The literature pertaining to recent research works conducted in India and abroad on the influence of organics on growth, yield, quality and economics of production of different fruits have been reviewed in this chapter.

2.1. Plant growth

2.1.1. Effect of organic manures on plant growth

Kurer et al. (2017) studied the effect of organic manures on growth of pomegranate (*Punica granatum* L.) cv. ‘Super Bhagwa’ under northern dry zone of Karnataka during *hasta bahar* season of 2016-17. They reported that the highest vegetative growth (Plant height, N-S and E-W spread) observed with 100% RDN through vermicompost.

Ghosh et al. (2012) carried out an investigation to study the role of organics in pomegranate grown in laterite soil and observed that FYM was better than vermicompost with regard to improvement in plant growth. Similarly, FYM resulted in maximum basal girth and canopy spread.

Jain et al. (2012) while studying the response of mycorrhiza and vermicompost as well as their interaction on plant growth characteristics of Nagpur mandarin (*Citrus reticulata* Blanco) during pre-bearing stage found best result in mycorrhiza @ 30 g treated plants which significantly increase the plant height; scion girth, canopy volume leaves and plant spread E-W and N-S over control.
Trivedi et al. (2012) investigated the impact of organic manures and inorganic fertilizers on growth, yield, nutrient uptake and soil nutrient status in guava and reported that maximum East-West plant spread was observed with castor cake application.

Rey et al. (2008) studied the effects of FYM, vermicompost, poultry manure, neem cake and inorganic fertilizer mix (control) on yield in quality of pawpaw (cv. Pusa Delicious). Among the organic amendments, pawpaw was more responsive to FYM and poultry manure.

Kaur et al. (2007) investigated an experiment in 24 years old litchi trees to find out the effect of organic manures on growth and yield with five treatments of organic manures viz., no manure (control), neem Cake (10kg/tree), neem Cake (20 kg/tree), FYM (50kg/tree) and FYM (100kg/tree). They recorded that maximum plant spread was observed with plants treated with FYM @ 100 kg/tree.

Sabarad et al. (2004) examined the influence of vermicompost on vegetative growth of banana cv. ‘Rajapuri’ and recorded that plants treated with vermicompost exhibited higher plant height compared with control.

Kanamadi et al. (2004) conducted an experiment on influence of organic and inorganic fertilisers on growth and yield characters of banana cv. Rajapuri and observed that the application of FYM and neem cake had maximum pseudostem girth in banana cv. Rajapuri

2.1.2. Effect of bio-fertilizers on plant growth

Jamwal et al. (2018) carried out an experiment at Sam Higgin bottom University of Agriculture Technology and sciences at Allahabad (U.P) on three years old guava cv. Allahabad Safeda. They observed that the maximum increase in tree
height, canopy spread N-S direction and E-W was obtained with *Azobacter* + 100% Nitrogen through urea.

Kumar *et al.* (2015) observed that the combination of vermicompost and PSB showed highest plant height, leaves plant$^{-1}$, primary branches plant$^{-1}$ and secondary branches plant$^{-1}$ in strawberry cv chandler.

A field experiment was conducted by Manoj *et al.* (2013) on the effect of bio-fertilizers on growth, yield and fruit quality in low chill pear cv. Gola and concluded that the application of 30g *Azotobacter* incorporated with 20 kg FYM increased the tree height, tree spread and shoot growth of pear plant.

Lata *et al.* (2013) studied the impact of organics and bio-fertilizers with inorganic fertilizers on the vegetative growth parameters of strawberry cv. Chandler. The maximum growth in terms of height of the plant, length of leaves and width of leaves were recorded in the treatment with *Azotobactor (50%) + Azospirillum (50%) + NPK (50%) + FYM)*.

A field experiment was conducted by Nazir *et al.* (2012) on organic nutrient sources on soil nutrient status and microbial population in strawberry field and observed that plants treated with poultry manure + *Azotobacter* + wood ash + phosphorus solubilizing bacteria + oil cake recorded maximum plant growth.

Dutta *et al.* (2010) examined the effect of bio-fertilizers on homestead fruit production of papaya cv. Ranchi and revealed that *Azotobacter + Azospirillum + VAM + 2 kg FYM* showed maximum plant height in Papaya.

Yadav *et al.* (2010) carried out a field trial on optimization of integrated nutrient supply system for strawberry cv. Chandler and reported that strawberry
plants applied with 100% inorganic fertilized treatments + *Azotobacter* recorded higher values in terms of plant height, plant spread and leaf area.

Patel *et al.* (2009) studied microbial and inorganic fertilizers application influenced vegetative growth, yield, and leaf nutrient status in sweet orange cv. Mosambi and noted that the maximum plant height was with the combined application of ¾ NPK + *Azospirillum* + AMF and micronutrients.

Shukla *et al.* (2009) evaluated the response of combinations of organic manures (FYM, vermicompost and organic, inorganic fertilizers, bio-fertilizers (*Azospirillum, Azotobacter, Pseudomonas fluorescense, Aspergillus niger*) on guava trees cv. Sardar under high density planting and revealed that the application of 50 per cent RDF of NPK + 50 kg FYM + 250 g *Azotobacter* significantly improve the canopy volume.

Yadav *et al.* (2009) revealed that the maximum and significant percent increment in growth parameters (plant height, girth and spread) with the soil application of 50% NPK + 50% FYM + 250g each (*Azotobacter + Azospirillum + PSB*) followed by 25% NPK + 75% FYM + 250g PSB.

Nowsheen *et al.* (2006) carried out an investigation to study the effects of organic nutrient management in strawberry cv Senga Senga and revealed that maximum plant height and plant spread was observed with integrated application of poultry manure + *Azotobacter* + wood ash + PSB + oil cake in strawberry.

### 2.1.3. Effect of biodynamic preparations on plant growth

Pathak and Ram (2012) reported that bio enhancers (BD 500 and BD 501) are rich source of microbial consortia, macro and micronutrients and plant growth
promoting substances including immunity enhancers. They are utilized to treat seeds/seedlings, and enhance decomposition of organic materials thereby enrich soil and induce better plant vigour.

Punam et al. (2012) conducted an experiment on the effect of organic management treatments on the productivity and quality of lemon grass (*Cymbopogon citratus*) and revealed that highest plant height and maximum number of offshoots was observed with the integrated application of organic manure+ BD-500.

Ram and Nagar (2004) studied the effect of different organic treatment combined with bio dynamic preparations on yield and quality of guava cv. Allahabad Safeda and observed the maximum vegetative growth (plant height and basal girth) with BD preparations and maximum increase in plant spread (East-west) with CPP.

### 2.2. Yield attributing characters and yield

#### 2.2.1. Effect of organic manures on yield attributing characters and yield

Kurer et al. (2017) studied response of pomegranate to different organic manures under northern dry zone of Karnataka and reported that the higher yield was observed in plants treated with 100% RDN through poultry manure and it was *at par* with 100% RDN through neem cake. Increase in yield with poultry manure application was higher than control (RDF) in pomegranate.

Lal and Dayal (2014) worked on acid lime and reported that treatment (50% RDF + 50% through Goat manure), performed best in terms of maximum vegetative growth and yield and highest fruit length, fruit diameter and fruit weight was recorded under 50% RDF + 50% through Goat manure.
Akash et al. (2013) carried out an experiment on integrated nutrient management in guava and reported that highest fruit yield was observed with FYM + 75% of N tree\(^{-1}\) through inorganic fertilizer.

Kumar and Kumar (2013) observed the response of organic manures on growth and yield of mango (Mangifera indica L) cv. Dashehari and reported that the maximum number of fruits per tree and yield per tree was observed with application of 75 kg vermicompost per tree followed by 50 kg vermicompost per tree.

Verma et al. (2013) studied the effect of organic manure and FYM in apple and reported that fruit weight, length and width increased considerably by application of organic manures.

Shivakumar et al. (2012) carried out an investigation on organic cultivation of papaya on yield and observed that application of farm yard manure equivalent to 100% RDN yielded more fruit number and fruit weight in papaya.

Yadav et al. (2012) examined the response of nutrient management through organic sources on the productivity of guava and revealed that application of poultry manure on guava trees resulted significantly increased no. of fruits per plant and higher yield.

Singh et al. (2011) worked on the integrated nutrient management on guava and reported that the highest fruit yield per plant was observed with 50% RDF + 25 kg FYM + 50 kg vermicompost treated plants.

Rajbir et al. (2010) carried out an investigation on the effect of vermicompost (VC) on strawberry cv. Chandler and observed that vermicompost application at 10 t ha\(^{-1}\) resulted in highest fruit yield.
Bashir et al. (2009) observed the effect of manure and fertilizers on 10-12 years old guava cv. Larkana Surahi and found that maximum yield per plant, fruit weight, pulp weight, fruit size and number of seeds were obtained in guava plants applied with 40 kg FYM + 1 kg each of N-P₂O₅-K₂O per plant.

Musmade et al. (2009) evaluated integrated nutrient management in acid lime and they reported that maximum yield and better quality were obtained by applying NPK + 15 kg each of FYM and neem cake.

Rai et al. (2009) conducted an investigation on the effect of four different organic amendments (FYM, vermicompost, poultry manure and neem cake) on yield and quality of pear cultivar Gola. They recorded that application of 40 kg vermicompost per tree significantly increased the yield and yield attributing characters.

As reported by Athani et al. (2007), the highest polar diameter (of fruit, fruit weight, fruit volume, pulp thickness and pulp weight was observed with the application of 75 per cent recommended dose of fertilizers with 10 kg vermicompost per plant in 6-years-old guava cv Sardar

Korwar et al. (2006) found that the combined application of vermicompost and FYM significantly increased number of harvested fruits in 4 year old aonla.

Balakrishna et al. (2005) observed that banana plants applied with 75% RDF along with vermicompost recorded significantly maximum bunch weight, bunch width, number of hands per bunch and yield per hectare, while the banana plants treated with RDF along with Trichoderma harzianum produced significantly more number of fingers per hand and total number of fingers per bunch.
Kanamadi et al. (2004) examined the influence of organic and inorganic fertilizers on growth and yield characters of banana cv. Rajapuri and revealed that the application of FYM and neem cake recorded highest yield of 26.81 t ha$^{-1}$ than control (15.65 t ha$^{-1}$) in banana cv. Rajapuri.

Dubey and Yadav (2003) determined the effect of Khasi mandarin to organic versus inorganic fertilization and they reported that the maximum fruit yield was observed with the application of pig manure.

Gamal and Rajab (2003) recorded combined application of inorganic and organic fertilizers increased leaf area and yield (fruit weight and fruit number) compared to either inorganic or organic fertilizers supplied alone. They found best results with the application of farmyard manure at 52 kg/tree + inorganic N at 1.82 kg N/tree.

Mustaffa et al. (2003) reported that in Karpuravalli banana vermicompost + neem cake + poultry manure significantly increased the bunch weight, number of hands and total number of fingers in karpuravalli banana.

### 2.2.2. Effect of bio-fertilizers on yield attributing characters and yield

Manjare et al. (2018) investigated the effect of application of bio-fertilizers with chemical fertilizers on growth, yield and quality of sapota (*Manilkara achras* (Mill.) cv. Kalipatti and observed that integrated application of NPK, *Azospirillum* and PSB resulted in highest fruit set and number of fruit per tree in sapota.

Sharma et al. (2017) conducted an experiment on the response of organic and inorganic sources of nutrients on productivity and profitability in high density orchard of mango (*Mangifera indica* L) cv. Amrapali and observed the highest fruit set, fruit retention, number of fruit per plant with plant treated with inorganic
fertilizers in combination with vermicompost + oil cake + Azotobacter + VAM + TV + PSB.

A field experiment was conducted by Bohane et al. (2016) on integrated nutrient management in ber (Zizyphus mauritiana Lamk.) cv. Gola and reported that plants treated with 50% RDF through vermicompost + 50% RDF through NPK + 50 g Azotobacter + 50 g PSB significantly increased fruit set, fruit retention, fruit length, diameter, fruit volume, pulp weight, stone weight, fruit weight and yield.

Dutta et al. (2014) worked on the effect of bio-fertilizers on physico-chemical qualities and leaf mineral composition in guava and observed the maximum fruit weight and yield per plant with integrated application of Azospirillum + Azotobacter + VAM.

Barne et al. (2013) conducted trial on the effect of different combinations of organic, inorganic manures and bio-fertilizers on yield and quality of guava during 2010-2011 and reported that the highest fruit yield was observed with plants treated with kg FYM + 250 g Azotobacter + 250 g PSB/plant.

Binepal et al. (2013) conducted field trial on integrated approach for nutrient management in guava cv. L-49 under Malwa Plateau conditions of Madhya Pradesh and concluded that maximum yield was recorded with the application of 100% N + 100% P₂O₅ + Azospirillum 30g+ PSB 30g + 10 kg vermicompost.

Mandal et al. (2013) recorded the highest plant height, number of fruit and yield of aonla cv. NA-7 under red and lateritic region of West Bangal with NPK+ FYM + PSB.

Manoj et al. (2013) studied the effect of fertilizers on growth, yield and fruit quality in low chill pear cv. Gola and recorded that 30 g Azotobacter augmented
with 20 kg FYM resulted the maximum fruit length, fruit breadth, fruit weight and fruit volume.

Meena et al. (2013) found that combined application of 2/3rd quantity of recommended dose of fertilizers NPK + FYM @ 25 kg/plant + Azospirillum @ 250g and Azotobacter @ 250 g/plant significantly increases number of fruits per plant, yield per plant and yield per hectare on a pooled basis.

Sharma et al. (2013) emphasized that bio-fertilizer is chief source of different micronutrients which play an important role in regulation of length and diameter of guava fruit by enhancing metabolic activities in plant cells.

Singh and Varu (2013) investigated the effect of integrated nutrient management in papaya (Carica papaya L.) cv. ‘Madhubindu’ and recorded that fruit length, fruit girth, fruit weight and number of fruits were maximum in plants treated with RDF (100:100:125 NPK g/plant) + Azotobacter at 50 g/plant + PSB.

Devi et al. (2012) conducted trial on effect of different organic and bio-fertilizer sources on guava (Psidium guajava L.) ‘Sardar’ and reported that application of neem along with vermicompost + Azotobacter + phosphorous solubilizers + potash mobilizers each significantly increased fruit weight in guava.

Dwivedi et al. (2012) studied the effect of bio-fertilizer and organic manures on yield and quality of ‘Red Fleshed’ guava and revealed that the maximum fruit yield for the rainy and winter season crop with Azotobacter + FYM.

Mishra and Tripathi (2012) conducted an experiment on vegetative growth, flowering, yield and quality of strawberry fruits cv. Chandler and revealed that combined application of Azotobacter and PSB exhibited maximum fruit length, fruit width, fruit weight, fruit volume number of flowers and fruit set.
Baviskar et al. (2011) concluded that the plants which were treated with integrated application of 1125:750:375 g NPK + 15 kg vermicompost + 250 g \textit{Azotobacter} + 250 g PSB/plant resulted in maximum fruit yield in sapota.

Singh et al. (2011) reported that highest number of fruits (194.30) was recorded with 50% RDF + 25 kg FYM + 50 kg vermicompost.

Mitra et al. (2012) conducted an experiment on the effect of different organic (neem cake, farm-yard-manure, vermicompost), inorganic fertilizers and bio-fertilizers (\textit{Azotobacter} and \textit{Azospirillium}) on yield of guava cv. ‘Sardar’ and observed that’s plants receiving combined application of 50 g N, 40 g P$_2$O$_5$, 50 g K$_2$O/plant/year resulted maximum fruit set per cent and yield.

Mahendra et al. (2009) investigated the effect of organic and inorganic fertilizer on eight year old plant of ber cv. Banarasi Karaka and recorded the highest plant height, spread, trunk girth, fruit set and fruit retention with the FYM + 100% NPK + \textit{Azotobacter} + PSB and FYM + 75% NPK + \textit{Azotobacter} + PSB.

Singh and Singh (2009) carried out an experiment on the response of bio-fertilizers and bioregulators on growth, yield and nutrient status of strawberries cv. ‘Sweet Charlie’ and noted that the highest fruit set and yield were found maximum with \textit{Azotobacter} + \textit{Azospirillum} + 50% of N of recommended dose + 100 ppm GA$_3$.

Umar et al. (2009) found that fruit size and fruit weight was maximum with application of 25 per cent nitrogen through FYM along with \textit{Azotobacter}, which was \textit{at par} with the plants supplied with cent per cent nitrogen in the form of urea applied with \textit{Azotobacter} in strawberry.
Verma et al. (2009) in an experiment on effects of bio-fertilizers on fruit productivity under organic cultivation of apple observed the highest fruit weight, length, width with organic manure at 5 kg tree$^{-1}$ and organic manure at 10 kg tree$^{-1}$ treated plants.

Karlidaga et al. (2007) studied the response of root inoculation of plant growth promoting rhizobacteria (PGPR) on growth and yield of apple and observed that plants treated with *Pseudomonas* resulted in significant increase in fruit weight and fruit diameter.

Babu Ratan (2006), while standardized Banana (*Musa spp.*) production by organic farming recorded that plants received poultry manure + *Azospirillum* + AMF recorded highest bunch yield in the first year crop while in the second crop vermicompost + *Azospirillum*+ PSB and in ratoon crop Poultry manure + *Azospirillum* + AMF recorded higher yields.

Boray et al. (2006) studied apple tree fertilization and concluded that the maximum fruit weight of apple was observed after dual inoculation of N-fixing bacteria (*Azotobacter chrococcum*) and PSB.

Mia et al. (2005) observed that the highest number of hands per bunch, weight of hand, bunch weight and yield was recorded with 50% or 33% recommended dose of N + *Azospirillum* + Phosphate Solubilizing Bacteria treated banana plants.

Shenawi and Sayed (2005) studied the effect of bio and organic fertilization on growth and productivity of Grand Naine banana and revealed that combined application of 100 kg FYM and 3 liters bio-fertilizers per plant per year resulted significant increase in number of hands per bunch of Grand Naine banana.
Rana and Chandel (2003) conducted an experiment on the effect of bio-fertilizers and nitrogen on growth, yield and fruit quality of strawberry and the maximum fruit length, fruit width and fruit weight was obtained with *Azotobacter* combined with 60 kg N ha\(^{-1}\) fertilized plants.

### 2.2.3. Effect of biodynamic preparations on Yield attributing characters and yield

Sharma *et al.* (2012) reported that application of BD 500 and BD 501 along with either FYM or vermicompost recorded a significant increase in seed yield of cumin over the application of FYM @ 6 t ha\(^{-1}\) and vermicompost @ 2 t ha\(^{-1}\) alone, respectively. Combined application of biodynamic manure BD 500 and BD 501 with FYM or vermicompost gave additional yield in comparison to sole application of FYM or vermicompost to cumin.

Jennifer *et al.* (2010) conducted an experiment on influence of biodynamic preparations on grapes and reported that bio-dynamics treated grapes had highest average cluster per vine, yield per vine and berry weight than the organic grapes.

Goldstein (1986) reported that biodynamically managed fields had greater microbial biomass, respiration and organic matter and longer roots and more grain yield than organic system.

### 2.3. Quality parameters of fruits

#### 2.3.1. Effect of organic manures on fruit quality

Narayan *et al.* (2016) studied the response of organic Manures on quality of Peach (*Prunus persica* Batsch) cv Florda Prince and concluded that plants treated with FYM + vermicompost + poultry manures + neem cake recorded maximum TSS,
ascorbic acid, reducing sugar and total sugar of fruits. Non reducing sugar was highest with application of poultry manures.

Nandi et al. (2013) conducted an experiment on pomegranate cv. Ganesh and found significant improvement in biochemical properties such as TSS, vitamin C, total and reducing sugar content of pomegranate by the use of enriched vermicompost with 75 and 100 % RDF.

Lal et al. (2012) investigated the response of organic manure on yield and quality of litchi (*Litchi chinensis*) cv. Rose Scented by using soil application of vermicompost, poultry manure, farmyard manure and they observed highest TSS, ascorbic acid and total sugar content with FYM 150 kg/plant followed by FYM 125 kg/plant.

Yadav et al. (2012) determined the effect of nutrient management through organic sources on the productivity of guava and reported that the application of poultry manure followed by FYM significantly increased TSS values and total sugars.

Ravishankar et al. (2010) conducted an experiment on performance of Coorg Honey Dew papaya under organic farming regimes in the hill zone of Karnataka and reported that the highest TSS, ascorbic acid, total sugar and least value of titrable acidity was observed in plants treated with FYM 20 kg/plant.

Singh et al. 2010 studied response of bio-inoculants and inorganic fertilizers on yield, nutrient balance, microbial dynamics and quality of strawberry (*Fragaria ananassa*) in Kashmir valley and observed that the strawberry fruits harvested from plants receiving vermicompost had significantly better TSS, ascorbic acid and had lower acidity than those harvested from plants receiving inorganic fertilizers only.
Verma and Sharma (2010) conducted trial on the influence of organic manure and FYM on apple and found that lowest titratable acidity in plants treated with organic manure at 10 kg tree\(^{-1}\).

Rai et al. (2009) determined the effect of four different organic amendments (FYM, vermicompost, poultry manure and neem cake) on yield and quality of pear cultivar Gola. The results indicated that application of 40 kg vermicompost per tree significantly increased quality parameters TSS, ascorbic acid content and reducing sugar content.

Naik and Sri Hari Babu (2007) in their study on the feasibility of organic farming in guava (*Psidium guajava* L.), found that the TSS was highest with animal manures and least in control. Acidity was highest under FYM and it was closely followed by vermicompost.

Ram and Pathak (2007) studied the effect of organic and inorganic fertilizers on three years old guava cv. Allahabad Safeda and reported that fruit quality parameters *viz.* TSS and vitamin C were improved with application of 20 kg FYM + BD-500.

Bhobia et al. (2005) conducted a trial on the effect of organic (FYM) and inorganic nitrogen on quality of winter season guava cv. Hisar Surkha at HAU, Hisar. They recorded that the maximum TSS, total sugars, reducing sugars and non-reducing sugars with the application of 60 per cent N through organic and 40 per cent through inorganic, however, maximum ascorbic acid was observed with the application of 20 per cent nitrogen through inorganic and 80 per cent through organic.
Sivecev et al. (2005) studied the effect of microbial bio-fertilizers (Azotobacter and Bacillus megaterium) on fruit quality of grapes and obtained highest total acid content with accumulation of higher sugars and maturity index. Application of AM fungi resulted in highest total soluble solids, TSS/acid ratio and vitamin C.

Antuono et al. (2004) examined quality differences between organic and integrated cultivation and observed that strawberry fruits obtained from integrated organic production system were firmer and recorded high sugar content, better fruit colour, higher acid and nitrate contents were observed.

Lamprecht et al. (2004) experienced that organically produced apples cvs. Jonagold, Pinova and Topaz had higher contents of soluble dry substance, titratable acids and minerals than conventionally grown ones.

Yusuf et al. (2003) determined the effect of different combinations of nitrogen, phosphorus and farm yard manure on strawberry cv. Tuft and reported that total soluble solids and vitamin C contents of strawberry fruits were recorded highest in combined application of nitrogen (150 kg ha\(^{-1}\)) + phosphorus (100 kg ha\(^{-1}\)) + farmyard manure (20 t ha\(^{-1}\)) treated plants.

Amaro and Monteiro (2001) studied pulp yield and physicochemical characteristics of yellow passion fruit produced by organic and conventional cultivation and reported that fruit pulp was more in organically grown fruits than conventionally grown fruits.
Pereira and Mitra (1999) conducted an investigation on response of organic along with inorganic nutrient on guava and observed that fruits from the plants treated with FYM at 30 kg per plant exhibited highest TSS, TSS acid ratio and vitamin C content.

Srivastava and Soni (1988) studied the quality of grape cv. Perlette as influenced by NPK and FYM. They concluded that increasing nitrogen and phosphorus along with FYM (30 kg) increased TSS content.

2.3.2. Effect of bio-fertilizers on fruit quality

Das et al. (2017) conducted an experiment on the effect of different bio-fertilizers on fruit quality in guava cv. L-49. and reported that *Azospirillum brasilense* + AMF resulted in best quality fruit production.

Devi et al. (2014) emphasized that farm yard manure + *Azotobacter* + phosphorous solubilizers + potash mobilizers recorded higher total soluble solids (17.79°Brix) and total sugar content (17.57%) in “Bombai” litchi.

Dutta et al. (2014) studied the effect of bio-fertilizers on physico-chemical qualities on guava fruits and observed that bio-fertilizers combination of *Azospirillum* + *Azotobacter* + VAM was the most effective in improving the fruit quality of guava L-49 among different treatments.

Vanilarasu and Balakrishnamurthy (2014) conducted an experiment on effect of organic Manures and amendments on quality attributes of banana cv. Grand Naine and concluded that the treatment with *Azospirillum*, PSB and *Trichoderma harzianum* registered maximum values of quality attributes in terms of TSS, Acidity, Ascorbic acid, non-reducing and total sugars in banana cv Grand Naine.
Akash et al. (2013) studied the combined effect of organic and inorganic sources on guava cv. Sardar and reported that the highest TSS and total sugars were obtained from application of 50% of N/tree through FYM + 50% of N/tree through inorganic fertilizer. They further reported that the highest ascorbic acid content was found due to application of 100% nitrogen from FYM along with inoculation of *Azotobacter*.

Singh and Varu (2013) conducted a trial on the effect of integrated nutrient management in papaya (*Carica papaya* L.) cv. Madhubindu and revealed that the highest total soluble solids (15.47°B) was observed with the applications of ½ RDF + *Azotobacter* @ 50 g/plant + PSB @ 2.5 g/m2.

Dadashpour and Jouki (2012) studied the influence of different organic nutrient combinations on yields and quality of strawberry cv. Kurdistan in Iran by using organic nutrient combinations and reported that manure + *Azotobacter* + wood ash + PSB + oil cake improved significantly the quality of fruits in terms of total sugars, total soluble solids (TSS), acidity and TSS: acidity ratio.

Vazquez-Ovando et al. (2012) reported that the application of compost and bio-fertilizers, enriched with beneficial microorganisms on banana “Grand Naine” plants without any synthetic fertilizer, provides sweeter fruits due to higher contents of reducing and total sugars and vitamin C.

Sharma et al. (2011) revealed that the application of full dose of nitrogen in the form of poultry manure, augmented with *Azotobacter* and *Azospirillum*, plays a vital role in increasing fruit nutrient status of guava.

Iqbal et al. (2009) observed that FYM integrated with urea and *Azotobacter* in strawberry increase the fruit quality *viz.* total soluble solids, total sugars, ascorbic
acid and anthocyanin contents where plants were treated with 25 per cent nitrogen through FYM + 75 per cent nitrogen in the form of urea + Azotobacter.

Mahendra et al. (2009) carried out the effect of integrated nutrient management on yield and quality of ber (*Zizyphus mauritiana* Lank.) cv Banarasi Karaka) and reported that the highest quality parameters viz., TSS, ascorbic acid, reducing sugar, non-reducing sugar, total sugar and minimum acidity content was recorded with the soil application of FYM+100% NPK+ Azotobacter+ PSB closely followed by FYM.

Sharma et al. (2009) observed the effect of bio-fertilizers and organic manures on physico-chemical characteristics and soil Nutrient composition of guava (*Psidium guajava* L.) cv. Sardar and observed that the application of cent per cent nitrogen through poultry manure along with Azotobacter and Azospirillium recorded maximum TSS, total sugars and ascorbic acid of guava fruits.

Shukla et al. (2009) observed that application of 50 percent dose of recommended NPK+50 kg FYM+250g Azotobacter significantly increased TSS, ascorbic acid, reducing sugars and total sugars.

Yadav et al. (2008) reported that in phalsa (*Grewia subinaequalis* D.C.) maximum fruit size, average fruit weight, juice percentage, total soluble solids and ascorbic acid were recorded with the use of 110 g urea+125 g SSP+26 g MOP+10 kg FYM + Azotobacter + PSB. Maximum sugars and pulp/stone ratio were recorded with the use of 55 g urea + 63 g SSP + 13 g MOP+15 kg FYM + Azotobacter + PSB.

Selvabai et al. (2007) summarized that application of Azospirillum at the rate of 3.3 g/plant along with 100 g inorganic nitrogen in two split doses during 3rd and 5th month of planting increased TSS of banana.
Suresh and Hasan (2001) evaluated the response of Dwarf Cavendish banana (Musa AAA) to bio-fertilizer inoculation and suggested application of *Azospirillum* along with 50 per cent recommended Nitrogen for enhancing total soluble solids and reduced total sugars, whereas combined application of *Azospirillum* and phosphobacteria along with 100 per cent recommended dose of nitrogen and potassium had increased the total sugars in Dwarf Cavendish (AAA) Banana.

2.3.3. **Effect of biodynamic preparations on fruit quality**

Pathak *et al.* (2005) studied the effect of organic treatment in papaya cv Pusa Delicious and reported that maximum fruit yield, highest TSS were observed with integrated application of CPP 500 g and 50kg FYM.

The positive impact of biodynamic practices and ‘panchgavya’ alone or in combination with various organic nutrient management practices has been found in improving the quality of various crops (Shwetha, 2007)

Jayasree and George (2006) observed that the highest ascorbic acid content in chilli was observed with the application of BD 500 + BD 501 by adopting biodynamic calendar as compared to control.

2.4. **Soil nutrient status**

2.4.1. **Effect of organic manures on soil nutrient status**

Wani *et al.* (2017) reported that in walnut integrated application of 75% NPK through inorganic fertilizers + 25% through vermicompost exhibited highest available soil nitrogen, phosphorus and calcium, available zinc, manganese, iron and copper content. Whereas, maximum available potassium and magnesium was observed in treatment 100% through manure (FYM 50% + vermicompost 25% + poultry manure 25%).
A field experiment was conducted by Adak et al. (2014) on soil organic carbon, dehydrogenase activity, nutrient availability and leaf nutrient content as affected by organic and inorganic source of nutrient in mango orchard soil and reported that the buildup of available nitrogen was observed due to the addition of vermicompost than FYM in soil.

Trivedi et al. (2012) observed maximum available organic carbon (0.50%), P$_2$O$_5$ (59.13 kg/ha) and K$_2$O (382.79 kg/ha) was observed with FYM and bio compost application. They further reported that incorporation of vermicompost resulted in the maximum nitrogen uptake and that of FYM resulted in the maximum phosphorus uptake and organic carbon content in the soil.

Verma and Chauhan (2012) studied apple productivity and soil properties under organic farming in temperate zone of Himachal Pradesh and reported that the maximum available N, P and K were observed with the application of FYM @100 kg/tree

Marathe et al. (2011) reported that farmyard manure and green manuring with sunhemp plus 50% NPK supplied through inorganic fertilizers showed significant increase in available organic carbon, N, P and K in the soil.

Verma et al. (2009) reported that the increase in soil moisture availability, pH, organic carbon and nutrient status of the soil was significant under organic manure. Soil moisture, pH, organic carbon and available N, P and K were recorded maximum under FYM @ 100 kg tree$^{-1}$ and organic manure @ 20 kg tree$^{-1}$.

Babu and Sharma (2005) conducted an experiment on integrated nutrient management on productivity of ‘Jahajee’ banana and soil properties under Nagaland foot hills condition and observed that FYM supplies nitrogen, phosphorus, potassium...
and sulphur in available forms to the plants through biological decomposition. Indirectly it improves the physical properties of soil such as aggregation of soil, permeability and water holding capacity.

Yadav and Vijayakumari (2003) observed that the improvement in growth of plants might be due to better moisture retention capacity of organic manures and supply of nutrients due to favourable soil condition brought out by the application of vermicompost.

Mukherjee et al. (2000) experienced that vermicompost application significantly improved the soil health. This might be due to better soil aggregation and aeration brought about by organic amendments by adding various humic fractions and thereby, increased microbial and enzymatic activity accelerated by vermicompost.

The increased in available N, P, K, Fe and Cu status in the soil were observed with the application of vermicompost (Vasanthi and Kumaraswamy, 1999). Webber and Singh (1995) also observed that application of cow manure increased the zinc availability in the soil profile.

2.4.2. Effect of bio-fertilizers on soil nutrient status

Mir et al. (2013) observed that integrated application of bio-fertilizers 80 g/tree, vermicompost 20 kg/tree, FYM 20 kg/tree, green manure sunhemp (Crotalaria juncea L.) and RD of NPK, resulted in significantly increased organic carbon (1.90%), soil pH (6.89), soil N (405.56%), P (22.02%), K (419.00%).

Marathe et al. (2012) reported that FYM, vermicompost, wheat straw on nitrogen equivalent basis and green manuring with sunhemp as singly or in combination with inorganic or bio-fertilizers like Azotobacter and PSB were highly
effective in increasing the microbial population with soil organic manures application.

Dutta and Kundu (2012) conducted a trial on the effect of bio-fertilizers on nutrient status and fruit quality of Himsagar mango grown in new alluvial zones of West Bengal and reported that the combined application of *Azotobacter* + *Azospirillum* + AM + PSM showed maximum organic carbon, available N, P and K in soil.

Nazir et al. (2012) also reported that population of *Azotobacter* and PSB were observed maximum with the combined application of poultry manure + *Azotobacter* + wood ash + PSB + oil cake and whereas, poultry manure + *Azospirillum* + Wood ash + PSB + oil cake increased available nitrogen and phosphorus of soil.

Singh et al. (2010) conducted trial on conjoint application of bio-organics and inorganic nutrient sources for improving cropping behaviour, soil properties and quality attributes of apricot (*Prunus armeniaca* L) and recorded that addition of bio-organic significantly improved availability of N, P and K content of soil.

Verma and Charan (2009) observed that soil moisture, pH, organic carbon and available N, P and K were recorded maximum with the application of farm yard manure and organic manure in apple.

Umar et al. (2010) conducted an experiment on response of Subabul (*Leucaena leucocephala*), urea and bio-fertilizer application and they reported that soil application of *Azotobacter* increased soil pH.
Usha et al. (2004) reported that combined application of bio-fertilizers and FYM significantly increased the organic carbon, nitrogen, phosphorus and potassium of the soil and the soil.

**2.4.3. Effect of bio-dynamic preparations on soil nutrient status**

Rana et al. (2015) observed that nutrient supply through organic nutrient sources along with biodynamic preparations and ‘panchgavya’, alone and in combination with cropping system Basmati rice-Chickpea-Sesbania green manure have a potential impact on improving the soil quality in terms of biological health.

Giannattasio et al. (2013) studied Microbiological features and bioactivity of a fermented manure product (Preparation 500) used in biodynamic agriculture and revealed that the fermented manure derivative known as Preparation 500 as a field spray resulted in increased soil fertility.

Procter (1997) studied the effect of BD-500 on soil and found that there were improvement in soil structure, better root development and plant growth with BD-500 application compared with the effects of conventional chemical fertilizer application.

Koepf (1989) reported that the use of cow-horn manure (BD 500) and horn silica (BD 501) improved soil quality in terms of biological properties.

Koepf et al. (1976) reported that the biodynamic preparations consist of manure, silica, or plants and most are treated or fermented with animal organs, water, and/or soil. The preparations were developed to improve soil and crop quality.

Abele (1976) reported that application of biodynamic compost to soil resulted in greater soil C and N, microbial biomass and dehydrogenase to biomass ratio than applications of chemical fertilizers or non-biodynamic compost.
2.5. Leaf nutrient content

2.5.1. Effect of organic manures on leaf nutrient content

Athani et al. (2007) conducted trial on the effect of organic and inorganic fertilizers on growth, leaf, major nutrient and chlorophyll content and yield of guava cv. Sardar and reported that application of 75% recommended doses of fertilizers + 10 kg vermicompost significantly increased the leaf nitrogen, phosphorus and potassium. The same treatment resulted in the highest total chlorophyll and chlorophyll ‘a’.

Ram et al. (2007) studied organic production on guava and recorded that leaf nutrients N, P, K, Ca, S, Zn, Cu, Mn and Fe levels, were improved with the application of different organic treatments in guava cv. Allahabad safeda.

Doran et al. (2005) experienced the effects of compost prepared from waste material of banana on the growth, yield and quality properties of banana plants and observed that the maximum nutrient content of banana leaves were observed with the application of Farmyard manure, FYM + mineral fertilizers and 45 kg banana residue compost.

El-Kobbia (1999) observed the response of Washington navel orange to organic fertilizer bio-humus and cattle manure application and he concluded that, the highest content of N, P and K in the leaves was observed with biohumus and cattle manure in ‘Washington naval’ orange trees.

El-Hady et al. (1991) evaluated that application of FYM significantly improved leaf nutrient contents during the main growth cycle and the autumn growth cycle of 6-year-old olive cv. Wateken. Similarly, FYM and a locally prepared
bitumen emulsion (Bit) increase N, P and K during the main autumn cycles by 43.51 and 22 per cent

Gubbuk et al. (1993) conducted an experiment on the response of application of nitrogen and farm yard manure on the leaf nutrient contents of banana cvs. Cavendish and Basrai. They reported that maximum K content was observed with application of FYM.

2.5.2. Effect of bio-fertilizers on leaf nutrient status

Karma Beer and Singh (2015) conducted trial on the effect of vermicompost and bio-fertilizers on chlorophyll and nutrients concentration in strawberry and reported plants treated with vermicompost + Azotobacter + PSB + AM resulted in maximum chlorophyll, nitrogen and phosphorus. Whereas potassium and boron were maximum in vermicompost + PSB + AM treated plants. Calcium and magnesium were observed highest in vermicompost + PSB and vermicompost + Azotobacter, respectively. The contents of iron and zinc were highest in vermicompost + Azotobacter + AM.

Manoj et al. (2013) studied the response of bio-fertilizers on growth, yield and fruit quality in low chill pear cv Gola and observed that highest leaf N was found in 60 g Azotobacter along with 20 kg/plant FYM. Application of 150g PSB incorporated with 20 kg FYM to individual plant of Gola pear showed highest phosphorus content.

Singh et al. (2012) reported that maximum phosphorus content in strawberry leaf was found in 50% NP + 100% K + Azotobacter + PSB + arbuscular mycorrhizal fungi treated plants.

Trivedi et al. (2013) observed that application of organic manures, inorganic fertilizers and bio-fertilizers on guava variety resulted in significant differences
amongst various growth attributes, fruit yield, leaf nutrient uptake and soil nutrient availability due to varieties, organic manures and bio-fertilizers.

Sharma et al. (2011) conducted an experiment on the effect of organic manures and bio-fertilizers on leaf nutrient status in guava (Psidium guajava L.) cv. Sardar and observed that the application of full dose of nitrogen in the form of poultry manure, augmented with Azotobacter and Azospirillum, plays a vital role in increasing N, P, K, Ca and Mg content in leaves of guava.

Shashi et al. (2011) reported that boron content (31.24 ppm, 33.80 ppm respectively) in Aonla was maximum in 50% NPK + 100 kg/ha FYM + Azotobacter + Azospirillum + PSB (100 g/tree each).

Selvamani and Manivannan (2009) worked on impact of organic manures, inorganic fertilizers and bio-fertilizers on the nutrient concentration of banana cv. Poovan mysore (AAB) and revealed that 50 percent RDF through inorganic fertilizers, organic manures with bio fertilizers recorded significantly highest leaf N, P, K, Na and Mg during vegetative stage, flowering and harvesting stages.

Ram and Pathak (2007) conducted trial on integration of organic farming practices for sustainable production of lemon and reported that plants treated with conjoin application of 20 kg FYM and Azotobacter recorded maximum fruit number and yield. Leaf nutrients N, P, K, Ca, S, Zn, Cu, Mn and Fe levels were optimum with the application of different organic treatments.

Eman El-Sayed (2006) found that that total chlorophyll content of Arabi pomegranate leaf increased significantly by the application of bio-fertilizer than traditional control trees. Trees treated with microbial bio-fertilizer and received 100 % of recommended mineral fertilization doses had the highest leaf chlorophyll
content followed by those received microbial bio fertilization + 75 % of recommended mineral fertilizers.

Soliman (2001) conducted an experiment on the effect of organic manures source on growth, yield, fruit quality and some minerals content of Maghrabi banana and reported that the highest N, P and K in leaves were observed with plants inoculated with free nitrogen fixing bacteria, yeast and mycorrhiza in their combinations.

Tiwary et al. (1999) carried out an investigation on leaf nutrient and chlorophyll content in banana under the influence of Azotobacter and Azospirillum and reported that leaf nitrogen and potassium content was highest with Azospirillum inoculated suckers, Phosphorus content in leaves was the highest for plants inoculated with Azotobacter.

2.6. Economics of cultivation

2.6.1 Effect of organic manures on economics of cultivation

Garhwal et al. (2014) recorded maximum B: C ratio was in the application of 60 kg FYM and maximum net returns were found in the application of 80 kg FYM per plant in Kinnow Mandarin.

Dwivedi (2013) evaluated the effect of integrated nutrient management on the economics of guava (cv. Allahabad Safeda). Application of 50% RDF (250:100:250g NPK) + 25 kg FYM +5 kg vermicompost /tree were found significantly superior than other treatments.

Shivakumar et al. (2012) worked on the effect of organic cultivation of papaya on yield, economics and soil status and reported that FYM alone produced
higher fruit yield and the B:C ratio was maximum against application of chemical fertilizers in papaya.

Singh et al. (2011) observed that in guava (cv. Allahabad Safeda) treatment with 50 per cent dose of recommended fertilizers + 25 kg FYM + 5 kg vermicompost/tree gave maximum net profit with a benefit cost ratio.

Marathe et al. (2011) conducted trial on the effects of integrated nutrient supply through organic manures and inorganic and bio- fertilizers on soil fertility status as well as yield and quality of sweet orange and recorded that application of farmyard manure and green manuring with sunhemp plus 50% NPK supplied through inorganic fertilizers showed supremacy with benefit: cost ratios.

Yadav et al. (2010) observed that N substitution by FYM provided highest B:C ratio than vermicompost due to its lower cost of production in strawberry.

Mennone (2006) concluded that, due to the technical, economic problems and higher prices, organic peach production was more profitable than integrated production.

2.6.2. Effect of bio-fertilizers on economics of cultivation

Srivastava et al. (2014) recorded the highest cost: benefit ratio under treatment combination FYM + 50% NPK + Aztobacter + PSB was due to the higher fruit production in papaya and reduced cost of chemical fertilizers as compared to other treatments.

Thakur and Thakur (2014) reported that the highest annual net income and benefit-cost ratio of plum cv. Santa Rosa was recorded under the treatment 75% NPK + bio-fertilizers + green manuring (Sunhemp @ 25 g seeds/tree basin).

Atom (2013) studied the effect of inorganic and bio-fertilizers on growth, yield and quality of Sardar guava at College of Agriculture, Latur. The gross and net
monetary returns were highest in 100% RDF + FYM + *Azotobacter* + PSB. Whereas, the highest benefit: cost ratio (3.15) was recorded in the treatment of 100% RDF + *Azotobacter* + PSB.

Kirad *et al.* (2010) reported that 75 per cent RDF + 25 per cent vermicompost + rhizosphere bacteria culture was found economically viable for papaya cv. Surya.

Shukla *et al.* (2009) evaluated the effect of integrated nutrient management under high density planting of guava (cv. Sardar) at Rajasthan College of Agriculture, Udaipur during 2005-07 and reported that the integrated application of 50 per cent dose of recommended NPK + 50 kg FYM + 250 g *Azotobacter* gave the highest B: C ratio (2.53:1).

Sharma (2004) studied the blending impact of nutrients on the economics of papaya (*Carica papaya* L.) cv. Washington at IGKV, Raipur, (Chhattisgarh) and concluded that highest gross and net returns was obtained in 75% RDF + PSB + *Azospirillum*.

### 2.6.3. Effect of biodynamic preparation on economics of cultivation

Trivedi *et al.* (2013) studied the effect of biodynamic preparations in Black gram and observed that the maximum net returns Rs. 23966.00 ha\(^{-1}\) was obtained in spray with BD 501 and lowest net returns was obtained from untreated control (17356.00 ha\(^{-1}\)). The maximum B: C ratio 2.24 was obtained with silicon BD and lowest B:C ratio was obtained from untreated control (1.55).