_{13}) (1.19%) during the first year of study (2018-2019). During the second years of study (2019-2020) the maximum record for cladode potassium percentage (2.83%) was observed with PM +AZ+PSB+ KSB (T_{11}) followed by NC +AZ+PSB+ KSB (T_{10}) (2.78%) and the lowest was recorded in control (T_{13}) (1.41%).

The pooled analysis presented that cladode potassium percentage from two years data showed that the highest (2.24%) was recorded with PM +AZ+PSB+ KSB (T_{11}) followed by NC +AZ+PSB+ KSB (T_{10}) (2.23%) and the lowest was recorded in control (T_{13}) (1.30%).

4.2.7.4. Cladode Fe (ppm)

Table 4.2.28 and Fig. 4.2.29 showed that significant influence was observed across treatments in iron content of the cladodes of dragon fruit plants. The maximum records for cladode iron (Fe) content (232.35ppm) was observed with PM +AZ+PSB+ KSB (T_{11}) followed by FYM +AZ+PSB+ KSB (T_8) (227.67ppm) and the lowest (105.64%) was in control (T_{13}) during the first year of experimental study while in the second years, the maximum record (296.60ppm) of cladode Fe content was observed under FYM +AZ+PSB+ KSB (T_8) followed by NC +AZ+PSB+ KSB (T_{10}) (288.50ppm) and the least was recorded in control (T_{13}) (115.45ppm).

Table 4.2.27 : Effect of organic nutrient management on cladode nitrogen, phosphorus and potassium content of dragon fruit plants

Treatments	Cladode Nitrogen (%)			Cladode Phosphorus (%)			Cladode Potassium (%)		
	2018-19	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**
T_1	1.92	2.08	2.00	0.21	0.37	0.29	1.43	2.77	2.10
T_2	1.82	1.85	1.84	0.19	0.32	0.26	1.37	2.56	1.97
T_3	1.85	1.96	1.91	0.19	0.35	0.27	1.39	2.65	2.02
T_4	1.89	1.92	1.91	0.20	0.33	0.27	1.40	2.62	2.01
T_5	1.56	1.75	1.66	0.15	0.28	0.22	1.28	2.32	1.80
T_6	1.62	1.72	1.67	0.16	0.23	0.20	1.26	2.28	1.77
T_7	1.75	1.82	1.79	0.17	0.29	0.23	1.30	2.56	1.93
T_8	2.24	2.27	2.26	0.25	0.47	0.36	1.74	2.86	2.30
T_9	1.98	2.03	2.01	0.22	0.39	0.31	1.54	2.66	2.10
T_{10}	2.17	2.11	2.14	0.22	0.45	0.34	1.68	2.78	2.23
T_{11}	2.04	2.17	2.11	0.23	0.51	0.37	1.65	2.83	2.24
T_{12}	1.78	1.89	1.84	0.18	0.31	0.25	1.32	2.53	1.93
T_{13}	1.23	1.36	1.30	0.12	0.19	0.16	1.19	1.41	1.30
SEm(±)	**0.114**	**0.041**	**0.089**	**0.023**	**0.029**	**0.019**	**0.066**	**0.080**	**0.065**
CD(0.05)	**0.334**	**0.120**	**0.259**	**0.067**	**0.084**	**0.055**	**0.193**	**0.233**	**0.190**

Table 4.2.28 : Effect of organic nutrient management on iron and manganese content of cladode of dragon fruit plants

Treatments	Cladode Fe (ppm)			Cladode Mn (ppm)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	192.38	198.78	195.58	324.00	155.80	239.90
T_2	179.42	189.48	184.45	331.90	277.40	304.65
T_3	186.54	201.30	193.92	332.00	262.20	297.10
T_4	182.79	191.30	187.05	342.30	225.40	283.85
T_5	137.58	172.60	155.09	245.00	141.20	193.10
T_6	158.72	135.80	147.26	238.50	134.70	186.60
T_7	168.39	188.80	178.60	196.20	133.90	165.05
T_8	227.67	296.60	262.14	329.60	227.70	278.65
T_9	198.75	249.40	224.08	437.60	328.60	383.10
T_{10}	219.83	288.50	254.17	529.30	584.90	557.10
T_{11}	232.35	253.80	243.08	363.40	239.30	301.35
T_{12}	176.48	182.38	179.43	271.60	125.20	198.40
T_{13}	105.64	115.45	110.55	112.20	114.20	113.20
SEm(±)	**1.289**	**1.291**	**0.826**	**3.352**	**2.172**	**2.065**
CD(0.05)	**3.762**	**3.767**	**2.412**	**9.785**	**6.341**	**6.028**

Table 4.2.29 : Effect of organic nutrient management on copper and zinc content of cladode of dragon fruit plants

Treatments	Cladode Cu (ppm)			Cladode Zn (ppm)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	7.84	10.35	9.10	45.32	46.72	46.02
T_2	9.05	11.17	10.11	38.23	40.60	39.42
T_3	9.36	11.18	10.27	41.46	42.29	41.88
T_4	9.11	13.55	11.33	42.59	44.28	43.44
T_5	7.45	9.32	8.39	35.36	38.08	36.72
T_6	8.37	9.14	8.76	37.32	37.14	37.23
T_7	8.66	10.32	9.49	36.70	38.76	37.73
T_8	10.46	11.52	10.99	58.13	67.17	62.65
T_9	10.80	14.59	12.70	48.83	54.27	51.55
T_{10}	11.50	14.36	12.93	46.19	56.32	51.26
T_{11}	9.53	16.21	12.87	60.30	61.34	60.82
T_{12}	7.10	9.36	8.23	37.86	39.23	38.55
T_{13}	6.98	7.47	7.23	23.21	32.94	28.08
SEm(±)	**0.198**	**0.531**	**0.299**	**0.606**	**0.626**	**0.360**
CD(0.05)	**0.578**	**1.549**	**0.871**	**1.769**	**1.828**	**1.051**

The pooled analysis presented that cladode Iron (Fe) content from two years data showed that the highest (262.14ppm) was observed under FYM +AZ+PSB+KSB (T_8) followed by (T_{10}) (254.17 ppm), while the lowest (110.55ppm) was observed in treatment control (T_{13}).

4.2.7.5. Cladode Manganese (ppm)

From the data shown in Table 4.1.27 it is obvious that there is a significant variation due to different treatments during the experimental study. The maximum records for cladode manganese content (529.30ppm) was observed with NC +AZ+PSB+ KSB (T_{10}) followed by PM +AZ+PSB+ KSB (T_{11}) (363.40ppm) and the lowest (112.20%) was in control (T_{13}) during the first year of experimental study while in the second years the maximum record (584.90ppm) of cladode Fe content was observed under NC +AZ+PSB+ KSB (T_{10}) followed by VC +AZ+PSB+ KSB (T_9) (328.60ppm) and the least was recorded in control (T_{13}) (114.20ppm).

The pooled analysis presented that cladode manganese (Mn) content from two years data showed that the highest (557.10ppm) was observed in NC +AZ+PSB+ KSB (T_{10}) followed by VC +AZ+PSB+ KSB (T_9) (383.10ppm) while the lowest (113.20ppm) was observed in control treatment (T_{13}).

4.2.7.6. Cladode Copper (ppm)

From the Table 4.2.27, it is clear that significant variation was observed due to different treatments during the experimental study. The maximum records for cladode copper content (11.50ppm) was recorded in NC +AZ+PSB+ KSB (T_{10}) which was followed by VC +AZ+PSB+ KSB (T_9) (10.80ppm) and the minimum cladode copper content (6.98ppm) was recorded in control (T_{13}) during the first year 2018-2019. While, in the second years (2019-2020), the maximum record (16.21ppm) of cladode copper content was observed under PM +AZ+PSB+ KSB (T_{11}) followed by VC +AZ+PSB+ KSB (T_9) (14.59ppm) and the minimum cladode copper content was recorded in control (T_{13}) (7.47ppm).

The pooled analysis presented that cladode copper content from two years data showed that the highest (12.93ppm) was observed with NC +AZ+PSB+ KSB

(T_{10}) followed by PM +AZ+PSB+ KSB(T_{11}) (12.87ppm) and the lowest cladode copper content was recorded in control (7.23 ppm).

4.2.7.7. Cladode Zinc (ppm)

Significant variation in cladode zinc content was observed due to different treatments during the experimental study. The maximum records for cladode zinc content (60.30ppm) was recorded in PM +AZ+PSB+ KSB (T_{11}) which was followed by FYM +AZ+PSB+ KSB (T_8) (58.13 ppm) and the lowest cladode zinc content was recorded in control (T_{13}) (23.21 ppm) during the first year of study (2018-2019). The maximum records for Cladode zinc content (67.17ppm) was recorded in FYM +AZ+PSB+ KSB (T_8) which was followed by PM +AZ+PSB+ KSB (T_{11}) (61.34 ppm) and the lowest cladode zinc content was recorded in control (T_{13}) (32.94ppm) during the second years of study (2019-2020).

The pooled analysis presented that cladode zinc content from two years data showed that the highest (62.65ppm) was observed with FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11}) (60.82ppm) and the lowest cladode zinc content was recorded in control (28.08 ppm).

4.2.7.8. Cladode carbohydrate (%)

Results of the impact of different nutrient treatments on dragon fruits showed in Table 4.2.30 revealed that the highest cladode carbohydrate percentage (3.09% and 3.98%) was observed in FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11}) (2.84% and 3.65%) and the minimum cladode carbohydrate percentage was observed in control (T_{13}) (0.89% and 0.97) for two consecutive years.

The pooled data analysis presented that cladode carbohydrate percentage from two years showed that the highest (3.54%) was observed under FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11}) (3.25%), and the lowest cladode carbohydrate percentage content was recorded in control (0.93%).

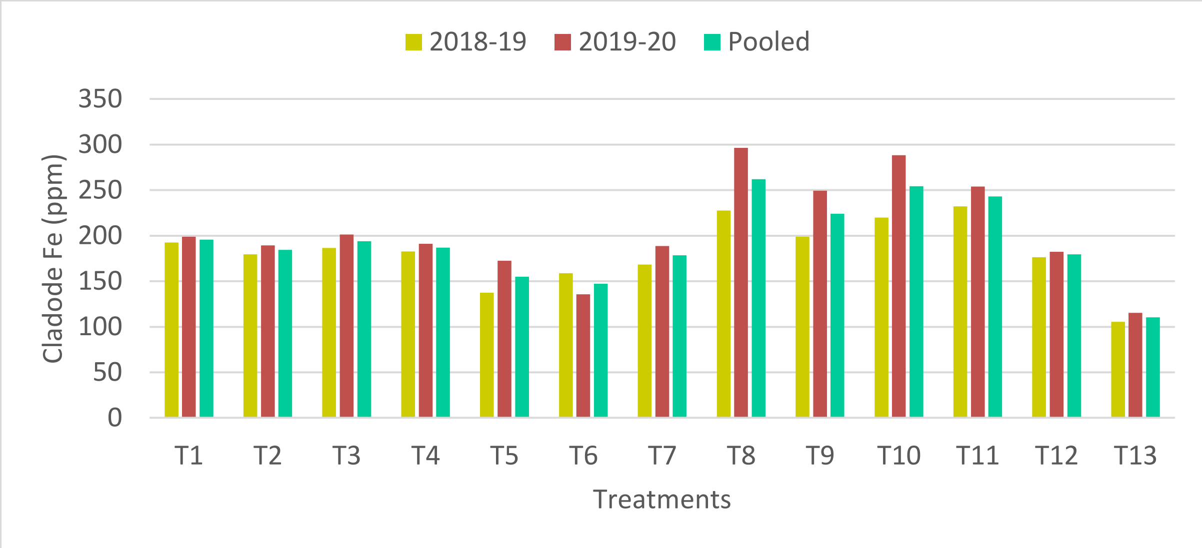


Fig. 4.2.29 Effect of organic nutrient management treatments on cladode iron content

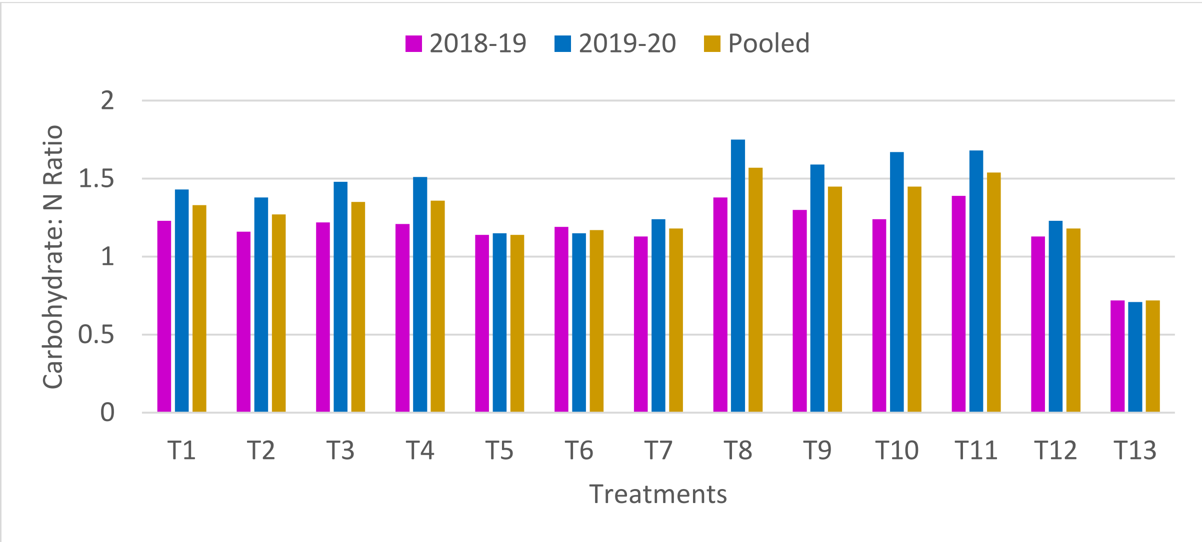


Fig. 4.2.30 Effect of organic nutrient management treatments on cladode carbohydrate: nitrogen ratio

4.2.7.9. Cladode Carbohydrate: Nitrogen (C: N) ratio

Carbohydrate: Nitrogen (C: N) ratio of cladode of dragon fruit showed significant variation among each treatment shown in Table 4.2.30 and Fig. 4.2.30. It revealed that the highest cladode C: N ratio (1.39) was observed in PM +AZ+PSB+ KSB (T_{11}) followed by FYM +AZ+PSB+ KSB (T_8) (1.38) and the lowest was observed in control (T_{13}) (0.72) in the year 2018-2019. Whereas, in the second year of study (2019-2020), the maximum C:N ratio was recorded in FYM +AZ+PSB+ KSB (T_8) (1.75) followed by (T_{11}) (1.68%) and the lowest was observed in control (T_{13}) (0.71).

The pooled data analysis presented that cladode carbohydrate: nitrogen ratio from two years showed that the highest ratio (1.57) was observed under FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11}) (1.54) and the lowest cladode carbohydrate: nitrogen ratio was recorded in control (T_{13}) (0.72).

4.1.7.10 Cost Benefit analysis

Perusal of the data presented in Table 4.1.31 showed that the highest gross expenditure was obtained with VC +AZ+PSB+ KSB (T_9) (Rs 830128.75) followed by T_2(Vermi compost (VC) (Rs 768253.75) and the lowest gross expenditure was in control (T_{13}) (Rs 342760.00). Whereas, the highest gross income was observed in FYM +AZ+PSB+ KSB (T_8) (Rs 2002500.00) followed by NC +AZ+PSB+ KSB (T_{10}) (Rs 1425000.00) and the lowest gross income was in control (T_{13}) (Rs 162500.00). Therefore, the highest net income was obtained with FYM +AZ+PSB+ KSB (T_8) (Rs 1295846.25) followed by PM +AZ+PSB+ KSB (T_{11}) (Rs 851746.25) and the lowest net income was in control (T_{13}) (Rs -180260.00). Among all the treatment, the highest benefit to cost ratio was obtained in FYM +AZ+PSB+ KSB (T_8) (1.83) followed by (PM +AZ+PSB+ KSB (T_{11}) (1.73) and the lowest benefit to cost ratio was observed in control (T_{13}) (-0.53).

Table 4.2.30 : Effect of organic nutrient management on carbohydrate and carbohydrate: nitrogen (C:N) ratio of cladode of dragon fruit plants

Treatments	Carbohydrate (%)			Carbohydrate: N Ratio		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	2.37	2.98	2.68	1.23	1.43	1.33
T_2	2.11	2.56	2.34	1.16	1.38	1.27
T_3	2.25	2.91	2.58	1.22	1.48	1.35
T_4	2.28	2.89	2.59	1.21	1.51	1.36
T_5	1.78	2.01	1.90	1.14	1.15	1.14
T_6	1.92	1.98	1.95	1.19	1.15	1.17
T_7	1.98	2.25	2.12	1.13	1.24	1.18
T_8	3.09	3.98	3.54	1.38	1.75	1.57
T_9	2.58	3.23	2.91	1.30	1.59	1.45
T_{10}	2.69	3.52	3.11	1.24	1.67	1.45
T_{11}	2.84	3.65	3.25	1.39	1.68	1.54
T_{12}	2.01	2.32	2.17	1.13	1.23	1.18
T_{13}	0.89	0.97	0.93	0.72	0.71	0.72
SEm(±)	**0.052**	**0.098**	**0.067**	**0.067**	**0.082**	**0.059**
CD(0.05)	**0.153**	**0.287**	**0.195**	**0.195**	**0.241**	**0.174**

Table 4.2.31 : Effect of organic nutrient management on cost: benefit ratio of dragon fruit cultivation

Treatment	Gross expenditure (Rs)	Gross income (Rs)	Net income (Rs)	B:C ratio
T_1	644778.75	1175000.00	530221.25	0.82
T_2	768253.75	830000.00	61746.25	0.08
T_3	697922.50	925000.00	227077.50	0.33
T_4	431378.75	922500.00	491121.25	1.14
T_5	370810.00	522500.00	151690.00	0.41
T_6	370810.00	537500.00	166690.00	0.45
T_7	370810.00	647500.00	276690.00	0.75
T_8	706653.75	2002500.00	1295846.25	1.83
T_9	830128.75	1180000.00	349871.25	0.42
T_{10}	759797.50	1425000.00	665202.50	0.88
T_{11}	493253.75	1345000.00	851746.25	1.73
T_{12}	412060.00	722500.00	310440.00	0.75
T_{13}	342760.00	162500.00	-180260.00	-0.53

* Calculated based on one hectare land.

4.3 Discussion

Dragon fruit cultivation is very suitable in the agro-climatic condition in Mizoram. It cultivation has grown so much in the recent year and became one of the most popular commercially cultivated fruit crop in the state and dragon fruit production is continuously gaining popularity for local, intra state and export market demand of the fruit. However, commercial dragon fruit cultivation is still new venture, which still not available the systematic protocol on integrated nutrients management and organic nutrients management for dragon fruit at Mizoram condition. So, the current study 'Standardization of integrated nutrient management and organic nutrient management for dragon fruit production in Mizoram' was conducted so that the standardized nutrient management protocol can be able to use for farmer's practice. Current investigation results described in previous chapter have been discussed below along with recent research support findings.

4.3.1 Experiment No.1: Integrated nutrients management of dragon fruits

For integrated nutrient management of dragon fruit different nutrients were applied in the form of chemical fertilizer viz. urea, muriate of ppotash (MOP) and single super phosphate (SSP) and organic manure viz. farm yard manure (FYM), vermi-compost (VC), neem cake (NC), poultry manure (PM) along with bio-fertilizer like Azotobacter (AZ), Phosphate Solubilizing Bacteria (PSB) and Potash Solubilizing Bacteria (KSB) were applied to plants to check the influence on dragon fruit growth and development.

Significant differences were observed related to dragon fruit plant growth and development under integrated nutrients application. The maximum cladode length was observed in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) followed by FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB (T_{12}) in both years of study. However, calculated percentage promotion of cladode length over initial showed the longest cladode length promotion percentage was observed in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) followed by (T_{11}) during 2018-2019. Whereas, in 2019-2020 the maximum cladode length promotion percentage was observed in T_2 (Farm Yard Manure (FYM) to supply 50% K+ 50% RDF) followed by T_1 (Recommended dose of fertilizer (RDF) as 100% inorganic). While the maximum cladode circumference was observed in Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_5) followed by FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) in both years of experimental study. Whereas, Cladode circumference percentage promotion over initial revealed the maximum was observed in T_1 (Recommended dose of fertilizer (RDF) as 100% inorganic) followed by NC to supply 50% K+ 50 % RDF+AZ+PSB+ KSB(T_7) during 2018-2019 and in the second year 2019-2020 the maximum cladode circumference promotion percentage was observed in T_7 (NC to supply 50% K+ 50 % RDF+AZ+PSB+ KSB) followed by T_3 (Vermicompost (VC) to supply 50% K+ 50% RDF). It was found that the maximum number of cladode per plants was observed in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50%RDF+AZ+PSB+ KSB) for both years, where the second highest was in FYM to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_5) during 2018-2019 but in 2019-2020 the second highest was found in FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB (T_{12}). Soil nutrients status was significantly influenced by the application of combine treatment of organic, inorganic and bio-fertilizer in the improvement of plants growth development. Our findings are in agreement with Gautam *et al.* (2012) in mango cv. Sunderja that maximum increase in plant height, number of branches, canopy spread was obtained with the application of N:P:K + vermicompost + FYM. Similar results were reported by Gupta *et al.* (2017) in Guava. Yadav *et al*. (2011b) in papaya and Singh and Sadawarti (2021) in strawberry reported that combined application of N:P:K + Vermicompost + Azotobactor improved the plant growth development. Significant superior results observed by the application of nitrogen and vermicompost in various plant growth characters, Pareek *et al.* (2017) opined that application of nitrogen and vermi-compost provides nutrients for better development of a plant growth. Vermicompost contains all the major and micro nutrients which were essential for plants development along with micro-organism which improved the physical, chemical and biological properties of soil along with its moisture holdings capacity. Plant growth improvement could be due to large increase in soil microbial mass after application of vermi-compost. Whereas nitrogen application also show significant influence on plant growth and also boost the photosynthetic activity of the plant and greater synthesis of carbohydrate in the leaves which in turn favour better development of plants. Similar findings by the application of inorganic fertilizer and vermicompost have also been reported by Mishra *et al.* (2011). Vishwakarma *et al.* (2017) reported in bael cv. Narendra Bael-9 that maximum growth character like plant height, plant girth and plant spread (E-W and N-S) was resulted with the application of NPK in combined with FYM and Azotobacter + PSB. Goramnagar *et al.* (2000) in Nagpur orange found that tall bushy plants with increased leaf area, spread and good scionic relationship was observed with plant treated with FYM and inorganic fertilizer. Ram *et al.* (2007) reported in case of guava that combined application of FYM and N:P:K along with bio-fertilizer produced maximum increases in plant height , plant spread E-W & N-S. Sharma *et al*. (2014) reported in custard apple cv. Arka Sahan in terms of growth parameters likes plant height, rootstock girth, scion girth, plant spread, and number of primary branches per plant were significantly improved in plants which received treatment comprising of 50% RDF + 50% N through vermicompost and bio fertilizers (Azotobacter 50 g + PSB 50 g + VAM 20 g). Kushwah *et al.* (2018) reported in strawberry cv. Chandler that maximum plant height, number of leaves and petiole length was observed with application of N:P:K + Vermicompost + Azotobacter + PSB. Shukla *et al*. (2009) also reported that 50% RDF of NPK + 50 kg FYM + 250 g Azotobacter observed significant improvement in canopy volume in guava plants.

Result depicted significant difference among each treatment related to fruit growth and development under integrated treatment. Dragon fruit treated with FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) had maximum number of flower per pillar (No.), number of fruit per pillar (No.) which was followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) in both the experimental years and in pooled analysis date. FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+

KSB (T_8) was also found with highest percentage of fruit set and lowest with percentage of flower bud drop. Similarly, maximum number of yield per pillar, yield per hectare and longest day from fruit set to maturity was observed in (T_8) which was followed by (T_{12}) in both the experimental years and in pooled. It was found that significant improvement was recorded in plant applied with inorganic fertilizer, vermicompost and FYM along with bio-fertilizer. Vermi-compost was superior over other organic sources in improving vegetative growth, flowering, fruiting, yield and fruit attributes and fruit quality along with improvement in soil fertility and leaf nutrient status of the guava plant (Naik *et al.*, 2007). The application of vermicompost along with inorganic sources of NPK showed significant improvement in plant growth, fruit yield per tree and reduce the number of fruit drop in ber. These may be due to the translocation of nutrients from soil and enhanced supply of essential nutrients during plant growth and microbial deposition (Mishra *et al*., 2011). Kamatyanatti *et al* (2019) found out that the plants which received NPK + vermicompost + FYM+ Biofertilizers recorder maximum number of flower, number of fruit set, fruit yield. Jamwal *et al.* (2018) reported that guava plants has maximum in number of fruits/tree , average fruit weight, fruit length , fruit diameter, fruit volume, fruit yield/tree, fruit yield/ha when treated with Azotobacter + 75% Nitrogen through urea + 25 % Vermicompost. Baraily and Deb (2018) found out that application of vermicompost + N:P: K and bio-fertilizers in pineapple increase in higher fruiting, maximum yield with higher nutrients uptake and more flowering. Gupta and Sangma (2017) reported that maximum number of flowers per plant, fruit set were recorded with the application of 50% RDN through chemical fertilizer +50% RDN through vermicompost.

From the experimental study, it was clearly showed that the maximum fruit length was observed in plants treated with T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) in the year 2018-2019. Whereas, T_{10} (VC to supply 25% K + NC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) recorded maximum fruit length during 2019-2020 and from pooled data. FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) also gives maximum fruit diameter in both the experimental years and in pooled analysis data. Regarding fruit weight FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB(T_8) showed maximum fruit weight during 2018-2019 and in pooled analysis, but during 2019-2020 maximum fruit weight was observed in FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB (T_{12}), pooled data from both years showed that maximum fruit diameter was observed in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB(T_8) while the lowest was in T_{13} (control) . Plants at (T_{12}) FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB showed maximum fruit volume in both years of study and in pooled analysis. Significantly heavier pulp weight was observed in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) in the year 2018-2019 as well as in and pooled. During 2019-2020 highest was observed in FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB (T_{12}). In case of pulp recovery the highest pulp recovery percentage was observed with T_9 (FYM to supply 25% K + NC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) during both years of experimental study and in pooled. Regarding peel weight the lowest was in control (T_{13}) for both year and in pooled. While the highest was observed in T_1 (Recommended dose of fertilizer (RDF) as 100% inorganic) during the first year of study and in pooled analysis, but during the second year of study the highest was observed in T_5 (Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB)). In case of peel thickness the highest was found in T_4 (Neem Cake (NC) to supply 50% K+ 50% RDF) during the first year of experimental study and in pooled, while in the second year of study (2019-2020) it was observed in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB). Specific gravity was found highest in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) during 2018-2019 and in pooled analysis while in 2019-2020 the highest was found in T_7 (NC to supply 50% K+ 50 % RDF+AZ+PSB+ KSB). In case of pulp: peel ratio T_9 (FYM to supply 25% K + NC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) was found highest in both the experimental years and in pooled analysis. Gautam *et al.* (2012) reported that mango cv. Sunderja plant treated with N:P:K +FYM+ Vermicompost gave maximum number of fruit weight, number of fruits, fruit length, diameter, pulp weight and yield. Patel *et al.* (2022) revealed that plants which received 100% NPK soil analysis basis + 100 kg FYM per tree showed maximum physical parameters viz., fruit weight, fruit length, fruit diameter and fruit volume. This result might be due to increase in morphological character which influenced the growth of physical parameter like increase in cladode might improve the photosynthetic activity and synthesis of carbohydrates which in turn promoted the weight of fruits. Kuttimani *et al.* (2013), Pattar *et al*. (2018) and Patil and Shinde (2013) also reported similar finding in banana. Talang *et al.* (2017) found that the application of N:P: K+ 50 kg FYM + 5 kg Vermicompost + 100 g of Potassium mobiliser has observed the highest fruit weight. Gupta and Sangma (2017) found that maximum number of fruit weight, fruit length, fruit diameter, fruit volume and specific gravity, were recorded with the application of 50% RDN through chemical fertilizer +50% RDN through vermicompost. Binepal *et al*. (2013) revealed that the application of 100% N + 100% P_2O_5 + Azospirillum + PSB + 10 kg vermicompost significantly influenced the fruit quality parameter like fruit length, fruit diameter, fruit volume, pulp weight, specific gravity of guava, application of combined nutrients attributed to the translocation of essential nutrients to the plants from soil and enhanced the availability of macro and micro nutrients which in turn enhanced physical characters of the fruit during entire growing season. This finding are in conformation with Dey *et al.* (2005), Kumar *et al.* (2008), Athani *et al.* (2007) and Dwivedi *et al*. (2010) also reported similar results in guava.

Significant differences were observed in fruit bio-chemical parameter among each treatment during the experimental study under integrated nutrients management. The maximum TSS was observed with T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) during 2018-2019, while during 2019-2020 and pooled analysis of data showed the highest TSS was observed in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8). T_6 (VC to supply 50% K + 50% RDF+AZ+PSB+ KSB) was found highest with TSS: Acid ratio during the first year of study and pooled analysis while during the second year of study FYM to supply 25% K + VC to supply 25% K+ 50%

RDF+AZ+ PSB + KSB (T_8) was found highest. However, maximum acidity was observed in T_1 (Recommended dose of fertilizer (RDF) as 100% inorganic) in both the experimental years and in pooled. During 2018-2019 and pooled analysis showed the highest total sugar was found in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) while 2019-2020 years highest was recorded in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8). In case of reducing sugar the highest was found in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) during the first year of study and in the second years and from pooled data the highest was observed in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8). Ascorbic acid was observed highest in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) during the first year of study and in the second years and in pooled analysis the highest was observed in T_5 (Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB)). Related to peel anthocyanin content the highest was found in Farm Yard Manure (FYM) to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_5) in both the experimental years and in pooled analysis. Whereas, pulp anthocyanin content was observed highest in T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) during 2018-2019 and in the year 2019-2020 and in pooled analysis the highest was observed with FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB + KSB (T_8). Our findings are closely conformity with the findings of Gupta and Sangma (2017) reported in guava that application of 50% RDN through chemical fertilizer +50% RDN through vermicompost observed superior result of maximum TSS value, ascorbic acid and minimum titratable acidity. Sharma *et al.* (2013) found that maximum TSS content and total sugar were observed with that application of Azotobacter along with 50% of N/tree through FYM + 50% of N/tree through inorganic fertilizerin guava plants. Talang *et al.* (2017) recorded the highest TSS, lowest acidity content, highest total sugars, ascorbic acid and beta-carotene content was highest with plants treated with N:P:K + 50 kg FYM + 5 kg Vermicompost +

Potassium mobiliser. Application of vermicompost may attributed to better morphological growth which might improve the accumulation of higher ascorbic, sugars and less acidity content. Patel and Naik (2010) reported in sapota that plant that received vermicompost+ N:P:K significantly gave highest TSS, reducing sugar, non-reducing sugar, acidity and ascorbic acid content. Bohane *et al.* (2016) found that application of 50% RDF through NPK + vermicompost + 50 g Azotobacter + 50 g PSB significantly influenced the TSS content, ascorbic acid, reducing sugar, non-reducing sugars, total sugars, TSS/acid ratio and chlorophyll content in ber. Goswami *et al*. (2012) reported in guava that production of quality fruits are enchanced by the application of half dose of recommended fertilizer along with bio-fertilizer and FYM. Raghavan *et al.* (2018) found that quality fruit parameter like total sugar, reducing sugar in litchi was attained with the supply of N:P:K + FYM+ Azotobacter+ PSM+VAM. Kanwar *et al.* (2020) reported that maximum TSS, reducing sugar percentage, minimum acidity, total sugar (%), reducing sugar, ascorbic acid and minimum acidity was found in plant with the application of 75% RDF of N:P:K + 10 kg Vermi-compost + 100 g Azotobacter +100 g PSB per Plant. Kour *et al*. (2019) reveals that maximum TSS, TSS /acid ratio, total sugars, reducing sugars and non-reducing sugars were observed with the application of 50% nitrogen per tree through FYM + 50 % through urea augmented with Azotobacter. Meena *et al*. (2018) reported in guava that maximum TSS content of, minimum acidity, highest TSS/acid, ascorbic acid content, reducing sugars, non-reducing sugar, and total sugar was observed with plant treated with the application of 10 kg vermicompost + 5 kg neemcake + 25 % recommended dose of NPK + 20g PSB. This is conformity with the finding of Ram *et al*. (2007) in guava. Shukla *et al*. (2009) reported that maximum TSS, ascorbic acid, reducing sugar, total sugars were observed with the combined application of organic manures (FYM, vermi-compost and organic mulch), inorganic fertilizers (NPK), bio-fertilizers (Azospirillum, Azotobacter, Pseudomonas flourescenceAspergillusniger etc.) in guava fruits.

Experimental study of integrated nutrients management of dragon fruits showed significant variation among soil analysis. The highest soil pH was observed in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8)

in the year 2018-2019 and in pooled analysis data, while T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ +PSB+ KSB) showed highest in the second years of study. Organic carbon showed highest with FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) in both the experimental years and in pooled. Similarly, organic carbon and C: N ration was observed highest in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) for both the experimental years and from pooled analysis. Similarly, The available soil nitrogen, potassium and zinc was found highest in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) for both the experimental years and pooled data. Whereas, phosphorus content was found highest in FYM to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_5) during 2018-2019. Whereas, during the second year 2019-2020 the highest was observed in FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB (T_{12}) but pooled analysis data showed the highest was observed in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8). Regarding the iron content of experimental soil The highest was observed in FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB (T_{12}) during 2018-2019 and in the second year 2019-2020 and pooled data the highest was found in FYM to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_5). In case of manganese content in soil the pooled analysis from two years data showed that the highest available manganese in the experimental soil was observed in treatment control (T_{13}) followed by (T_3), while the lowest was observed in FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB (T_{12}). However, copper was found highest with control (T_{13}) followed by T_3 (Vermi compost (VC) to supply 50% K+ 50% RDF). Soil analysis data revealed that application of chemical fertilizers + organic manure and bio-fertilizer were found to be significantly superior over the application of 100% RDF of NPK. Our findings are in similar with Meena *et al*. (2018) revealed that application of VCM + neemcake + NPK + PSB showed higher fertility status of the soil in N:P:K content of soil. Talang *et al.* (2017) found that application of integrated nutrients significantly enhanced the soil nutrients status and reported that maximum nitrogen, phosphorus and potassium content in the soil was recorded with the application of N:P:K + FYM + Vermicompost + Potassium mobiliser. Raina *et al*. (2011) reported that soil nutrients content nitrogen, phosphorus and potassium, zinc, iron and soil organic carbon was observed maximum with the application of FYM, vermicompost and chemical fertilizers. Korwar *et al.* (2006) reported that used of inorganic fertilizer with FYM along with vermicompost recorded highest available nitrogen, phosphorus and potassium. Sharma *et al.* (2013) revealed that highest soil available nitrogen, phosphorous, potassium, calcium and magnesium were obtained with the treatment of inorganic fertilizer along with FYM and Azotobacter in guava. Trivedi *et al.* (2012) reported that maximum available phosphorus and potassium were observed with application of bio-compost. Incorporation of bio-fertilizer recorded maximum available phosphorus content in the soil.

From the experimental study integrated nutrients management of dragon fruits showed significant variation related to soil microbial counting and the maximum *Azotobacter* count was observed in FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB (T_{12}) in the first years of study, while in the second year of study and pooled analysis data showed maximum *Azotobacter* count was recorded in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB). Whereas, the highest Phosphate Solubilizing Bacteria (PSB) count was observed in FYM to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_5) during 2018-2019, during the second year 2019-2020 and from pooled data it was clear that the highest was in FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB (T_{12}). Potash Solubilizing Bacteria (KSB) count was found highest in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) in both years of study and pooled data. Our finding are in support with Bakshi *et al*. (2017) found that maximum Azotobacter count, bacterial counts and fungal counts were recorded with the application of full doze of nitrogen through vermicompost along with Azotobacter. Marathe *et al.* (2012) found that application of FYM, vermi-compost along with wheat straw on nitrogen equivalent basis and green manuring with sun hemp as singly or in combination with inorganic or bio-fertilizers like Azotobacter and PSB increased the microbial population in the soil. Patel *et al.* (2009) found that maximum microbial count was observed with the application of full dose of recommended NPK along with farm yard manure. Kour *et al.* (2019) also opined that the application of organic matter influenced the increase growth and multiplication of Azotobacter and reported that maximum Azotobacter, bacterial and fungal population was observed in soil with the application of full dose of nitrogen through FYM augmented with Azotobacter. The present results are in agreement with the findings of Kuttimani *et al.* (2013) who reported that application of organic manures enhanced the microbial biomass (fungi and bacteria) than inorganic fertilizers because they increase the proportion of liable carbon and nitrogen directly by stimulating the activity of microorganism.

In the present study, the highest cladode nitrogen, potassium and zinc was observed with FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) in both the experimental years and from pooled analysis. While the highest cladode phosphorus was observed in FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB (T_{12}). In case of Cladode Iron and Cladode manganese the maximum percentage was observed in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8) during 2018-2019 and Pooled data whereas during 2019-2020 the highest was observed in FYM to supply 50% K+ 50% RDF+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_5). Copper content of cladode of dragon fruit plants showed highest was observed in control (T_{13}) and lowest cladode copper content was found with plant treated with FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8). Regarding carbohydrate content of cladode of dragon fruit, the highest was found in FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB (T_{12}) during the first year of study, while in the second years of study and from pooled analysis data the highest was observed in FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB (T_8). Carbohydrate: Nitrogen ration was observed highest in

FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF +AZ+PSB+ KSB (T_{12}) in two consecutive years of study and from pooled analysis data. Sharma *et al.* (2013) found in guava the maximum leaf nitrogen, phosphorous, potassium, calcium and magnesium contents was reported with the application of Azotobacter + 50% of N/tree through FYM + 50% of N/tree through inorganic fertilizer. Bakshi *et al*. (2017) reported that highest leaf nitrogen, calcium and magnesium were recorded with the application of Azotobacter + 25% nitrogen as vermicompost and 75% nitrogen as urea whereas higher phosphorus was found with plant treated with 50% N as vermicompost and urea along with Azotobacter while maximum leaf potassium were found with full dose of Nitrogen as vermicompost along with azotobacter application. Trivedi *et al.* (2012) reported that addition of vermi-compost resulted in the maximum nitrogen uptake and application of FYM obtained maximum phosphorus uptake and organic carbon content in the soil. Thakur *et al*. (2015) found that maximum phosphate solubilizing bacteria (PSB) count was reported with the application of inorganic fertilizer NPK along with bio-fertilizers and Green manuring. Whereas, application of 50% NPK+ Biofertilizers (60 g each tree/basin)+Green manuring (Sun hemp @ 25 g seeds tree/basin)+40 kg of FYM +11.5 kg of Vermicompost showed maximum Azotobacter count. Marathe *et al.* (2012) reported that highest concentration of nitrogen, phosphorus and potassium, magnesium, zinc and copper in the leaves with the combined application of FYM along with inorganic fertilizers and calcium with green manure with sun hemp along with inorganic fertilizers. Sole application of FYM to supply 100% N recorded highest manganese and iron contents in sweet orange. Shukla *et al*. (2009) found that in guava that nitrogen, phosphorus and potassium content of the leaf were significantly influenced by the combined application of 50% RDF of NPK + 50 kg FYM + 250 g Azotobacter.

Among all the treatment, benefit:cost ratio was also influenced by different nutrients combinations. Therefore, the highest Gross Expenditure was obtained with T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB) and the highest gross income, highest net income was recorded in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50%

RDF+AZ+PSB+ KSB) followed by T_{12} (FYM to supply 25% K+ VC to supply 25% K+ NC to supply 25% K + 25% RDF+AZ+PSB+ KSB). Therefore, highest benefit to cost ratio was obtained in T_8 (FYM to supply 25% K + VC to supply 25% K+ 50% RDF+AZ+PSB+ KSB) followed by T_1 (Recommended dose of fertilizer (RDF) as 100% inorganic) and the lowest benefit to cost ratio was observed in control (T_{13}). Our findings are in support with Talang *et al.* (2017) reported that the highest benefit: cost was observed in half RDF (1000 : 500 : 1000 g NPK/tree/year) + 50 kg FYM + 5 kg Vermicompost + 100 g potassium mobiliser while lowest was recorded in control. Our findings are also in agreement with Gupta and Sangma (2017) concluded that the application of 50% RDN through chemical fertilizer +50% RDN through vermicompost was superior and economically viable as compare to other treatments with a maximum cost benefit (C:B) ratio. Pandey *et al.* (2013) reported that application of FYM along with RDF gave highest net return with B:C ration.

4.3.2 Experiment No.2: Organic nutrients management of dragon fruits.

Among all the treatment, the highest cladode length (cm) was observed with FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11}) and lowest was in control (T_{13}) at 15MAP as well as at 30MAP. Plants at (T_8) FYM +AZ+PSB+ KSB showed maximum percentage promotion of cladode length over initial (%) at 15MAP as well as at 30MAP followed by Potash Solubilizing Bacteria (KSB)(T_7) at 15MAP which is during the first year of study while in the second year of study i.e 30MAP second highest was observed in PM +AZ+PSB+ KSB (T_{11}). Maximum cladode circumference (cm) and maximum percentage promotion of cladode circumference over initial was observed highest in FYM +AZ+PSB+ KSB (T_8) at 15MAP as well as at 30MAP. Maximum number of cladode per plants (No.) was observed highest in FYM +AZ+PSB+ KSB (T_8). Farmyard manure holds a major stand among organic manures. FYM act as a nutrient which increased plants growth and yield as it supplies nitrogen, phosphorus and potassium to plants through biological decomposition (Prasad *et al.* (2017). Mahadeen (2009) observed that the higher fruit yield was recorded with the application of FYM along with organic fertilizer as compared with the untreated plot. Lakpale *et al.* (2003) reported that the maximum growth regarding the number of branches per plant and pod yield was observed with the application of FYM. Rana *et al*. (2007) reported that effect of inorganic fertilizer and FYM resulted in significant increase in plant height, number of pods plant^{-1}, number of seeds pod^{-1} and yields. Gogoi *et al.* (2004) found that application of PSB along with single super phosphate significantly increased the growth and yield parameters in banana due to more availability of phosphorous. Ghosh *et al.* (2012) reported that FYM (20kg/ plant) result in highest basal girth and canopy spread.

From the experimental study, it can be concluded that the maximum number of fruit per pillar, number of flowers per pillar, percentage of fruit set, and yield was recorded in treatment FYM +AZ+PSB+ KSB (T_8) and the minimum was obtained in plant under treatment control (T_{13}) for two consecutive years as well as pooled data. On the other hand, plant at FYM +AZ+ PSB+KSB (T_8) showed that the lowest flower bud drop. However, the highest was recorded under treatment control (T_{13}). Longest maturity days was observed with NC +AZ+PSB+ KSB (T_{10}) during the first year of study and in the second year and pooled data showed the highest was observed with VC +AZ+PSB+ KSB (T_9). Ram *et al.* (2007) observed that maximum number of fruits and yield was obtained with application of FYM inoculated with *Azotobacter*. Similar finding are also reported by Dutta *et al.* (2010) reported that application of FYM along with Bio-fertilizer showed maximum increased in the physico-chemical qualities of fruits and growth parameter of papaya plants. Ghosh *et al.* (2012) observed that FYM performed better regarding the improvement in plant growth and fruit production as compared to vermicompost. The finding are in agreement with Anubha *et al.* (2013) observed that application of FYM resulted in maximum fruit set, fruit retention, fruit yield and minimum fruit drop in litchi. Pattanayak *et al.* (2001) reported Azotobacter inculation enhanced fruit yield but when FYM is added at it resulted in more production of fruit yield. Dahama (2007) reported that application of Azotobacter increased the yield of wheat, rice, maize, pearl millet and sorghum by 0-30% over control. Our findings are also in support with Yadav and chaudhauri (1994).

From the experimental study, the pooled data clearly showed that the maximum fruit length, fruit diameter, fruit weight, fruit volume, pulp weight, pulp recovery was observed in treatment FYM +AZ+PSB+ KSB (T_8) and the minimum was obtained in plant under treatment control (T_{13}). However, peel weight and peel thickness showed significant varied among treatment where the highest peel weight were recorded in PM +AZ+PSB+ KSB (T_{11}) in the first year of study 2018-2019. During the second years 2019-2020 highest peel weight were observed in NC +AZ+PSB+ KSB (T_{10}). From the pooled analysis the highest peel weight was observed in PM +AZ+PSB+ KSB (T_{11}) and minimum peel weight was recorded in T_{13} (control). The highest peel thickness was observed in plant treated with Poultry Manure (PM) (T_4) in the first year of study 2018-2019 and in the second year 2019-2020 the highest was recorded in NC +AZ+PSB+ KSB (T_{10}). However the minimum peel thickness was observed in control (T_{13}). Pooled data for both years showed that the highest peel thickness was recorded in AZ+PSB+ KSB (T_{12}) and minimum pulp thickness was observed in control (T_{13}). Maximum specific gravity was found in FYM +AZ+PSB+ KSB (T_8) during 2018-2019.Whereas, during the year 2019-2020 plants at T_5 Azotobacter (AZ) has a maximum specific gravity. The pooled analysis shown that the highest specific gravity was observed under FYM +AZ+PSB+ KSB (T_8), Azotobacter (AZ) (T_5) and Potash Solubilizing Bacteria (KSB) (T_7) and the lowest is in AZ+PSB+ KSB (T_{12}). Similarly the highest pulp: peel ratio was found in FYM +AZ+PSB+ KSB (T_8) and the lowest was observed under (T_{13}) Control for two consecutive years as well as from the pooled analysis data. Our findings are in similarity with the findings of Dwivedi *et al.* (2012) recorded that maximum fruit yield was found with the application of 250 g *Azotobactor* + 20 kg FYM. Devi *et al.* (2012) reported that the application of PSB 100gm per tree + FYM 26kg per tree/ year + potash mobilizers 100gm per tree + Azotobactor100gm per tree gives the maximum guava fruit yield. Umar *et al.* (2008) reported that the maximum yield of strawberry was observed with the application 25% nitrogen in the form of FYM + 75% N through urea + Azotobacter. Sharma *et al.* (2002) revealed significant influence in the bunch weight and yield of banana with the application of Azotobacter and organic manures supplements over 100% fertilizer. Azotobacter also enhanced shooting and shortened crop duration. Similar finding were also reported by Osman and El-rhman (2010) results show that poultry manure +

azotobacter and poultry manure + azospirillum treatments gained best vegetative growth, productivity and fruit quality in fig Tree.

Fruits quality characters were significantly influenced by the application of different source of nutrients. Among the treatment VC +AZ+PSB+ KSB (T_9) showed highest TSS in the first year. In the second years as well as from the pooled data analysis the maximum TSS was observed in FYM +AZ+PSB+ KSB (T_8) as compared with the lowest TSS which was found in control (T_{13}). Titratable acidity was highest with (T_{13}) Control (no fertilizer) and the lowest was found under the treatment of FYM +AZ+PSB+ KSB (T_8) for both the year of experimental study and from pooled analysis. However, TSS: Acid was found highest in VC +AZ+PSB+ KSB (T_9) during 2018-2019. Plants at FYM +AZ+PSB+ KSB (T_8) observed highest acidity content during the second year 2019-2020 as well as pooled analysis. Total sugar percentage showed significant variant under each treatment due to different application of nutrients. During first year of experiment 2018-2019 maximum Total sugar percentage was obtained in VC +AZ+PSB+ KSB (T_9). While, during 2^{nd} years of experiment 2019-2020 maximum Total sugar percentage was obtained in FYM +AZ+PSB+ KSB (T_8). Pooled data from both years show that maximum total sugar percentage was obtained in FYM +AZ+PSB+ KSB (T_8) and T_{13} (control) showed lowest total sugar percentage. Reducing sugar percentage varies from each treatment during the experiment. Pooled data from both year showed that maximum reducing sugar percentage was obtained in FYM +AZ+PSB+ KSB (T_8) and T_{13} (control) showed lowest reducing sugar percentage. Whereas, ascorbic acid content of the fruit showed that significant variation was observed among treatment. Maximum ascorbic acid was obtained in FYM +AZ+PSB+ KSB (T_8) during 2018-2019 and in the year 2019-2020 maximum ascorbic acid was obtained in PM +AZ+PSB+ KSB (T_{11}) compared with control (T_{13}). Pooled data from both years shows that maximum ascorbic acid was obtained in FYM +AZ+PSB+ KSB (T_8). The presented pooled date shown that the highest anthocyanin content of peel was recorded in VC +AZ+PSB+ KSB (T_9) followed by PM +AZ+PSB+ KSB (T_{11}) as well as the highest anthocyanin content of pulp was recorded FYM +AZ+PSB+ KSB (T_8) followed by in NC +AZ+PSB+ KSB (T_{10}). Our findings are in support with Hassan (2015) reported that bio-fertilizer increased chemical constituents of fruit, i.e., TSS%, vitamin C, titratable acidity, anthocyanins and total sugars. Tripathi *et al.* (2016) reported on strawberry cv. Chandler that maximum TSS, total sugars and ascorbic acid were obtained with plants fertilized with 7 kg of Azotobacter per hectare. Ram *et al.* (2002) recorded in guava that treatment with farmyard manure recorded the highest acidity, highest ascorbic acid content and total soluble solid content. TSS and total sugars contents increase with Azotobacter application may be due to the quick metabolic transformation of starch as well as pectin into soluble compounds and quick translocation of sugars from leaves to part of the plants for developing fruits. Our finding are in agreement with Antipchuk *et al.* (1982) in tomato and Gupta and Tripathi (2012) in strawberry also reported increased amount of TSS and total sugars with the application of Azotobactor. Tripathi *et al.* (2014) reported that application of FYM @5kg/plants as a basal dose along with Azotobacter @ 7 kg/ha treated plants produced berries with maximum TSS, total sugars and ascorbic acid contents as compared to other treatments.

From the experimental study, it was clearly showed that the data presented from Soil pH, organic carbon (%), C:N ratio , Nitrogen (kg/ha), Potassium, manganese and zinc revealed that highest was recorded in FYM +AZ+PSB+ KSB (T_8) as compared to control (T_{13}) for two consecutive year and pooled analysis data. However, available phosphorus content of experimental soil showed that highest phosphorus was recorded in VC +AZ+PSB+ KSB (T_9) during 2018-2019. Whereas, in 2019-2020 The highest phosphorus content was recorded in FYM +AZ+PSB+ KSB (T_8) while the pooled data revealed that from both years of study the highest phosphorus content of soil was observed in VC +AZ+PSB+ KSB (T_9) while the lowest was observed in treatment control (T_{13}). Available iron content in the experimental soil data presented during 2018-2019 the maximum Iron content in the soil was recorded with PM +AZ+PSB+ KSB (T_{11}) while in the year 2019-2020 the highest Iron content in the soil was recorded in NC +AZ+PSB+ KSB (T_{10}) and the lowest Iron content was observed in control (T_{13}). However, the pooled analysis from two years showed that the highest available Iron was observed in FYM +AZ+PSB+ KSB (T_8) while the lowest was observed in treatment control (T_{13}). The highest available manganese in the experimental soil was observed in VC +AZ+PSB+ KSB (T_9) followed by (T_{10}) while the lowest manganese content of soil was observed in control (T_{13}) for two consecutive years of experimental study and pooled analysis. The highest available copper in the experimental soil was observed in NC +AZ+PSB+ KSB (T_{10}) followed by (T_9) during 2018-2019. Plant at VC +AZ+PSB+ KSB (T_9) observed highest copper content in the soil during the year 2019-2020. The pooled analysis from two years data showed that the highest available copper was observed in VC +AZ+PSB+ KSB (T_9) while the lowest was observed under both the treatment of (T_{12}) AZ+PSB+ KSB and Phosphate Solubilizing Bacteria (PSB) (T_6). Our findings are in agreement with Gogoi et al. (2004) that Azotobacter fix sufficient quantity of N in the rhizosphere, thus encouraging enough N uptake as well as available nitrogen. A buildup of Nitrogen in soil with different N sources and levels combined with biofertilizers increases the P, Ca and Mg. thereby found an increased availables nutrients in soil after fruit harvest due to the application of Azotobacter and poultry manures. The evidences that poultry manure increases the organic carbon, available N, P, K, Ca and Mg in soil as reported by Albregts and Howard (1981).

From the experimental study organic nutrients management of dragon fruits showed significant variation related to soil microbial counting and the maximum *Azotobacter* count of experimental soil was observed in NC +AZ+PSB+ KSB (T_{10}) during 2018-2019. In the second year 2019-2020, the maximum count was recorded in FYM +AZ+PSB+ KSB (T_8). The pooled analysis from two years data showed that the maximum soil *Azotobacter* count was recorded in FYM +AZ+PSB+ KSB (T_8) while the minimum *Azotobacter* population count was observed in treatment control (T13).Whereas, the highest Phosphorus solubilising bacteria count of experimental soil was observed in VC +AZ+PSB+ KSB (T_9) during the first year. In the second year 2019-2020, the maximum PSB population count was recorded in FYM +AZ+PSB+ KSB (T_8). The pooled analysis from two years data showed that the maximum soil Phosphorus solubilising bacteria count was recorded in VC +AZ+PSB+ KSB (T_9) while the minimum population count was observed in treatment control (T_{13}). However, during the year 2018-2019, the highest Potassium solubilising bacteria (KSB) Count was observed in FYM +AZ+PSB+ KSB (T_8) and the lowest population count was observed in control (T_{13}) for two consecutive years and pooled data. Our findings are in agreement with Mitra et al. (2012) revealed that application organic manures along with bio¬fertilizers substantially increased soil microbial population which improved soil health and thereby the growth and productivity of guava tree. Jayathilake *et al.* (2006) reported that bacterial population of Azotobacter and Azospirillum in soil after harvest was markedly increased with integrated use of bio fertilizer, organic manure and chemical fertilizer system and was reduced with the exclusive application of chemical fertilizers

Experimental study of organic nutrients management of dragon fruits showed significant variation among soil analysis. The highest cladode nitrogen was recorded with FYM +AZ+PSB+ KSB (T_8) while the lowest was observed in treatment control (T_{13}) for two consecutive years and pooled data. Whereas, in the year 2018-2019, the highest cladode phosphorus was recorded with FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11}) and in the second years of study 2019-2020, the highest Cladode phosphorus was recorded with PM +AZ+PSB+ KSB (T_{11}) followed by FYM +AZ+PSB+ KSB (T_8) and the minimum cladode phosphorus percentage was recorded in control (T_{13}). The pooled analysis presented that cladode phosphorus percentage from two years data showed that the highest was observed in PM +AZ+PSB+ KSB (T_{11}) followed by FYM +AZ+PSB+ KSB (T_8), while the lowest was observed in treatment control (T_{13}). The maximum record for cladode potassium percentage was observed with FYM +AZ+PSB+ KSB (T_8) followed by NC +AZ+PSB+ KSB (T_{10}) during the first year of study 2018-2019 and during the second years of study 2019-2020 the maximum record for cladode Potassium percentage was observed with PM +AZ+PSB+ KSB (T_{11}). The pooled analysis presented that cladode potassium percentage from two years data showed that the highest was recorded with PM +AZ+PSB+ KSB (T_{11}) and the lowest was recorded in control (T_{13}). However significant influenced was observed across treatments regarding cladode iron content. The maximum records for cladode iron (Fe) content was observed with PM +AZ+PSB+ KSB (T_{11}) during the first year of experimental study while in the second years the maximum record of cladode Fe content was observed under FYM +AZ+PSB+ KSB (T_8). The pooled analysis presented that cladode iron (Fe) content from two years data showed that the highest was observed under FYM +AZ+PSB+ KSB (T_8) while the lowest was observed in treatment control (T_{13}). Regarding cladode manganese (ppm) the maximum records for cladode manganese content was observed with NC +AZ+PSB+ KSB (T_{10}) for both the years of experimental study. The pooled analysis presented that cladode manganese (Mn) content from two years data showed that the highest was observed in NC +AZ+PSB+ KSB (T_{10}) while the lowest was observed in treatment control (T_{13}).Whereas**,** The pooled analysis presented that cladode copper content from two years data showed that the highest was observed with NC +AZ+PSB+ KSB (T_{10}) and the lowest cladode copper content was recorded in control (T_{13}).The maximum records for cladode zinc content was recorded in PM +AZ+PSB+ KSB (T_{11}) during the first year of study 2018-2019 while maximum records for cladode zinc content was recorded in FYM +AZ+PSB+ KSB (T_8) during the second years of study 2019-2020. The pooled analysis presented that cladode zinc content from two years data showed that the highest was observed with FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11}) and the lowest cladode zinc content was recorded in control. Results of the impact of variant nutrient treatments on dragon fruits shown in table 4.2.30 revealed that the highest cladode carbohydrate percentage was observed in FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11}) and the minimum cladode carbohydrate percentage was observed in control (T_{13}) for two consecutive years. The pooled data analysis presented that cladode carbohydrate percentage from two years showed that the highest was observed under FYM +AZ+PSB+ KSB (T_8) and the lowest cladode carbohydrate percentage content was recorded in control. Carbohydrate: Nitrogen (C: N) ratio revealed that the highest cladode C: N ratio was observed in PM +AZ+PSB+ KSB (T_{11}) and the lowest was observed in control (T_{13}) in the year 2018-2019. Whereas, in the second year of study 2019-2020 the maximum C:N ratio was recorded in FYM +AZ+PSB+ KSB (T_8). The pooled data analysis presented that cladode carbohydrate: nitrogen ratio from two years showed that the highest was observed under FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11}) and the lowest cladode carbohydrate: nitrogen ratio content was recorded in control (T_{13}). FYM supplies nitrogen, phosphorus and potassium to plants through biological decomposition (Prasad *et al.*

2017) and it might be the fact that application of organic manure along with bio-fertilizer helped in increasing soil microbial population which in turn gave best uptake of nutrients by the plants. These finding are in support with Yadav *et al.*, (2012a). Trivedi *et al.* (2012) reported that application of FYM obtained maximum phosphorus uptake and organic carbon content in the soil. Sole application of FYM to supply 100% N recorded highest manganese and iron contents in sweet orange (Marathe *et al.* 2012) and supported by Shukla *et al*. (2009)

In the present study among all the treatments, the highest gross expenditure was obtained with VC +AZ+PSB+ KSB (T_9) followed by T_2 (Vermi compost (VC)). However, the highest gross income was obtained in FYM +AZ+PSB+ KSB (T_8) followed by NC +AZ+PSB+ KSB (T_{10}). Highest net income as well as the highest benefit to cost ratio was obtained in FYM +AZ+PSB+ KSB (T_8) followed by PM +AZ+PSB+ KSB (T_{11}). This can be due to the production of higher yield fruit, as well as might be the lowest cost of manure used which is FarmYard Manure. Our finding are in support with Yadav *et al.* (2010) that FYM provided highest B:C ratio than vermicompost due to its lower cost of production. Jaipaul *et al.* (2011) observed that highest B:C ratio was recorded with the application of poultry manure+ biofertilizer for capsicum and garden pea.

CHAPTER 5

SUMMARY AND CONCLUSION

The investigation entitled 'Standardization of integrated nutrient management and organic nutrient management for dragon fruit production in Mizoram' was carried out during 2018-2020 at farmer's field situated at Ailawng village, Mamit district, Mizoram. The findings from the research trial under two experiments are summarized below.

Experiment 1: Integrated Nutrient Management of Dragon Fruit

- Dragon fruit plants applied with 50% RDF of NPK + 25% K through FYM + 25% K through VC+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_8) attained maximum cladode length [242.78 cm (2018-19), 314.44 cm (2019-20)] after 15 and 30 months of planting compared with control [155.44 cm (at 15 MAP); 217.56 cm (at 30 MAP)].
- Cladode circumference was found maximum [23.22 cm (at 15 MAP); 23.67 cm (at 30 MAP)] in case of the dragon fruit plants fertilized with 50% RDF of NPK + 50% K through Farm Yard Manure (FYM) + AZ+PSB+ KSB (T_5) followed by the plants fertilized with 50% RDF of NPK + 25% K through FYM + 25% K through VC+ AZ+PSB+ KSB [(T_8); 21.56 cm (at 15 MAP), 22.56 cm (at 30 MAP)] compared with control [17.89 cm (at 15 MAP); 19.11 cm (at 30 MAP)].
- Highest number of cladodes per plant [10.11 (at 15 MAP); 26.22 (at 30 MAP) was recorded at T_8 compared with control [3.11 (at 15 MAP); 9.89 (at 30 MAP)].
- Dragon fruit plants applied with 50% RDF of NPK + 25% K through FYM + 25% K through VC+ AZ+PSB+ KSB (T_8) had maximum number of flower per pillar (23.67); highest number of fruits per pillar (22.50) along with maximum fruit set (95.02%) and minimum percentage of flower bud drop

(4.98%) compared with control [5.00 (no. of flower per pillar); 3.00 (no. of fruits/pillar); 59.27% (fruits set) and 40.73% (flower bud drop)].

- Yield per hectare was recorded highest (10.18 tonnes/hectare) in case of the plant at T_8 followed by T_{12} (8.96 t/ha) compared with control (0.77 t/ha).
- Dragon fruit plants at T_8 showed maximum fruit diameter (88.27 mm); fruit weight (362.42g), pulp weight (261.26g), fruit specific gravity (1.18) and reasonably high fruit length (98.15 mm), fruit volume (307.50 cc). Whereas pulp: peel ratio (2.67), pulp recovery (72.08%) was highest at T_9 followed by T_8 pulp recovery (72.08%), pulp: peel ratio (2.58) compared with other treatments.
- It was observed that dragon fruit plants treated with 25% RDF of NPK + 25% K through FYM+ 25% K through VC+ 25% K through NC +AZ+PSB+ KSB (T_{12}) also had high fruit weight (346.00g), fruit volume (321.67 cc), pulp weight (246.83g), pulp recovery (71.39%) and pulp: peel ratio (2.50) compared with other treatments.
- In case of the fruit biochemical quality parameters, it was observed that plants at T_8 had highest TSS (12.45 ^{0}Brix), TSS:acid ratio (58.11), total sugar (8.34%), reducing sugar (6.06%), peel and pulp anthocyanin content (4.51 and 13.22 mg/100g), ascorbic acid (19.88 mg/100g) compared with other treatments.
- Among the other treatments, dragon fruit plant at T_5 i.e. fertilized with 50% RDF of NPK + 50% K through Farm Yard Manure (FYM) + AZ+PSB+ KSB also had high fruit TSS (12.28 ^{0}Brix), TSS:acid ratio (57.22), total and reducing sugar (8.30% and 5.87%), ascorbic acid (22.85 mg/100g) and peel anthocyanin content (4.99 mg/100g).
- Analysis of the experimental soil manifested that plants at T_8 had maximum soil organic carbon (1.00%), C:N ratio (30.38), nitrogen (733.40 Kg/ha), phosphorus (86.01 Kg/ha), potassium (871.72 Kg/ha) and zinc (29.83 mg/Kg) compared with control [(0.27% (organic carbon), 21.98 (C:N ratio), 270.02 Kg/ha (nitrogen), 21.51 Kg/ha (phosphorus), 197.02 (potassium) and 5.90 mg/Kg (zinc)].

- Microbial analysis of the soil revealed that plants at T_8 had maximum count of soil azotobacter (56.16 $X10^6$ cfu/g) and KSB (72.43 $X10^6$ cfu/g) and moderately high PSB (49.62 $X10^6$ cfu/g) compared with control [AZ(5.93 $X10^6$ cfu/g), PSB (10.56 $X10^6$ cfu/g), KSB (12.52 $X10^6$ cfu/g)].
- Dragon fruit plant at T_8 had highest cladode nitrogen (3.28%), potassium (3.12%) and zinc (65.38 ppm) and high phosphorus (0.29%), Fe (228.61 ppm), Mn (736.50 ppm) and carbohydrate: N ratio (1.13) compared with others.
- Among the other treatments, it was found that dragon fruit plants at T_{12} had considerably high cladode nitrogen (2.35%), phosphorus (0.32%), potassium (3.01%), Fe (232.76 ppm), Mn (749.60 ppm), Cu (8.52 ppm), Zn (60.72 ppm) and carbohydrate: N ratio (1.35).
- Economic analysis of the experiment showed that T_8 had highest benefit : cost (B:C) ratio (1.96) followed by T_1 (1.86) and T_5 (1.53) compared with control (-0.44). For control; there was net loss of Rs.150260.00 per hectare in dragon fruit cultivation.

Experiment 2: Organic Nutrient Management of Dragon Fruit

- Dragon fruit plants manured with FYM + biofertilizers (AZ+PSB+ KSB) (T_8) had maximum cladode length [212.78 cm (at 15 MAP) and 297.44 cm (at 30 MAP)] followed by plants manured with poultry manure (PM) + AZ+PSB+ KSB (T_{11}) [200.56 cm (at 15 MAP) and 292.56 cm (at 30 MAP)] compared with control [142.78 cm (at 15 MAP) and 214.11 cm (at 30 MAP)].
- Maximum cladode circumference [21.22 cm (at 15 MAP), 23.56 cm (at 30 MAP)] was recorded in case of the dragon fruit plants under T_8 followed by the plants manured with neem cake + AZ+PSB+ KSB (T_{10}) [20.89 cm (at 15 MAP) and PM+ AZ+PSB+ KSB [T_{11}; 22.56 cm (at 30 MAP)] compared with control [16.89 cm (at 15 MAP); 18.56 cm (at 30 MAP)].
- Number of cladodes per plant was recorded maximum [8.56 (at 15 MAP); 24.44 (at 30 MAP)] at T_8 followed by T_{11} [8.11 (at 15 MAP); 24.33 (at 30 MAP)] compared with control [2.67 (at 15 MAP); 9.22 (at 30 MAP)].

- Plants at T_8 had maximum number of flowers per pillar (17.67) and fruits per pillar (16.50) with highest fruitset percentage (93.41%) and minimum flower bud drop (6.59%) compared with other treatments.
- Fruit set percentage (93.41%) was found high in plants at T_8; where flower bud drop percentage was also remained low (6.59%) compared with other treatments.
- Highest yield (8.01 tonnes /hectare) was recorded in T_8 followed by T_{10} (5.70 t/ha) and T_{11} (5.38 t/ha) compared with control (0.65 t/ha).
- Dragon fruit plants manured with FYM+ biofertilizers (AZ+PSB+ KSB) (T_8) had maximum fruit weight (382.17g), fruit volume (356.67cc), pulp weight (286.25g), pulp recovery percentage (74.57%) and pulp: peel ratio (2.98) compared with other treatments.
- Plants at T_{11} (PM+ AZ+PSB+ KSB) also had high fruit weight (364.50g), fruit volume (354.42cc), pulp weight (257.17g) and pulp recovery (70.10%) compared with others.
- Biochemical qualities of the fruits revealed that dragon fruit plants at T_8 had highest TSS (12.21 ^{0}Brix), TSS: acid ratio (44.42), total sugar (8.55%), ascorbic acid content (21.18 mg/100g) and pulp anthocyanin content (10.93 mg/100g).
- It was found that dragon fruit plants manured with vermi compost + AZ+PSB+ KSB (T_9) also had high fruit TSS (11.88 ^{0}Brix), TSS:acid ratio (40.33), total sugar (8.36%), ascorbic acid (18.03 mg/100g) and peel anthocyanin content (5.45 mg/100g) compared with other treatments.
- Analysis of the experimental soil revealed that plants at T_8 had maximum soil organic carbon (1.03%), C:N ratio (33.51), soil nitrogen (684.43 Kg/ha), potassium (827.35 Kg/ha) and other elements like Fe (153.60 mg/Kg) and Zn (25.90 mg/Kg).
- Plants treated with poultry manure along with biofertilizers (AZ+PSB+ KSB) (T_{11}) had high organic carbon (0.97%), C:N ratio (33.04), nitrogen (657.19 Kg/ha), phosphorus (72.69 Kg/ha) and potassium (746.44 Kg/ha), whereas,

soil potassium content was considerably high (809.12 Kg/ha) in case of the plants manured with vermi compost + AZ+PSB+ KSB (T_9).

- Soil microbial analysis manifested that plants at T_8 had maximum count of soil azotobacter (61.05 $X10^6$ cfu/g) and KSB count ($67.63X10^6$ cfu/g), whereas, plants at T_9 had maximum PSB content (43.33X 10^6 cfu/g) and considerably high KSB count (63.94 $X10^6$ cfu/g) compared with control [AZ ($5.63X10^6$ cfu/g); PSB ($9.86X10^6$ cfu/g), KSB ($13.65X10^6$ cfu/g)].
- Among the different treatments, plants at T_8 had maximum cladode nitrogen (2.26%), potassium (2.30%), Fe (262.14 ppm), Zn (62.65 ppm) along with carbohydrate: N ratio (1.57). Whereas T_{11} showed maximum cladode phosphorus (0.36%),
- It was found that plants at T_{11} also had high cladode nitrogen (2.11%), phosphorus (0.37%), potassium (2.24%), Cu (12.87 ppm), Zn (60.82 ppm) and carbohydrate: N ratio (1.54) compared with others.
- Economic analysis revealed that treatment with FYM + AZ+PSB+ KSB (T_8) had maximum benefit : cost (B:C) ratio (1.83) followed by T_{11} (1.73) compared with control (-0.53). Control had net loss of Rs.180260.00 for cultivation of dragon fruit in one hectare land without using any fertilizer or manure for crop growth.

Conclusion:

Experiment 1

- It was found that dragon fruit plants applied with 50% RDF of NPK + 25% K through FYM + 25% K through VC along with biofertilizers (AZ+PSB+ KSB)(T_8) had maximum cladode length, cladode circumference and highest number of cladode per plant.
- Besides, plants under this treatment had maximum fruit set with minimum flower bud drop.
- Plants at T_8 had highest yield of fruits with good physical (high fruit weight, pulp weight, pulp recovery percentage) and biochemical (TSS, TSS:acid

ratio, total sugar, pulp anthocyanin and ascorbic acid content) qualities compared with others.

- Microbial analysis manifested that soil at T_8 had highest azotobacter and KSB content and moderately high PSB content.
- Analysis of experimental soil and plants revealed that dragon fruit plants at T_8 had highest soil C:N ratio, soil N, P, K and plant N and K along with high in elements like Zn, Fe, Mn and carbohydrate: N ratio of plants.
- Economic analysis of the experiment revealed that T_8 had maximum B:C ratio. Thus, this is to be considered as most promising INM treatment for dragon fruit.

Experiment 2

- It was found that dragon fruit plants manured with FYM + AZ+PSB+ KSB (T_8) had maximum cladode length, cladode circumference and no. of cladode per plants.
- It was found that plants at T_8 had the highest fruit set with minimum flower bud drop. Besides, yield per plant and per hectare was recorded maximum under this treatment.
- Fruits physico-chemical characteristics viz. fruit weight, fruit volume, pulp weight, pulp recovery percentage, pulp: peel ratio, TSS, TSS:acid ratio, total sugar, pulp anthocyanin and ascorbic acid content was recorded highest in case of the plants at T_8.
- Soil-plant nutritional analysis recorded highest organic carbon, soil C:N ratio, soil and plant nitrogen, potassium, Fe and Zn content and carbohydrate: N ratio for this treatment.
- Furthermore, soil of the plants treated with FYM + AZ+PSB+ KSB (T_8) had maximum azotobacter and KSB count.
- Again, economic analysis revealed that this treatment (T_8) had highest B:C ratio compared with others.
- Further, it was found that plants manured with PM+ AZ+PSB+ KSB (T11) also had good plant growth in terms of cladode length, circumference and no.

of cladode per plant. Besides, plants under this treatment had good fruit set, low flower bud drop, high yield of quality fruits in terms of fruit weight, volume, pulp recovery, TSS, TSS:acid ratio, total sugar, ascorbic acid, peel and pulp anthocyanin content. Moreover, soil organic carbon, soil C:N ratio, soil and plant nitrogen, phosphorus, potassium, Fe, Cu, Zn content and microbial count of AZ, PSB and KSB in soil was found high under this treatment. B:C ratio was also remained high under this treatment.

Therefore, it may be concluded that FYM + AZ+PSB+ KSB (T_8) and PM+ AZ+PSB+ KSB (T_{11}) are the two potential organic nutritional treatments for dragon fruit plants.

- Biochemical qualities of the fruit were excellent under T_9 (VC+ AZ+PSB+ KSB) but the yield was comparatively low whereas, plant performance in terms plants growth and development parameters, fruit growth and development parameters, yield and fruit physico-chemical qualities were very good in case of the plants manured with neem cake + AZ+PSB+ KSB (T_{10}), but B:C ratio was comparatively low due to high input cost.

  Overall, it may be finally concluded that for integrated nutrient management, T_8, i.e. plants applied with 50% RDF of NPK + 25% K through FYM + 25% K through VC along with biofertilizers (AZ+PSB+ KSB) and for organic nutrient management; T_8 (FYM+ AZ+PSB+ KSB) and T_{11} (PM+ AZ+PSB+ KSB) are the best suited treatments for dragon fruit cultivation at Mizoram.

Plate 1: EXPERIMENTAL PLOT FOR EXPERIENT - 1

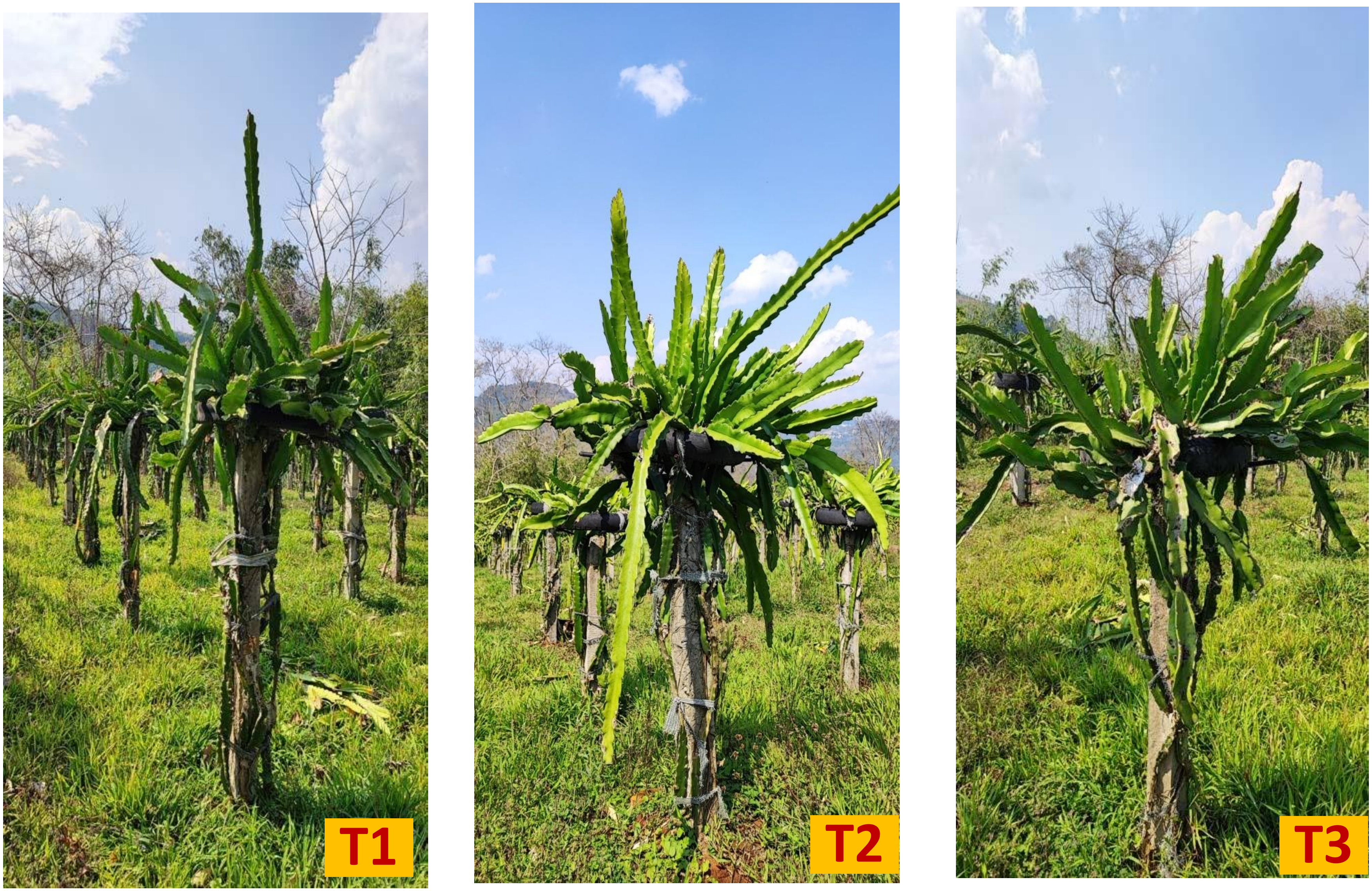


Plate 2: Dragon fruit plants under different treatments (T_1-T_3) at Experiment- 1

Plate 3: Dragon fruit plants under different treatments (T_4-T_6) at Experiment- 1

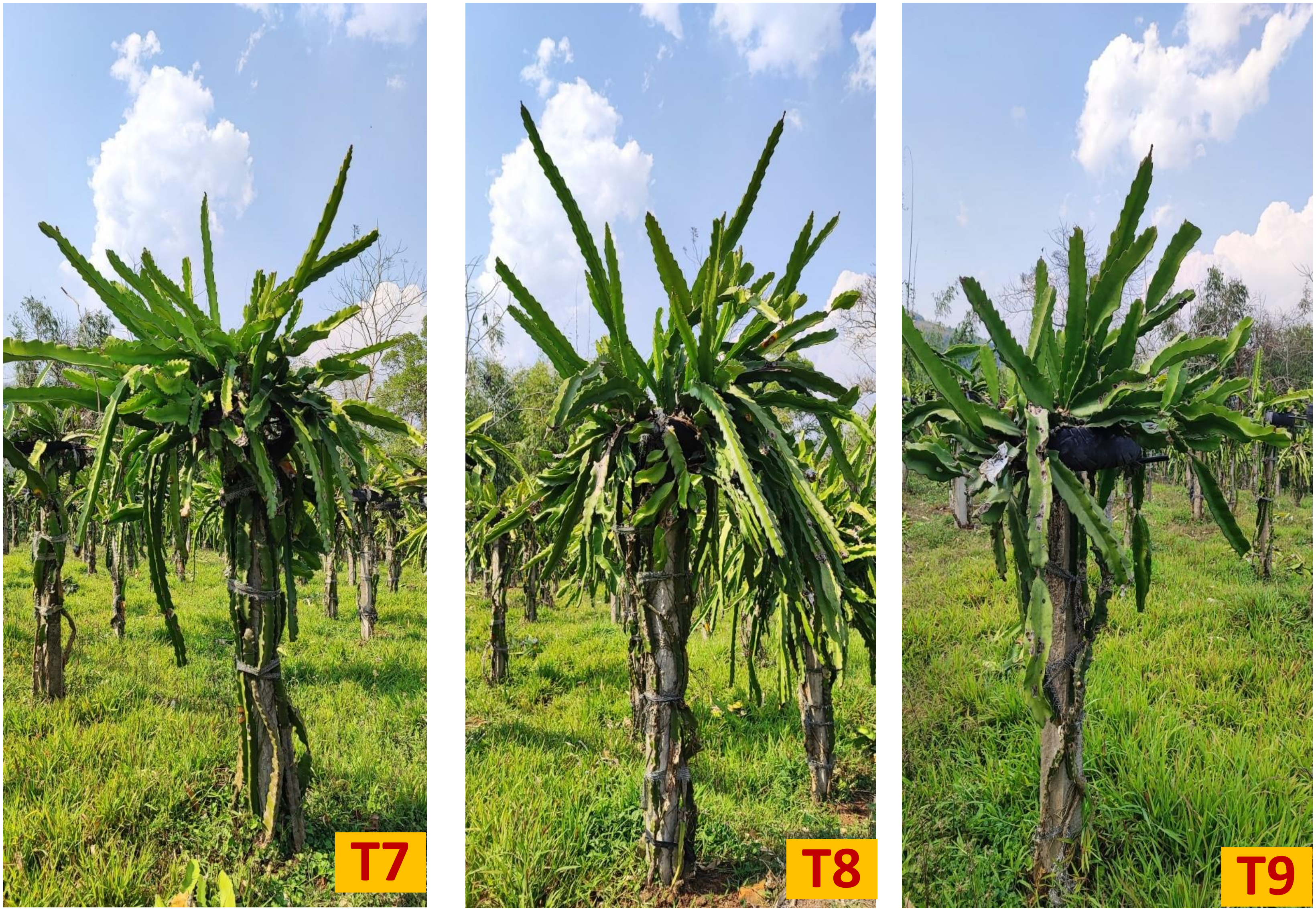


Plate 4: Dragon fruit plants under different treatments (T_7-T_9) at Experiment- 1

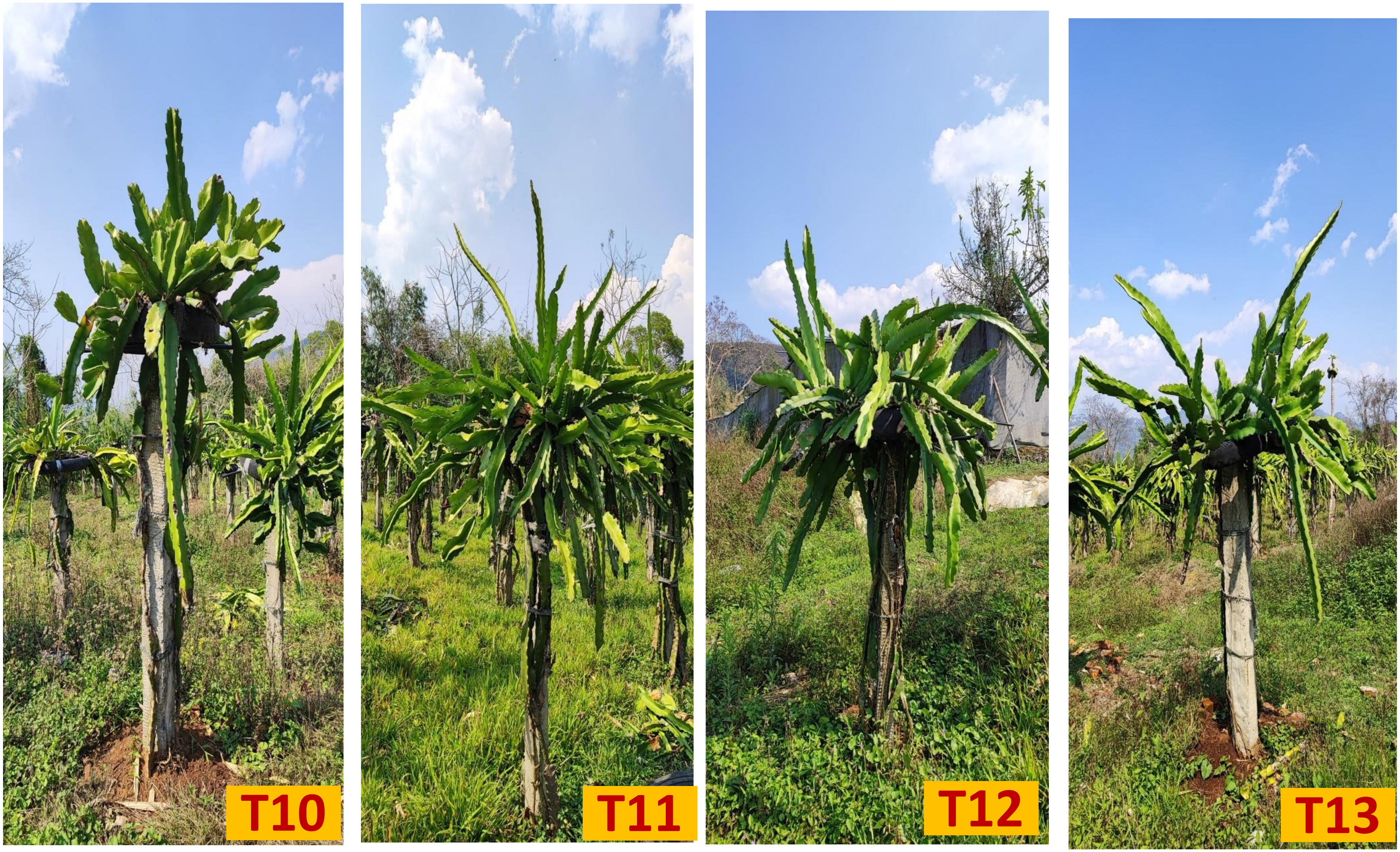
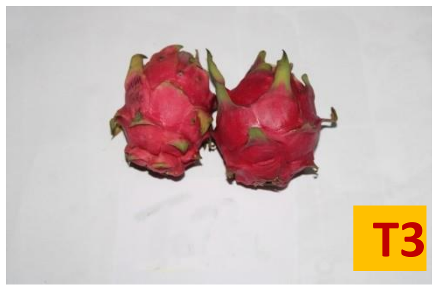
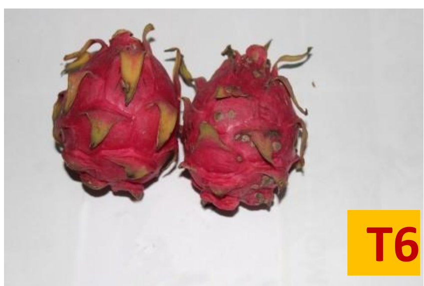


Plate 5: Dragon fruit plants under different treatments (T_{10}-T_{13}) at Experiment- 1

Plate 6: Fruits at different treatments in 2018-19 at Experiment -1





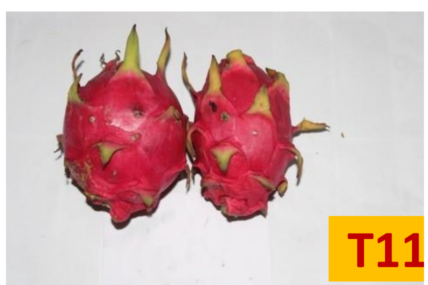


Plate 7: Fruits at different treatments in 2019-20 at Experiment -1

Plate 8: EXPERIMENTAL PLOT FOR EXPERIMENT 2

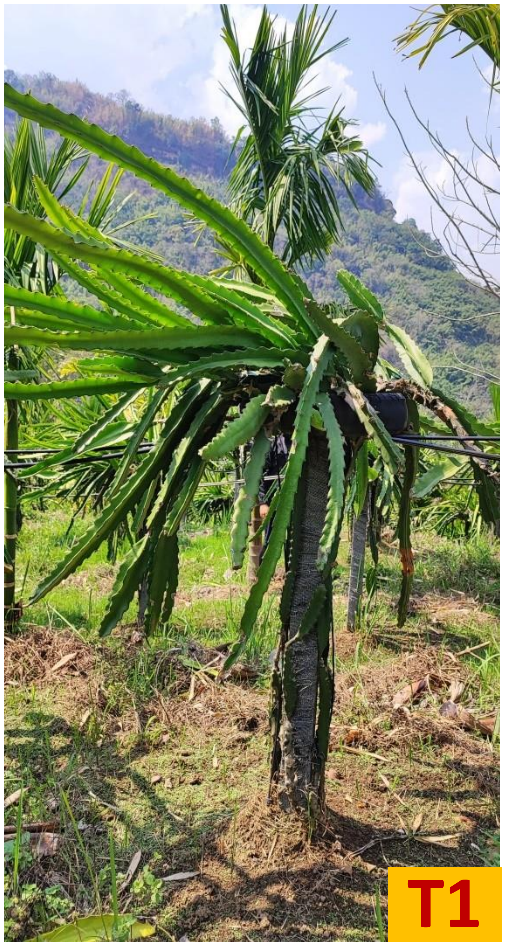


Plate 9: Dragon fruit plants under different treatments (T_1-T_3) at Experiment- 2

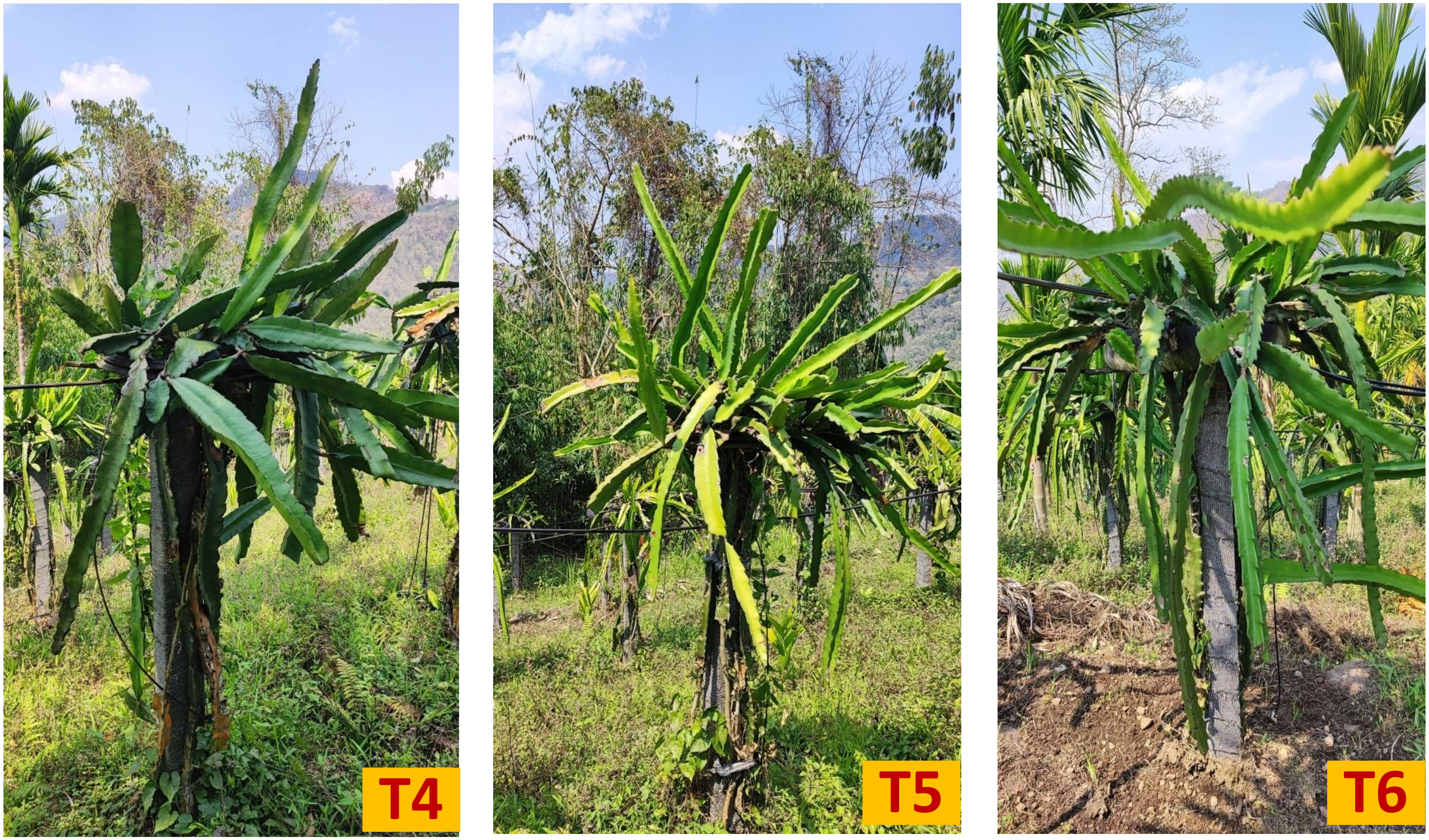


Plate 10: Dragon fruit plants under different treatments (T_4-T_6) at Experiment- 2

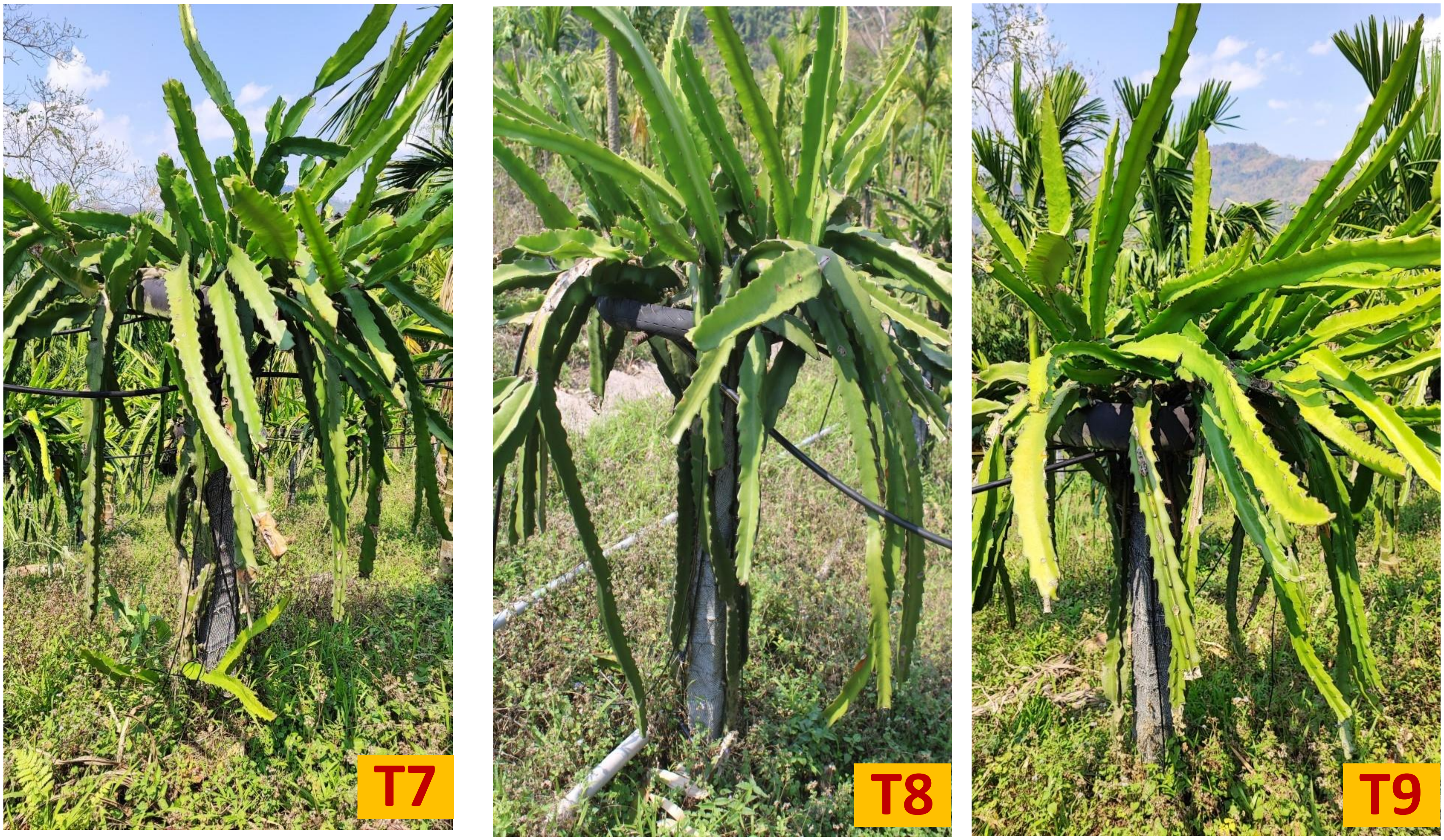


Plate 11: Dragon fruit plants under different treatments (T_7-T_9) at Experiment- 2

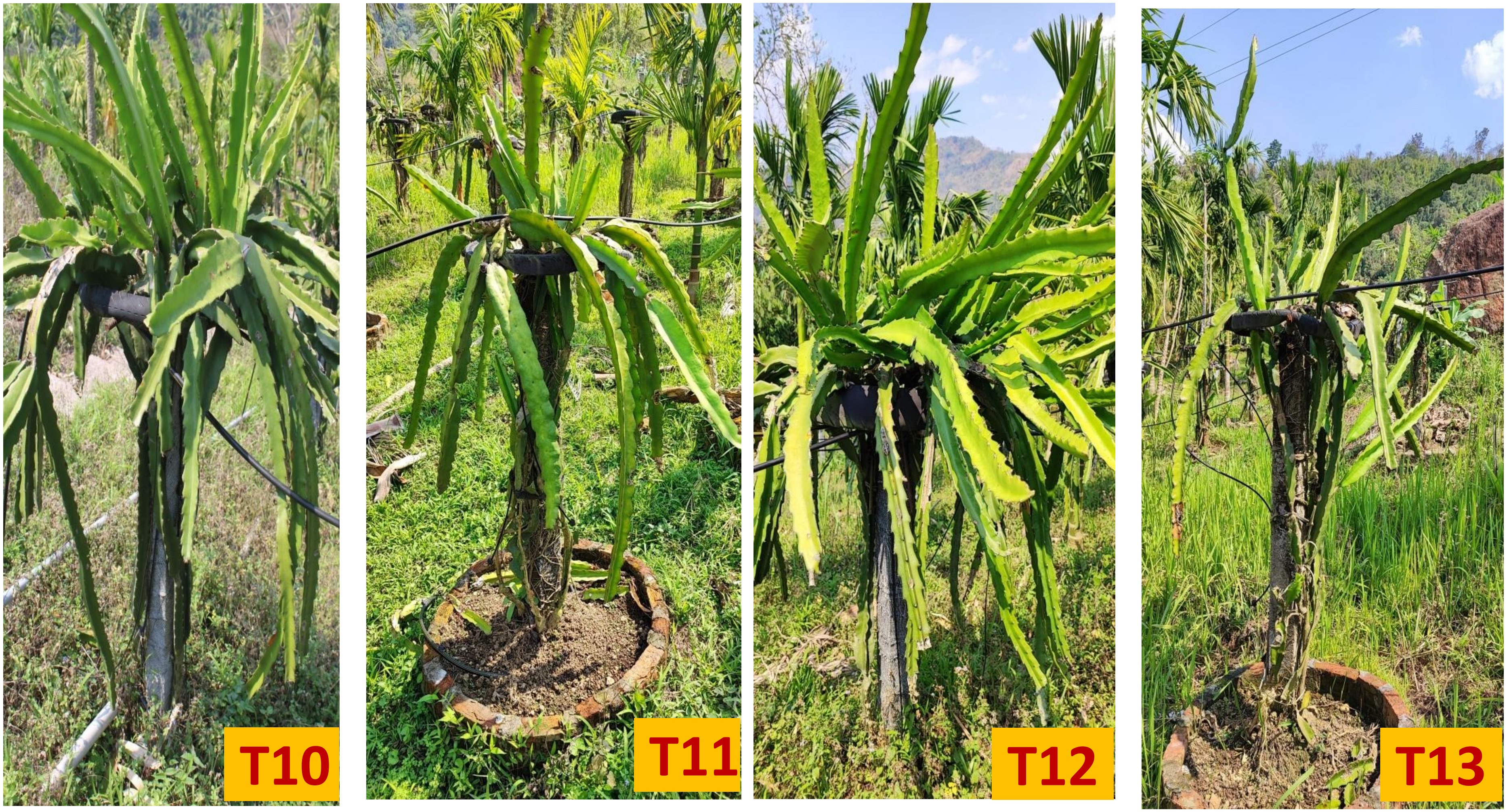
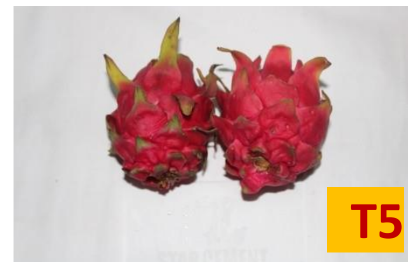
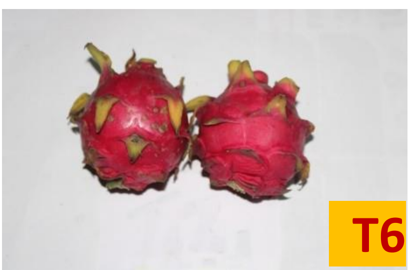


Plate 12: Dragon fruit plants under different treatments (T_{10}-T_{13}) at Experiment- 2

Plate 13: Fruits at different treatments in 2018-19 at Experiment -2





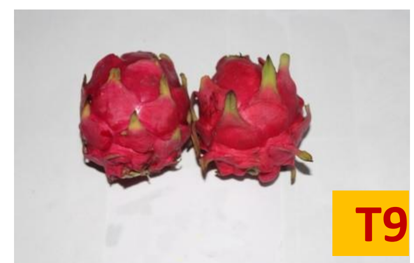
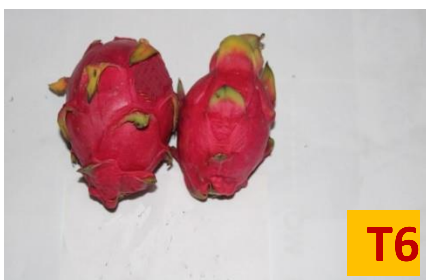


Plate 14: Fruits at different treatments in 2019-20 at Experiment -2



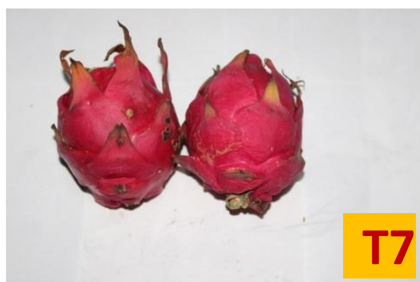


Plate 15: Dragon fruit orchard at flowering, fruiting and harvesting





Plate 16: Different field operation for manuring, data collection and sampling

Plate 17: Different lab operation formicrobial and fruit physico-chemicalanalysis

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BIO-DATA

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Sl. No.	Board/University	Class	Year of passing	Division/ Grade	Percentage
1	Mizoram Board of School Education	X	2007	First	65.2
2	Mizoram Board of School Education	XII	2011	First	62.6
3	Lovely professional University	B.Sc	2015	First	65.16
4	Mizoram University	M.Sc	2017	First	73.18

List of Publications:

1. **R.C. Lalduhsangi** and Debashis Mandal. 2021. Performance of Dragon Fruit under Integrated Nutrient Management at Mizoram. *Science and Technology Journal* . **9**(I): 72-76
2. **R.C. Lalduhsangi** and Debashis Mandal. 2023. Ripening associated physic-biochemical changes in red fleshed organic dragon fruit of Mizoram, India. *Journal of Postharvest Technology*, **11**(2): 1-8.
3. Hazarika, T.K., **Lalduhsangi, R.C**. and Ngurthankhumi, R. 2023. Morpho-physico-biochemical characterisation of Avocado (*Persea ameeicana*) for selection of elite types. *Ind. J. Agric. Sc.*, **93**(1**)**: 78-83.

Seminar/Symposium/Training attended:

1. Participated as a Resource person in the Workshop/Training on “Recent Developments and Basic Tools in Plant Biotechnology” held during 17^{th} -22^{nd} Nov, 2016 organized by Department of Biotechnology, Mizoram University sponsored by state Biotech-Hub facility, department of Biotechnology (DBT), New Delhi.
2. Attended training programme on “One month skill Development Training Program in Biotechnology for Students of North-East India” during 24^{th} to 23^{rd} February, 2018. This program jointly organized by Biotech Park, Lucknow and Department of HAMP, Mizoram University, Aizawl
3. Participated in Skill Development Programme on Cultivation and Primary Processing of Economically Important Aromatic & Medicinal Plants Under Aroma Mission from 23-24 April, 2018 at Mizoram University, Aizawl, Jointly Organised By CSIR & HAMP, Mizoram University
4. Participated in the Conference on “Startups and MSMEs in Food Processing” September 12, 2018, Hotel regency, Aizawl, Mizoram Inaugurated by the Hon’ble Governor of Mizoram.
5. Participated at the ‘State Level Workshop cum Awarness Programme on *Tinospora cordifolia’*, held at Administrative Conference Hall, Mizoram University on 19^{th} November 2019.

6. Oral presentation entitled" performance of Dragon Fruit Under Integrated Nutrients Management at Mizoram in the 2nd Annual convention of North East (India) Academy of Science and Technology (NEAST) & International Seminar on Recent Advance in Science and Technology (IRSRAST) during 16th-18th November 2020 (virtual) organized by NEAST, Mizoram University, Aizawl-796004, Mizoram (India).
7. Participant in the 12th International conference on Agriculture, Horticulture and Food Sciences. Presented a oral paper entitled "Studies on the production and nutrients management of dragon fruit in Mizoram" organized by The society of Tropical Agriculture, New Delhi, India during 29th to 30th December, 2021.

PARTICULARS OF THE CANDIDATE

NAME OF THE CANDIDATE	**:**	**R.C LALDUHSANGI**
DEGREE	**:**	**DOCTOR OF PHILOSOPHY**
DEPARTMENT	**:**	**DEPARTMENT OF HORTICULTURE, AROMATIC & MEDICINAL PLANTS.**
TITLE OF THE THESIS	**:**	**STANDARDIZATION OF INTEGRATED NUTRIENT MANAGEMENT AND ORGANIC NUTRIENT MANAGEMENT FOR DRAGON FRUIT PRODUCTION IN MIZORAM.**
DATE OF ADMISSION	**:**	**28.08.2017**
BOS	**:**	**11.04.2018**
SCHOOL BOARD	**:**	**27.04.2018**
MZU REGISTRATION NO.	**:**	**1506526**
PH.D. REGISTRATION NO. & DATE	**:**	**MZU/Ph.D./ 1121 of 27.04.2018**
EXTENTION (IF ANY)	**:**	**NIL**

HEAD

Dept. of Hort., Aromatic & Medicinal Plants

ABSTRACT

Dragon The genus *Hylocereus* (A. Berger) Britton and Rose (1909) comprises 18 species (Anderson, 2001). Dragon fruits [*Hylocereus spp.* (Hawort) Britton & Rose] have been called the most fascinating fruit in the family Cactaceae. Other names used include Pitaya, strawberry pear, pitahaya, sometimes also called ‘moon flower ‘ or’ Lady of the night, and kamalam, Sanskrit for the lotus flower in India. Dragon fruit is a long day plant. It is now commercially cultivated worldwide in over 20 tropical and subtropical countries such as Bahamas, Bermuda, Indonesia, Colombia, Israel, the Philippines, Myanmar, Malaysia, Mexico, Nicaragua, northern Australia, Okinawa Japan), Sri Lanka, southern China, southern Florida, Taiwan, Thailand, Vietnam, Bangladesh, and the West Indies (Mercado-Silva, 2018) due to its commercial interest, not demanding cultivation requirements, i.e. high drought tolerance, easy adaptation to light intensity and high temperature, a wide range of tolerance to different soil salinities, and benefits to human health (Nobel and La Barrera 2004; Nie *et al.* 2015; Crane *et al.* 2017; Mercado-Silva 2018). The fruit has gaining popularity in recent years due to its unique appearance and health benefits. It is well known for its rich nutrient contents, low in calories and its offers numerous nutrients, including vitamin C, phosphorus, calcium as well as its antioxidant characteristic (Patwary *et al.*, 2013), which help protect against cellular damage and reduce the risk of chronic diseases such as cancer and heart disease. Dragon fruit promote digestive health and prevent constipation due to its high content in fibre. Dragon fruit cultivation in India has gained popularity in recent years due to its high demand and potential for profitable farming. The tropical climate and diverse soil types in India make it suitable for the growth of dragon fruit, which requires well-drained soil, plenty of sunlight, and a warm climate. The major dragon fruit cultivated states in India are Karnataka, Kerala, Maharashtra, Gujarat, Andhra Pradesh, Tamil Nadu, and Telangana. The cultivation of dragon fruit in India has seen a steady increase in recent years due to its high yield and adaptability to different agro-climatic conditions. It is increasingly gaining interest, more and more farmers are turning towards it, including Mizoram which is a state with a climate ideal for its cultivation. In Mizoram approximately the total land area of 430ha is

under dragon fruit cultivation. In Aizawl District alone out of the total 430ha of land 210ha is under dragon fruit cultivation (Anon., 2017). Since the market price of the dragon fruit is relevantly high, this ranges from Rs 200/- to Rs. 400/- according to the quality of the fruit and also the availability in terms of harvest season. This makes it a good prospect for the farmers too. The climatic condition of Mizoram is suitable for the cultivation and also that Mizoram is the pioneer of the cultivation of dragon fruit on a large scale. The Department of Horticulture had chosen the beneficiaries in terms of the area of land which the farmer had and the kind of techniques which had been practiced in the past (Anon., 2017). In general, there are two species of dragon fruits commonly found in Mizoram market i.e. red pulped dragon fruit [*Hylocereus polyrhizus* (Weber) Britton & Rose] and white pulped dragon fruit [*Hylocereus undatus* (Hawort) Britton & Rose]. Mizoram which is one of the states in India to successfully produce dragon fruit while its commercial cultivation was started back in 2013 in some part of the State in Mizoram including Aizawl, Kolasib, Lunglei, Mamit, Lawngtlai and Serchhip Districts. With the intervention of the State Department of Horticulture, Government of Mizoram had made a tremendous contribution by emphasizing the cultivation of dragon fruit. However, till date the crop is cultivated in the state with no proper management of either integrated or organic farming. Therefore, it's become crucial to know the systematic management of nutrient regarding integrated and organic farming in dragon fruits for its successful cultivation to increase the yield production. Thus, current study was conducted so that the standardized nutrients management protocol can be suitable to be used for the farmer's practices in Dragon fruit growing areas of Mizoram as well as of NEH region.

Therefore, the present study was conducted with the following objectives:

i. To standardize the integrated nutrient management (INM) practices in Dragon Fruit
ii. To standardize the organic nutrient management practices in Dragon Fruit
iii. To study the benefit cost ratio under INM & organic nutrient management

Therefore, the present study was conducted with following two experiments:

a. Integrated Nutrient Management (INM) of dragon fruits
b. Organic nutrient management of dragon fruits

1. Experiment 1: Integrated nutrient management of dragon fruits

The experiment was in the farmer's field of Ailawng village of Mamit district of Mizoram in two consecutive years 2018-19 and 2019-20 with newly planted red fleshed dragon fruit (*Hylocerus polyrhizus*) planted with a spacing 4m x 2m in poles having three plants per pole. There were thirteen treatments viz. T_1: NPK 100 % Recommended dose of fertilizer (RDF), T_2: 50% RDF of NPK + Farm Yard Manure (FYM) to supply 50% K, T_3: 50% RDF of NPK + 50% K through vermi-compost (VC), T_4: 50% RDF of NPK + 50% K through Neem Cake (NC), T_5: 50% RDF of NPK + 50% K through Farm Yard Manure (FYM) + Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB), T_6: 50% RDF of NPK + 50% K through VC+AZ+PSB+ KSB , T_7: 50% RDF of NPK + 50% K through NC+AZ+PSB+ KSB, T_8: 50% RDF of NPK + 25% K through FYM + 25% K through VC+ AZ+PSB+ KSB, T_9: 50% RDF of NPK + 25% K through FYM + 25% K through NC+ AZ+PSB+ KSB, T_{10}: 50% RDF of NPK + 25% K through VC + 25% K through NC+AZ+PSB+ KSB, T_{11}: 50% RDF of NPK+ 25% K through FYM + 25% K through VC + 25% K through NC, T_{12}: 25% RDF of NPK + 25% K through FYM+ 25% K through VC+ 25% K through NC +AZ+PSB+ KSB and T_{13}: Control (no fertilizer); laid out in randomized block design with 3 replication and 3 plants per replication in a experimental plot size of 312 m^2 for covering 117 number of plants under 39 poles. Observations were recorded on plant growth parameters viz. cladode length, cladode circumference, number of cladodes per plant; fruit growth and development viz. number of fruits per pillar, number of flower per pillar, fruit set percentage, flower bud drop percentage, days required from fruit set to maturity and yield. Under fruit physical and biochemical parameters, fruit length, fruit diameter, fruit weight, volume, specific gravity, peel weight, peel thickness, pulp weight, pulp recovery percentage, pulp:peel ratio , TSS, titrable acidity, TSS:acid ratio, total sugar and reducing sugar, ascorbic acid, pulp and peel anthocyanin content were measured. Soil analysis was done to record total nitrogen, phosphorus, potassium, micro nutrients like Fe, Mn, Cu, Zn and for soil organic carbon, pH and C:N ratio. Soil microbial analysis was done for azotobacter, PSB and KSB count, whereas, cladode analysis was performed for estimating nitrogen, phosphorus, potassium, Fe, Mn, Cu, Zn, Carbohydrate, C:N ratio of the cladodes. Cost benefit analysis was done calculating the economic return.

Results from the current experiment revealed that dragon fruit plants applied with 50% RDF of NPK + 25% K through FYM + 25% K through VC+ Azotobacter (AZ) + Phosphate Solubilizing Bacteria (PSB) + Potash Solubilizing Bacteria (KSB) (T_8) attained maximum cladode length [242.78 cm (2018-19), 314.44 cm (2019-20)] after 15 and 30 months of planting compared with control [155.44 cm (at 15 MAP); 217.56 cm (at 30 MAP)]. Cladode circumference was found maximum [23.22 cm (at 15 MAP); 23.67 (at 30 MAP)] in case of the dragon fruit plants fertilized with 50% 50% RDF of NPK + 50% K through Farm Yard Manure (FYM) + AZ+PSB+ KSB (T_5) followed by the plants fertilized with 50% RDF of NPK + 25% K through FYM + 25% K through VC+ AZ+PSB+ KSB [(T_8); 21.56 cm (at 15 MAP), 22.56 cm (at 30 MAP)] compared with control [17.89 cm (at 15 MAP); 19.11 cm (at 30 MAP)]. Highest number of cladodes per plant [10.11 (at 15 MAP); 26.22 (at 30 MAP) was recorded at T_8 compared with control [3.11 (at 15 MAP); 9.89 (at 30 MAP)].

Dragon fruit plants applied with 50% RDF of NPK + 25% K through FYM + 25% K through VC+ AZ+PSB+ KSB (T_8) had maximum number of flower per pillar (23.67); highest number of fruits per pillar (22.50) along with maximum fruit set (95.02%) and minimum percentage of flower bud drop (4.98%) compared with control [5.00 (no. of flower per pillar); 3.00 (no. of fruits/pillar); 59.27% (fruits set) and 40.73% (flower bud drop)]. Yield per hectare was recorded highest (10.18 tonnes/hectare) in case of the plant at T_8 followed by T_{12} (8.96 t/ha) compared with control (0.77 t/ha).

Dragon fruit plants at T_8 showed maximum fruit diameter (88.27 mm); fruit weight (362.42g), pulp weight (261.26g), fruit specific gravity (1.18) and reasonably high fruit length (98.15 mm), fruit volume (307.50 cc), pulp recovery (72.08%) and pulp: peel ratio (2.58) compared with other treatments. It was observed that dragon fruit plants treated with 25% RDF of NPK + 25% K through FYM+ 25% K through VC+ 25% K through NC +AZ+PSB+ KSB (T_{12}) also had high fruit weight (346.00g), fruit volume (321.67 cc), pulp weight (246.83g), pulp recovery (71.39%) and pulp: peel ratio (2.50) compared with other treatments. In case of the fruit biochemical quality parameters, it was observed that plants at T_8 had highest TSS (12.45 ^{0}Brix), TSS:acid ratio (58.11), total sugar (8.34%), reducing sugar (6.06%), peel and pulp anthocyanin content (4.51 and 13.22 mg/100g), ascorbic acid (19.88 mg/100g) compared with other treatments. Among the other treatments, dragon fruit plant at T_5 i.e. fertilized with 50% RDF of NPK + 50% K through Farm Yard Manure (FYM) + AZ+PSB+ KSB also had high fruit TSS (12.28 ^{0}Brix), TSS:acid ratio (57.22), total and reducing sugar (8.30% and 5.87%), ascorbic acid (22.85 mg/100g) and peel anthocyanin content (4.99 mg/100g).

Analysis of the experimental soil manifested that plants at T8 had maximum soil organic carbon (1.00%), C:N ratio (30.38), nitrogen (733.40 Kg/ha), phosphorus (86.01 Kg/ha), potassium (871.72 Kg/ha) and Zinc (29.83 mg/Kg) compared with control [(0.27% (organic carbon), 21.98 (C:N ratio), 270.02 Kg/ha (nitrogen), 21.51 Kg/ha (phosphorus), 197.02 (potassium) and 5.90 mg/Kg (Zinc)]. Microbial analysis of the soil revealed that plants at T_8 had maximum count of soil azotobacter (56.16 X10^6 cfu/g) and KSB (72.43 X10^6 cfu/g) and moderately high PSB (49.62 X10^6 cfu/g) compared with control [AZ(5.93 X10^6 cfu/g), PSB (10.56 X10^6 cfu/g), KSB (12.52 X10^6 cfu/g)].

Dragon fruit plant at T_8 had highest cladode nitrogen (3.28%), potassium (3.12%) and zinc (65.38 ppm) and high phosphorus (0.29%), Fe (228.61 ppm), Mn (736.50 ppm) and carbohydrate: N ratio (1.13) compared with others. Among the other treatments, it was found that dragon fruit plants at T12 had considerably high cladode nitrogen (2.35%), phosphorus (0.32%), potassium (3.01%), Fe (232.76 ppm), Mn (749.60 ppm), Cu (8.52 ppm), Zn (60.72 ppm) and carbohydrate: N ratio (1.35).

Economic analysis of the experiment showed that T_8 had highest benefit : cost (B:C) ratio (1.96) followed by T_1 (1.86) and T_5 (1.53) compared with control (-

0.44). For control; there was net loss of Rs.150260.00 per hectare in dragon fruit cultivation.

Therefore, it may be concluded that T_8 (50% RDF of NPK + 25% K through FYM + 25% K through VC+ AZ+PSB+ KSB) is the best suitable INM treatment for red fleshed dragon fruit at the experimental situation.

2. Experiment 2: Organic nutrient management of dragon fruits

The organic trail was performed in separate location of the same Ailawng village, Mamit district, Mizoram with newly planted red fleshed dragon fruit at 4m x 2m spacing among pillar and three plants per pillar. There were 13 different organic treatments which were T_1: Farm Yard Manure (FYM) , T_2: Vermi compost (VC) , T_3: Neem Cake (NC) , T_4: Poultry Manure (PM) , T_5: Azotobacter (AZ) , T_6: Phosphate Solubilizing Bacteria (PSB) , T_7: Potash Solubilizing Bacteria (KSB) , T_8: FYM +AZ+PSB+ KSB, T_9: VC +AZ+PSB+ KSB, T_{10}: NC +AZ+PSB+ KSB, T_{11}: PM +AZ+PSB+ KSB, T_{12}: AZ+PSB+ KSB , and T_{13}: Control (no fertilizer) laid out in randomized block design with 3 replications and three plants per replication. Organic manured were applied @ 50% of K requirement of RDF (N:P:K= 540: 720 :300g pillar1 year-1) for the plants. There were total 117 number of plants under 39 pillar/poles (three plants per pole) comprising of experimental are of 312 m^2. Observations were recorded on plant growth parameters viz. cladode length, cladode circumference, number of cladodes per plant; fruit growth and development viz. number of fruits per pillar, number of flower per pillar, fruit set percentage, flower bud drop percentage, days required from fruit set to maturity and yield. Under fruit physical and biochemical parameters, fruit length, fruit diameter, fruit weight, volume, specific gravity, peel weight, peel thickness, pulp weight, pulp recovery percentage, pulp:peel ratio , TSS, titrable acidity, TSS:acid ratio, total sugar and reducing sugar, ascorbic acid, pulp and peel anthocyanin content were measured. Soil analysis was done to record total nitrogen, phosphorus, potassium, micro nutrients like Fe, Mn, Cu, Zn and for soil organic carbon, pH and C:N ratio. Soil microbial analysis was done for azotobacter, PSB and KSB count, whereas, cladode analysis was performed for estimating nitrogen, phosphorus, potassium, Fe, Mn, Cu, Zn, Carbohydrate, C:N ratio of the cladodes. Cost benefit analysis was done calculating the economic return.

Results revealed that dragon fruit plants manured with FYM + biofertilizers (AZ+PSB+ KSB) (T_8) had maximum cladode length [212.78 cm (at 15 MAP) and 297.44 cm (at 30 MAP)] followed by plants manured with poultry manure (PM) + AZ+PSB+ KSB (T_{11}) [200.56 cm (at 15 MAP) and 292.56 cm (at 30 MAP)] compared with control [142.78 cm (at 15 MAP) and 214.11 cm (at 30 MAP)]. Maximum cladode circumference [21.22 cm (at 15 MAP), 23.56 (at 30 MAP)] was recorded in case of the dragon fruit plants under T_8 followed by the plants manured with neem cake + AZ+PSB+ KSB (T_{10}) [20.89 cm (at 15 MAP) and PM+ AZ+PSB+ KSB [T_{11}; 22.56 (at 30 MAP)] compared with control [16.89 cm (at 15 MAP); 18.56 cm (at 30 MAP)]. Number of cladodes per plant was recorded maximum [8.56 (at 15 MAP); 24.44 (at 30 MAP)] at T_8 followed by T_{11} [8.11 (at 15 MAP); 24.33 (at 30 MAP)] compared with control [2.67 (at 15 MAP); 9.22 (at 30 MAP)].

Plants at T_8 had maximum number of flowers per pillar (17.67) and fruits per pillar (16.50) with highest fruits et percentage (93.41%) and minimum flower bud drop (6.59%) compared with other treatments. Fruit set percentage (88.13%) was found high in plants at T_{10}; where flower bud drop percentage was also remained low (11.87%) compared with other treatments. Highest yield (8.01 tonnes /hectare) was recorded in T_8 followed by T_{10} (5.70 t/ha) and T_{11} (5.38 t/ha) compared with control (0.65 t/ha).

Dragon fruit plants manured with FYM+ biofertilizers (AZ+PSB+ KSB) (T_8) had maximum fruit weight (382.17g), fruit volume (356.67g), pulp weight (286.25g), pulp recovery percentage (74.57%) and pulp: peel ratio (2.98) compared with other treatments. Plants at T_{11} (PM+ AZ+PSB+ KSB) also had high fruit weight (364.50g), fruit volume (354.42g), pulp weight (257.17g) and pulp recovery (70.10%) compared with others. Biochemical qualities of the fruits revealed that dragon fruit plants at T_8 had highest TSS (12.21 ^{0}Brix), TSS: acid ratio (44.42), total sugar (8.55%), ascorbic acid content (21.18 mg/100g) and pulp anthocyanin content (10.93 mg/100g). It was found that dragon fruit plants manured with vermi compost + AZ+PSB+ KSB (T_9)

also had high fruit TSS (11.88 ^{0}Brix), TSS:acid ratio (40.33), total sugar (8.36%), ascorbic acid (18.03 mg/100g) and peel anthocyanin content (5.45 mg/100g) compared with other treatments.

Analysis of the experimental soil revealed that plants at T_8 had maximum soil organic carbon (1.03%), C:N ratio (33.51), soil nitrogen (684.43 Kg/ha), potassium (827.35 Kg/ha) and other elements like Fe (153.60 mg/Kg) and Zn (25.90 mg/Kg). Plants treated with poultry manure along with biofertilizers (AZ+PSB+ KSB) (T_{11}) had high organic carbon (0.97%), C:N ratio (33.04), nitrogen (657.19 Kg/ha), phosphorus (72.69 Kg/ha) and potassium (746.44 Kg/ha), whereas, soil potassium content was considerably high (809.12 Kg/ha) in case of the plants manured with vermi compost + AZ+PSB+ KSB (T_9). Soil microbial analysis manifested that plants at T8 had maximum count of soil azotobacter (61.05 $X10^6$ cfu/g) and KSB count ($67.63X10^6$ cfu/g), whereas, plants at T9 had maximum PSB content (43.33X 10^6 cfu/g) and considerably high KSB count (63.94 $X10^6$ cfu/g) compared with control [AZ ($5.63X10^6$ cfu/g); PSB ($9.86X10^6$ cfu/g), KSB ($13.65X10^6$ cfu/g)].

Among the different treatments, plants at T_8 had maximum cladode nitrogen (2.26%), phosphorus (0.36%), potassium (2.30%), Fe (262.14 ppm), Zn (62.65 ppm) along with carbohydrate: N ratio (1.57). It was found that plants at T_{11} also had high cladode nitrogen (2.11%), phosphorus (0.37%), potassium (2.24%), Cu (12.87 ppm), Zn (60.82 ppm) and carbohydrate: N ratio (1.54) compared with others.

Economic analysis revealed that treatment with FYM + AZ+PSB+ KSB (T_8) had maximum benefit : cost (B:C) ratio (1.83) followed by T_{11} (1.73) compared with control (-0.53). Control had net loss of Rs.180260.00 for cultivation of dragon fruit in one hectare land without using any fertilizer or manure for crop growth.

In the present experiment dragon fruit plants at FYM + AZ+PSB+ KSB (T_8) performed well. Further, it was found that plants manured with PM+ AZ+PSB+ KSB (T_{11}) also had good plant growth in terms of cladode length, circumference and no. of cladode per plant. Besides, plants under this treatment had good fruit set, low flower bud drop, high yield of quality fruits in terms of fruit weight, volume, pulp recovery, TSS, TSS:acid ratio, total sugar, ascorbic acid, peel and pulp anthocyanin content. Moreover, soil organic carbon, soil C:N ratio, soil and plant nitrogen, phosphorus, potassium, Fe, Cu, Zn content and microbial count of AZ, PSB and KSB in soil was found high under this treatment. B:C ratio was also remained high under this treatment. Therefore, it may be concluded that FYM + AZ+PSB+ KSB (T8) and PM+ AZ+PSB+ KSB (T11) are the two potential organic nutritional treatments for dragon fruit plants.

Overall, it may be finally concluded that for integrated nutrient management, T_8, i.e. plants applied with 50% RDF of NPK + 25% K through FYM + 25% K through VC along with biofertilizers (AZ+PSB+ KSB) and for organic nutrient management; T_8 (FYM+ AZ+PSB+ KSB) and T_{11} (PM+ AZ+PSB+ KSB) are the best suited treatments for dragon fruit cultivation.