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Dr. Aradhana Barooah
College of Horticulture, Assam Agricultural University, Jorhat, Assam, India

Himadri Shekhar Datta
College of Horticulture, Assam Agricultural University, Jorhat, Assam, India

Corresponding Author:
Dr. Aradhana Barooah
College of Horticulture, Assam Agricultural University, Jorhat, Assam, India

Response of nutrient management on growth, yield and quality of strawberry: A review

Dr. Aradhana Barooah and Himadri Shekhar Datta

Abstract
Strawberry is a small fruit but for quality higher production large amount of nutrients are required for which efficient nutrient management is essential. Though inorganic fertilizers are major source of nutrients, imbalanced application of only chemical fertilizers may cause deleterious effect on soil health and environment. Organic manures can be used to supply nutrients for sustainable growth, yield and quality of strawberry. But sole application of organic manure has some problems like imbalanced supply of nutrients, not cost effective and less production as compared to inorganic fertilization. Biofertilizers are natural fertilizers with living microbial inoculants and can make unavailable nutrients available to plants. Integrated nutrient management can play important role for sustainable strawberry growth, yield and quality by maintaining long term soil fertility. Keeping in view of proper nutrient management for better growth, yield and quality of strawberry, different nutrient management in strawberry is reviewed.

Keywords: Strawberry, vermicompost, biofertilizer, integrated nutrient management

Introduction
Breeding between two American species, *Fragaria chiloensis* and *Fragaria virginiana* resulted in a hybrid plant which is the cultivated Strawberry (*Fragaria* × *ananassa* Duch.) (Trejo-Tellez and Gomez-Merino, 2014) [65]. It is a small fruit belonging to family Rosaceae which have acquired significant prominence among fruits and is now classified as a functional food offering multiple health benefits beyond basic nutrition with antioxidant and antihypertensive properties (Basu *et al*., 2014) [9]. Strawberry fruit is greatly appreciated by all irrespective of age group for its characteristic flavour, attractive red colour, juicy texture, and sweetness and the fruit is rich in vitamin C (40-120 mg/100 g fruit), protein and different minerals *viz.*, phosphorus, potassium, calcium and iron (Kanupriya, 2002) [30], phenolics and flavonoids (Hakkinen and Torronen, 2000) [23]. Strawberries have got great economic importance and are consumed either fresh or in prepared products like jams, juices, and jellies. This has led to the development of great interest in the study of Strawberry from the agronomic, genomic, and nutritional points of view (Giampieri *et al*., 2012) [18]. Strawberry is a permanent herbaceous plant with adventitious root system and most of the roots (50 to 90%) confined on the top surface soil and the plant is very sensitive to nutrient fluctuation (Yadav *et al.*, 2010) [74]. Strawberry can be cultivated in a wide range of soil varying from light sand to heavy clay but grows best in humus rich light porous soil (Sharma and Singh, 1999 [52]; Sharma, 2002 [51]). Proper nutrient management is inevitable as it affects vegetative growth as well as yield of crop (Sharma *et al.*, 2006) [50]. Nutrient management as well as maintenance of soil fertility is crucial for increased yield and fruit quality of strawberry and both macro and micro nutrients have positive effect on strawberry crop production (Trejo-Téllez and Gómez-Merino, 2014) [65]. Though application of chemical fertilizers is essential for significant enhancement of growth, development, yield and quality of strawberry, but continuous injudicious use of exclusive application of inorganic fertilizers only may cause deficiency of micronutrients and create hazardous effect on soil fertility and ecosystem, and ultimately poor crop yield (Singh and Singh, 2009) [53]. Okwuagwu *et al.*, (2003) [44] reported that increasing soil enzyme activity, available nitrates, carbon to total organic carbon ratio of organic manures enhance the soil fertility. Organic farming plays an important role by improving soil health as well as enzymatic activity of fruit plants (Kumar *et al*, 2018) [37]. But organic manure has some disadvantages as compared to chemical fertilizers like lower fertilizer efficiency, imbalance of nitrogen, phosphorus, potassium leading to lower yield of crop (Song *et al.*, 2017) [58] and organic manures are less available, expensive and production cost may increase up to 30% (Hamlet, 2001) [24]. Therefore, cost-effective increased yield with better quality fruits cannot be obtained by application of organic manures only. Being the carrier-based micro-organisms, biofertilizers help in increase of production by nitrogen fixation, phosphate solubilization and

releasing hormones, vitamins and growth promoting substances (Bamboriya *et al.,* 2018) [8] leading to enhancement of yield and quality of fruits. Therefore, a judicious integrated application of organic and inorganic nutrients along with biofertilizers may help in enhancing crop growth, yield and quality of strawberry (Subraya *et al.,* 2017) [61] as well as sustaining soil health (Meena *et al.,* 2019) [42].

A. Influence of organic nutrients on growth, yield and quality of strawberry

a. Effect of FYM (farm yard manure) on growth, yield and quality of strawberry: Being the most important and commonly used bulky organic manure, FYM, plays an important role in enhancement of strawberry yield by improving physico-chemical properties of soil along with release of macro and micro nutrients (Lakkineni and Abrol, 1994) [38]. Rashid (2018) [47] made a study on growth, yield and quality of strawberry cultivars *viz.,* Festival and AOG, by using different organic manures (cowdung, mustard oilcake and poultry manure) in single and in combined treatments and observed that combined application of cowdung + mustard oilcake + poultry manure is the best treatment in terms of yield (19.14 t/ha). Application of 40 tonnes of organic fertilizer (FYM) + 60 kg/ha NPK fertilizers in strawberry cultivation resulted higher fruit yield (27.62 t/ha) (Mahadeen, 2009) [40]. Maximum residual available major soil nutrient content like N (375.66 kg/ha), P (24.36 kg/ha) and K (164.52 kg/ha) was observed in the combined treatment of 100% NPK through FYM (Ahmadi *et al.,* 2018) [4]. Organic fertilization enhances early onset of reproductive stage of strawberry (Herenica *et al.,* 2011) [28]. Total sugars, TSS and juice percentage increased at organic manure treated strawberry plants (El-Hamid *et al.,* 2006) [17].

b. Effect of compost on growth, yield and quality of strawberry: Application of compost in soil with proper management can add array of nutrients to soil (Tejada *et al.,* 2001) [62], enhances soil organic matter, improves water holding capacity and other physical properties of soil (Wells *et al.,* 2000) [73], increases population of beneficial soil microbes, reduces plant pathogens (Abawi and Widmer, 2000) [1] and has positive effect on growth and yield of many plants (Sarwar *et al.,* 2008) [49]. Direct application of rice straw compost in soil and foliar application enhances yield and quality of strawberry. Application of 80% rice straw compost along with 20% soil resulted in highest yield (185.3 g/plant) and sweetness (total sugar 5.19%) of strawberry (Ashrafi *et al.,* 2019) [7]. In dryland conditions, application of sawdust, compost and manure to strawberry plantings, significantly increased organic matter content of the soil as compared to control (Webster, 1961) [71]. Better crop growth, higher yield and good quality fruits of strawberry can be derived by applying kitchen waste based liquid manure (Tiwari *et al.,* 2016) [63]. Recycled food waste based liquid compost can also increase strawberry production (Dara, 2017) [15]. Liquid organic fertilizer of vegetable waste @ 750 ml and 1:2 (soil rice husk charcoal) media revealed maximum leaf area (835.42 cm^2) and better quality of strawberry (Ginandjar *et al.,* 2019) [19]. Foliar application of aerobically prepared compost tea increased strawberry yield by 20% in comparison to control and water sprays (Welke, 2004) [72].

c. Effect of vermicompost on growth, yield and quality of strawberry: Vermicompost is an accelerated product of organic wastes, which is produced by interaction between earthworms and microorganisms, contains plant growth hormones and plant growth regulators (Kumar *et al.,* 2018) [37]. Vermicompost as well as vermiwash play an important role as growth promoter and protector of crop plants (Adhikary, 2012) [3] which help in increasing production. For transitional and organic production of strawberry, vermicompost can be applied as sustainable soil management strategy (Beck *et al.,* 2016) [10]. A study was conducted to evaluate the effect of vermicompost on growth and yield of 'Chandler' variety of strawberry under field condition. Significant enhancement in strawberry growth parameters and yield; including 37% increase in leaf areas, 37% in plant shoot biomass, 40% in numbers of flowers, 36% in numbers of plant runners and 35% in marketable fruit weights was found in vermicompost treated plants (Arancon *et al.,* 2004) [6]. Arancon *et al.* (2003) [5] also reported significant increase of leaf areas, number of strawberry suckers, number of flowers, shoot weights and total marketable strawberry yield in vermicompost added plots as compared to the inorganic fertilizer treated plots. Another study on foliar use of vermicompost and mustard oilcake as alternative source of nutrients for strawberry production revealed that maximum plant height (17.3 cm/plant), highest number of leaves (19.9/plant), highest number of runners (5.9/plant), highest number of fruits (26.9/plant), single fruit weight (14.3 g), fruit weight (383.7g/plant), brix (7.8%) and highest yield (11.0 t/ha) was found in vermicompost treated plants (Rahman *et al.,* 2018) [46]. In 18 weeks old greenhouse grown strawberry, maximum above ground vegetative biomass (15.3 g) was found when vermicompost at 25% is added with synthetic fertilizer as compared to synthetic fertilizer addition only (5.3 g) (Broz *et al.,* 2017) [12]. Enhanced vegetative growth as well as improved quality of strawberry fruits can be achieved by farm yard manure and vermicompost based organic amendments (Khalid *et al.,* 2013) [32]. Application of vermicompost @ 2.5 to 10 t/ha with inorganic fertilizer significantly increased plant spread, leaf area, dry matter and the marketable fruit yield of strawberry up to 58.6% with better quality parameters (Singh *et al,* 2008) [56]. Hasan (2013) [27] made a study on strawberry germplasm and organic matter response and reported that vermicompost was an excellent organic nutrient for growth, development and quality attributes including sweetness of strawberry. Changotra *et al.,* (2017) [13] also reported positive effect of vermicompost on growth and yield quality of strawberry. Singh *et al.,* (2010) [55] made a study on the effect of vermicompost on plant growth, fruit yield and quality of Chandler cultivar of strawberry and found that vermicompost application @ 10 t/ha increased plant spread (16.1%), leaf area (31.4%), dry matter (17.7%) and increased fruit yield (29.1%) over chemical fertilizer. Vermicompost treated plants produce healthy fruits with better quality (higher TSS, ascorbic acid content, lower acidity). Mehraj *et al.,* (2014) [50] made an experiment to study the response of different organic manures *viz.,* cowdung, vermicompost and poultry litre on strawberry and found that vermicompost gave maximum number of fruits (19.2/plant), fruit weight (14.4 g), total fruit weight (282.8 g/plant) and brix percentage (10.2%). Study also suggested vermicompost as a potential source of plant nutrients for organic strawberry production. For soilless production of strawberry, vermicompost + sand (20:80 and 15.85 v/v%) can be used as it has a high potentiality to enhance highest growth, yield (585 g/plant), quality and chemical contents (Abul-Soud *et al.,* 2015) [2]. Arancon *et al.,* (2004) [6] reported that application of food and paper waste vermicompost profusely

increase growth, flowering and yield of strawberry cv. Chandler.

d. Effect of biofertilizer on growth, yield and quality of strawberry: Biofertilizers are microbial inoculants help in increasing crop production by maintaining soil health. Organic manure use efficiency (Hassan, 2015) [26] and strawberry growth and yield was stimulated by application of plant growth promoting biofertilizers (Karlidag *et al.*, 2009) [31]. Plant growth, fruit quality and yield of strawberry can be significantly improved by appropriate combined application of bio-fertilizers with plant growth regulators (Sood *et al.*, 2018) [60]. A study on application of effective microorganisms (2%) and nitrogen treatment of 100 kg/ha through foliar application and fertigation in 'Paros' variety of strawberry in field condition showed maximum fresh (10.82 g) and dry weight (1.6 g) of berries (Einizadeh and Shokouhian, 2018) [16]. Application of NPK fertilizers with single microbial inoculation in strawberry plants can reveal positive effect on strawberry plant growth (Glinicki *et al.*, 2011) [20]. Mishra and Tripathi (2011) [43] made a study and found that combined application of *Azotobacter* and PSB significantly increased growth parameters like plant height, number of leaves, crowns, runners, number of flowers, fruit set per plant, fruit quality of berries (length, width, weight, volume, TSS, total sugars, ascorbic acid, titratable acidity). Highest fruit set yield and optimum fruit quality of strawberry cv. Sweet Charlie was found when the crop was inoculated with *Azotobacter* and *Azospirillum* @ 2kg/ha each, with 60 kg N/ha and 100 ppm GA3 (Singh and Singh, 2009) [53]. Significant effect on number of primary flowers per plant (8.0), number of secondary flowers per plant (10.0), total number of flowers per plant (7.0), number of primary fruit per plant (7.0), number of secondary fruit per plant (10.0) and total number of fruit per plant (17.0) was observed by combined application of PSB + nitrogen (225 kg/ha) and phosphorus (150 kg/ha) (Zargar *et al.*, 2008) [77]. A study on application of biofertilizer and nitrogen to strawberry cv 'Chandler' revealed that *Azotobacter* inoculated plants resulted in maximum plant height (24.92 cm), more number of leaves per plant (26.29 cm), more leaf area (96.12 cm^2), number of runners (18.70/plant), heavier fruit (10.02 g), more fruit length (35.9 mm) and more fruit breadth (22.91 mm) (Rana and Chandel, 2003) [45]. Tripathi *et al* (2017) [66] made an experiment to study the efficacy of bio fertilizers and mulching on growth, yield and quality of strawberry cv. Chandler and found that *Azotobacter* (7kg/ha) + black polythene produced higher yield (108.06 g/plant), maximum berry length (2.91 cm), width (1.81 cm), weight (7.13 g), volume (4.38 cc), TSS (7.18 ^oBrix), total sugars (5.62%), ascorbic acid (56.07 mg/100 g pulp) with minimum acidity (0.25%). In hydroponic system, the effect of *Azospirillum* and *Azotobcater* species on the growth and development of strawberry was studied and found *Azotobacter* and nitrogen treatments better than *Azospirillum* species (Rueda *et al.*, 2016) [48]. Todeschini *et al.*, (2018) [64] made an experiment and found that co-inoculation of different strains of arbuscular mycorrhizal fungi (AMF) with plant growth promoting bacteria (PGPB) (strains of *Pseudomonas* sp.) can enhance strawberry yield and quality as well as can help in maintenance of soil fertility. Use of fungal bacterial biofilm as a biofertilizer in strawberry cultivation reduces the use of chemical fertilizer (Singhalge *et al.*, 2019) [57].

e. Combined effect of organic manure and biofertilizer on growth, yield and quality of strawberry: A study on effect of organic manure and biofertilizers on growth, yield and quality of strawberry cv. Sweet Charlie revealed that integrated application of vermicompost (50%), poultry manure (50%) and *Azotobacter* showed maximum plant height (19.61 cm), number of leaves (21.11), number of flowers (30.41/plant), number of fruits (20.41/plant), fruit length (3.70 cm), fruit width (3.20 cm), fruit weight (11.83 g) and fruit yield (144.77 g/plant, 2.32 kg/plot, 7.72 t/ha) (Soni *et al.*, 2018) [59]. Kumar *et al.*, (2015) [36] revealed that vegetative growth parameter like fruit setting and Total Soluble Solids in strawberry plants increased when organic matter is applied in combination with biofertilizer. Influence of combined nutrient management on yield, quality, shelf life and economics of strawberry revealed that application of poultry manure, vermicompost, *Azotobacter* and PSB gave highest yield (112.63 g/plant), quality (TSS 7.05^0 B, ascorbic acid 53.42 mg/100 g of pulp) and shelf life (5.69 days) while highest B:C ratio (1:3.64) was found in FYM, vermicompost, *Azotobacter* and PSB treated strawberry crops (Jain *et al.*, 2017) [29]. In another study Kumar *et al* (2016) [37] revealed that integrated application of vermicompost @ 2.5 t/ha + half dose of recommended dose of NPK fertilizer resulted maximum plant height, number of leaves per plant, days taken to first flowering, number of flowers per plant, number of fruits per plant, duration of harvesting and yield per plant. A study on the effect of different organic combinations on yield and quality of strawberry cv. Kurdistan reported that combined application of manure + *Azotobacter* + wood ash + phosphorus solubilising bacteria + oil cake significantly enhanced fruit diameter (3.11 cm), length (3.95 cm), volume (20.397 cm^3), weight (11.11 g), total sugar (7.95%), TSS (9.01^oB), acidity (0.857), TSS: acidity ratio (11.12) and yield (238.95 g/plant) (Dadashpour and Jouki, 2012) [14]. Gupta and Tripathi (2012) [21] reported that combined application of *Azotobacter* (7kg/ha) + vermicompost (30 t/ha) significantly increased the plant height (19.45 cm), number of leaves (63.60), number of runners per plant (5.34) and maximum number of flowers (67.48) and fruit set (39.21) in strawberry cv. Chandler. Combined application of vermicompost + *Azotobacter* + PSB + Arbuscular mycorrhiza recorded maximum plant height, plant spread, number of leaves, leaf area and yield of strawberry (Singh *et al.*, 2015) [54].

B. Influence of Integrated Nutrient Management on growth, yield and quality of strawberry

Integrated application of organic manure and biofertilizer with chemical fertilizer is an important step in sustainable strawberry production, reduction of environmental contamination and can enhance the qualitative and quantitative characteristics of strawberry (Habibzadeh *et al.*, 2019) [22]. A study on the effect of organic, inorganic and biofertilizer based integrated nutrient management for nitrogen supply on growth of strawberry variety Chandler revealed that biofertilizer *(Azospirillum)* along with half of the Nitrogen through organic manuring *viz.*, vermicompost and remaining half Nitrogen through inorganic fertilization significantly increased sustainable growth and yield of strawberry in field condition (Yadav *et al.*, 2016) [76]. Maximum marketable strawberries (101.99 kg/ha) and TSS (total soluble solid) in berries (12.2^0 Brix) was also found in integrated application of biofertilizer, vermicompost and inorganic fertilizer. Combined application of mineral, organic and biofertilizer significantly increased leaf area (529.66 cm^2)/plant, number of leaves (28.56), number of fruits (33.73) and total production (367.24 g/plant) (Khalil and Agah, 2017)

[33]. Yadav *et al* (2010) [75] made a field study on application of various sources of nutrients without effecting the growth and yield of strawberry crop at lower cost and found that number of crown (4.33/plant), number of runners (11.33/plant), length of runners (45.67 cm), number of plantlets (12.53 lakh/ha), fruit characteristics like number of flowers (29.60/plant), number of berries (22.27/plant), and fruit yield (101.99 q/ha) were highest in integrated treatment of *Azotobacter* with 50% N substituted by vermicompost and remaining 50% through chemical fertilizer in two equal splits at establishment and before flowering stage. However due to lower cost of FYM than vermicompost, N substituted by FYM provided highest B:C ratio than vermicompost. Ahmadi *et al.* (2017) [4] made a polyhouse experiment to study the effect of integrated nutrient management on yield and quality of strawberry variety Sabrina and found that the strawberry plants treated with 100% RDF + VAM @ 10 kg/ha + 0.4% Boron + 0.5% $ZnSO_4$ spray resulted in significantly maximum number of fruits/plant (19.07), fruit weight (16.23 g), fruit length (4.28 cm), fruit diameter (2.56 cm), fruit volume (18.83 ml), yield/plant (309.70 g), yield/ha (17.20 tons), Benefit: Cost ratio (2.37), TSS (10.13 ^{0} Brix), total sugar (6.01%), reducing sugar (5.17%), TSS: Acid ratio (16.78) and lowest titrable acidity (0.61%). Significantly maximum leaf nutrient content like N (2.74%), P (0.51%), K (2.99%), Zn (29.00 ppm) and B (76.67 ppm) was also found in the strawberry plants treated with 100% RDF, VAM @ 10 kg/ha, 0.4% Boron, 0.5% $ZnSO_4$ spray. Kirad *et al.,* (2009) [34] made an integrated approach of application of chemical fertilizer, organic manures *viz.*, farmyard manure, vermicompost, poultry manure and rhizosphere bacteria culture, alone and in combination with different reducing level of chemical fertilizer and highest plant spread (32.37 cm), fruits per plant (8.77), fruit yield per hectare (8.07 t), shelf life (3.95 days) were found at 75% recommended fertilizer rate + 25% vermicompost + rhizosphere bacteria culture treatment but maximum plant height (20.35 cm) and acidity (0.83%) were observed in 75% recommended fertilizer rate + 25% vermicompost. Application of 25 per cent nitrogen through FYM + 75 per cent nitrogen as urea + *Azotobacter* in strawberry plant Cv. Chandler revealed highest amount of fruit quality parameters like total soluble solids, total sugars, ascorbic acid and anthocyanin content (Umar *et al.*, 2009) [67]. The impact of integrated nutrient management on yield and quality of strawberry (*Fragaria x ananassa Duch.*) under naturaly ventilated polyhouse condition was studied by Subraya *et al.* (2017) [61] and application of 75% of recommended dose of fertilizer + *Azospirillum* + PSB found best in terms of quality and yield of strawberry. The study also emphasized that by incorporating biofertilizer, inorganic fertilizer application can be reduced to 25%. Hammad *et al.*, (2014) [25] made an experiment to study the influence of compost, effective microorganisms and potassium on strawberry production in sandy soils and revealed that application of compost @ 8.3 kg/m^2 and effective microorganisms resulted in highest yield (1023 g/plant) and quality of strawberry but the fresh and dry weight as well as nitrogen, phosphorus and potassium uptake were significantly increased in compost @ 12.5 kg/m^{2}and effective microorganisms treated strawberry plot. Marketable and total fruit yield (1048 g/plant) and total soluble solids (10.65%) and firmness significantly increased in potassium treated plots. From the study it can be concluded that integrated application of effective microorganisms with organic and inorganic nutrients increase strawberry yield. Integrated application of inorganic and organic sources of nutrients positively affect the vegetative, reproductive and yield of strawberry plant and 75% of organic fertilizer integrated with 25% of inorganic fertilizer gave the best result (Wani *et al.*, 2013, [69] Wani *et al.*, 2015) [70]. Beer *et al.*, (2017) [11] studied the effect of organic, inorganic and bio-fertilizers on different growth parameters and yield of strawberry and found that integrated application of vermicompost (25 ton/ha) + *Azotobacter* (6 kg/ha) + NPK (70:80:80 kg/ha) needed minimum number of days to produce first flower, produced maximum number of flowers per plant, number of fruit set per plant, superior fruit quality and highest yield of strawberry. Integrated application of organic, inorganic and biological sources of optimum nutrients enhance the quality of strawberry fruits like size, TSS, sugars, acidity, anthocyanin pigmentation *etc.* (Yadav and Khokhar, 2012) [74]. Integrated application of *Azotobacter* (50%) + *Azospirillum* (50%) + NPK (50%) + FYM (30 t/ha) gave maximum plant height, number of leaves per plant, length of leaves and width of leaves of strawberry plant (Lata *et al.*, 2013) [39]. Verma and Rao (2013) [68] made an experiment to study the impact of INM on soil properties, plant growth and yield of strawberry cv. Chandler and reported that application of *Azotobacter* + PSB + vermicompost + 50% recommended dose of NPK recorded maximum plant height, plant spread, leaf area per plant, fruit weight, number of fruits and yield per plant and yield per hectare.

References

1. Abawi GS, Widmer TL. Impact of soil health management practices on soilborne pathogens, nematodes and root diseases of vegetable crops. Appl Soil Ecol. 2000; 15(1):37-47.
2. Abul-Soud MA, Emam MSA, Ei-Rahman NGA. The Potential Use of Vermicompost in Soilless Culture for Producing Strawberry. Int. J. Plant Soil Sci. 2015; 8(5):1-15.
3. Adhikary S. Vermicompost: the story of organic gold: A review. Agricultural Sciences. 2012; 3(7):Article ID:24396,13p DOI:10.4236/as.2012.37110
4. Ahmadi E, Honnabyraiah MK, Rao V, Sreekanth HS. Effect of Integrated Nutrient Management on Soil Nutrient Status, and Leaf Nutrient Status of Strawberry (*Fragaria* x *ananassa* Duch.) Cv. "Sabrina" under polyhouse. Int J Pure App Bio sci. 2018; 6(2):287-291.
5. Arnacon NQ, Edwards CA, Bierman P, Metzgar JD, Lee S, Welch C. Effects of vermicomposts on growth and marketable fruits of field-grown tomatoes, peppers and strawberries. Pedobiologia. 2003; 47:731-735. http://www.uIDanfischer.deljournals/pedo.
6. Arancon NQ, Edwards CA, Bierman P, Welch C, Metger JD. Influence of vermicomposts on field strawberries: 1. Effects on growth and yields. Bioresour Technol. 2004; 93(2):145-153.
7. Ashrafi R, Saiem RM, Kamruzzaman M, Mamun MSAA, Begum HA. Utilization of rice straw compost for strawberry and tomato production. Progress Agric. 2019; 30(4):335-343.
8. Bamboriya SD, Bamoriya JS, Shanti. Role of biofertilizers in agriculture-a review. Int. J Recent Sci Res. 2018; 9(7A):27727-27732.
9. Basu A, Nguyen A, Betts NM, Lyons TJ. Strawberry as a Functional Food: An Evidence-Based Review. Crit Rev Food Sci Nutr. 2014; 54:790-806.

10. Beck JE, Schroeder-Moreno MS, Fernandez GE, Grossman JM, Creamer NG. Effects of cover crops, compost, and vermicompost on strawberry yields and Nitrogen availability in North Carolina. Hortic Sci. 2016; 26(5):604-613.
11. Beer K, Kumar S, Gupta AK, Syamal MM. Effect of Organic, Inorganic and Bio-fertilizer on Growth, Flowering and Yield and Quality of Strawberry (*Fragaria* x *ananassa*Duch) cv. Chandler. Int. J Curr Microbiol App Sci. 2017; 6(5):2932-2939.
12. Broz A, Verma P, Appel C, Yost J, Stubler C, Hurley S. Nitrogen Dynamics of Strawberry Cultivation in Vermicompost-Amended Systems. Compost Sci Util. 2017, DOI: 10.1080/1065657X.2016.127780
13. Changotra P, Bashir D, Hussain S, Kaur A. Cultivation of strawberry (*Fragaria* x *ananassa* Duch) CV. Chandler as affected by bio and inorganic fertilizers under open conditions. Global J Biosci Biotechnol. 2017; 6(2):332-343.
14. Dadashpour A, Jouki M. Impact of integrated organic nutrient handling on fruit yield quality of strawberry. J Ornam Hortic. 2012; 2(4):251-256.
15. Dara SK. Evaluating a recycled food waste-based liquid compost in conventional California Strawberries. Agric Res Technol. 2017; 12(2):ISSN: 2471-6774.
16. Einizadeh S, Shokouhian AA. The effect of biofertilzer and nitrogen rates on quantitative and qualitative properties of strawberry cultivar 'Paros'. J Cent Eur Agric. 2018; 19(3):517-519.
17. El-Hamid Aza AS, Abbou AA, Mansour SAA, El-Sayed AAA. Effect of some biofertilizers on yield and fruit quality of strawberry. Ann Agric Sci. 2006; 44(10):251-64.
18. Giampieri F, Tulipani S, Alvarez-Suarez JM, Quiles JL, Mezzetti B, Battino M. The strawberry: Composition, nutritional quality, and impact on human health. Nutrition. 2012; 28:9-19.
19. Ginandjar S, Frasetya B, Nugraha W, Subandi M. The Effect of Liquid Organic Fertilizer and Planting Media on Growth and Yield of Strawberry (*Fragaria* spp.) Earlibrite Cultivar. IOP Conf. Series: Earth and Environmental Science. 2019; 334:012033, doi: 10.1088/1755-1315/334/1/012033
20. Glinicki R, Paszt LS, Tobjasz EJ. The effect of microbial inoculation with EM-farming inoculum on the vegetative growth of three strawberry cultivars. Horticulture and Landscape Architecture. 2011; 32:3-14.
21. Gupta AK, Tripathi VK. Efficiency of *Azotobacter* and vermicompost alone and in combination on growth, flowering and yield of strawberry. cv. Chandler. Progress Hortic. 2012; 44(2):256-261.
22. Habibzadeh F, Hazrati S, Gholamhoseini M, Khodaei D, Habashi D. Evaluation of Quantitaive and Qualitative Characteristics of Strawberry in Response to Bio- and Chemical Fertilizers. Hanif, Z. and Budiyati, E. (2011). Diversity technology strawberry cultivation in different regional production centre. Conference paper, 2019, DOI: 10.13140/RG.2.1.2719.8965
23. Hakkinen SH, Torronen AR. Content of flavonols and selected phenolic acids in strawberries and Vaccinium species: Influence of cultivar, cultivation site and technique. Food Res Int. 2000; 33:517-524.
24. Hamlet C. Fertilization strawberry (*Fragaria ananassa*). Available at http:://www.drcalderonlabs.com/Cultivos/Fresa/Fertilization_en_Suelo.pdf. 2001
25. Hammad S, Elzehery T, Ramadan A. Influence of compost, effective microorganisms (EM) and potassium on strawberry production in sandy soils. Acta Hortic. 2014; 1049:407-414. DOI: 10.17660/ActaHortic.2014104 9.57
26. Hassan AH. Effect of Nitrogen Fertilizer levels in the Form of Organic, Inorganic and Biofertilizer Application on Growth, Yield and Quality of Strawberry. Middle East J Appl Sci. 2015; 5(2):604-617.
27. Hasan M. Response of strawberry germplasm to organic fertilizers. M.Sc. Thesis. Department of Horticulture, Sher-e Bangla Agricultural University, Dhaka-1207, 2013.
28. Herenica JF, Garcia-Galavisa PA, Doradoa JAR, Maqueda C. Comparison of nutritional quality of the crops grown in an organic and conventional fertilized soil. Sci. Hortic. 2011; 129:882-888.
29. Jain N, Mani A, Kumari S, Kasera S, Bahadur V. Influence of INM on yield, quality, shelf life and economics of cultivation on strawberry (Fragaria X ananassa Duch) cv. Sweet Charlie. J. Pharmacogn Phytochem. 2017; 6(5):1178-1181.
30. Kanupriya. Crop Scan (strawberry). Agriculture Today, 2002, 48-49p.
31. Karlidag H, Yildirim E, Turan M, Donmez MF. Effect of Plant Growth-Promoting Bacteria on Mineral-Organic Fertilizer Use Efficiency, Plant Growth and Mineral Contents of Strawberry (Fragaria X ananassa L. Duch.). Reviwed papers, 2009, 218-226p.
32. Khalid S, Qureshi KM, Hafiz IA, Khan S, Qureshi US. Effect of organic amendments on vegetative growth, fruit and yield quality of strawberry. Pakistan J. Agric. Res. 2013; 26(2):104-112.
33. Khalil NH, Agah RJ. Effect of Chemical, Organic and Bio Fertilization on Growth and Yield of Strawberry Plant. Int J Adv Chem Engg Biol Sci. 2017; 4(1):167-171.
34. Kirad K, Barche S, Singh DB. Response of Integrated Nutrient Management in Strawberry (*Fragaria x ananassa* D.). Biology, 2009, DOI: 10.17660/ActaHortic 2009.842.140 Corpus ID: 83088260
35. Kumar D, Pratap B, Viswakarma G. Studies of Integrated nutrient management on vegetative, flowering and yield attributes of strawberry (Fragaria X ananassaDuch.) cv. Chandler. Ecol Environ Conserv paper. 2016; 22(2): 647-650.
36. Kumar N, Singh HK, Mishra PK. Impact of Organic Manures and Biofertilizers on Growth and Quality Parameters of Strawberry cv. Chandler. Indian J Sci Technol, 2015, 8(15). DOI: 10.17485/ijst/2015/v8i 15/51107.
37. Kumar R, Bakshi P, Singh M, Singh AK, Vikas V, Srivatava JN *et al*. Organic production of strawberry: A review. Int. J Chem Stud. 2018; 6(3):1231-1236.
38. Lakkineni KC, Abrol YP. Sulfur requirement in crop plants: Physiological Analysis. Fertilizer News. 1994; 39:11-18.
39. Lata R, Dwivedi D, Ram RB, Meena ML, Babu M. Impact of integrated nutrient management on growth parameters of strawberry cv. Chandler under sub-tropical conditions of Lucknow. Int. J. Adv. Biol. Res. 2013; 3(3):418-421.
40. Mahadeen AY. Influence of organic and chemical fertilization on fruit yield and quality of plastic house

grown strawberry. Jordan J Agric Sci. 2009; 5(2):167-177.
41. Mehraj H, Ahsan MK, Hussain MS, Rahman MM, Jamaluddin, AFM. Response of different organic matters in strawberry. Bangladesh res Publications J. 2014; 10(2):151-161.
42. Meena HR, Somasundaram J, Kaushik RA, Sarolia DK, Kala S, Meena GL. Integrated Nutrient Management Affects Fruit Yield of Sapota (*Achras zapota* L.) and Nutrient Availability in a Vertisol. Commun in Soil Sci Plant Anal, 2019, 50(22)
43. Mishra AN, Tripathi VK. Influence of Different Levels of *Azotobacter*, PSB alone and in combination in vegetative growth, flowering, yield and quality of strawberry cultivar cv. Chandler. Int J Appl Agric Res. 2011; 6(3):203-210.
44. Okwuagwu MI, Alleh ME, Osemwota IO. The effects of organic and inorganic manure on soil properties and yield of okra in Nigeria. African Crop Science Conf Proc. 2003; 6:390-393.
45. Rana RK, Chandel JS. Effect of biofertilizer and nitrogen on growth, yield and fruit quality of strawberry. Prog Hortic. 2003; 35(1):25-30.
46. Rahman MM, Islam MN, Roni MZK, Gani O, Jamal Uddin, AFM. Vermicompost and Mustard oil cake as an alternative fertilizer for strawberry production. Int J Bus Soc Sci Res. 2018; 6(3):78-84. ISSN: 2309-7892 (Online), 2519-5530 (Print), 6(3): 78-84, March-May 2018
47. Rashid MHA. Optimization of growth, yield and quality of strawberry cultivars through organic farming. J Environ Sci Nat Resour. 2018; 11(1&2):121-129.
48. Rueda D, Valencia G, Soria N, Rueda BB, Manjunatha B, Kundapur RR *et al*. Effect of *Azospirillum* spp. and *Azotobacter* spp. on growth and yield of strawberry (*Fragaria vesca*) in hydroponic system under different nitrogen levels. J Appl Pharm Sci. 2016; 6(01):048-054.
49. Sarwar G, Schmeisky H, Hussain N, Muhammad S, Ibrahim M, Safder E. Improvement of soil physical and chemical properties with compost application in rice-wheat cropping system. Pak J Bot. 2008; 40(1):275-282.
50. Sharma DK, Dashora LK, Sen LN. Influence of phosphorus rich organic manure (PROM), PSB and rhizobium inoculation on growth and yield of fenugreek (*Trigonella foenum-graecum* L) cv Rmt-1. The Orissa J Hort. 2006; 34:52-58.
51. Sharma RR. Growing Strawberry. International Book Distributing Co Lucknow, 2002.
52. Sharma RR, Singh SK. Strawberry Cultivation: a highly remunerative farming enterprise. Agro India. 1999; 3:20-22.
53. Singh A, Singh JN. Effect of biofertilizers and bioregulators on growth, yield and nutrient status of strawberry cv. Sweet Charlie. Indian J Hort. 2009; 66(2):220-224.
54. Singh AK, Karambeer, Pal AK. Effect of vermicompost and biofertilizers on strawberry: growth, flowering and yield. Ann Plant Soil Res. 2015; 17(2):196-199.
55. Singh R, Sharma RR, Singh DB. Effect of vermicompost on plant growth, fruit yield and quality of Strawberries in irrigatedarid region of northern plains. Indian J Hortic. 2010; 67(3):318-321.
56. Singh R, Sharma RR, Kumar S, Gupta RK, Patil RT. Vermicompost substitution influences growth, physiological disorders, fruit yield and quality of strawberry (Fragaria x ananassa Duch). Bioresour. Technol. 2008; 99:8507-8511.
57. Singhalge ID, Seneviratne G, Madawala HMSP, Wijepala PC. Profitability of strawberry (*Fragaria ananassa*) production with biofilmed biofertilizer application. Scientia Horticulturae. 2019; 243(3):411-413
58. Song K, Xue Y, Zheng X, Lv W, Qiao H, Qin Q *et al*. Effects of the continuous use of organic manure and chemical fertilizer on soil inorganic phosphorus fractions in calcareous soil. Sci Rep-UK. 2017; 7:1164. doi: 10.1038/s41589-017-01232-2.
59. Soni S, Kanawjia A, Chaurasiya R, Chauhan PS, Kumar R, Dubey S. Effect of organic manure and biofertilizers on growth, yield and quality of strawberry (*Fragaria* x *ananassa* Duch) CV. Sweet Charlie. J Pharmacogn Phytochem. 2018; SP2:128-132.
60. Sood MK, Kachawaya DS, Singh MC. Effect of Bio-fertilizers and Plant Growth Regulators on Growth, Flowering, Fruit Ion Content, Yield and Fruit Quality of Strawberry. Int J Agric Environ Biotechnol. 2018; 11(3):439-449.
61. Subraya BK, Madaiah D, Kumar DM. Effect of Integrated Nutrient Management on Yield and Quality of Strawberry (*Fragaria x ananassa Duch.*) Under Naturally Ventilated Polyhouse Condition. Int J Pure App Bio sci. 2017; 5(6):1704-1707.
62. Tejada M, Dobao MM, Benitez C, Gonzalez JL. Study of composting of cotton residues. Bioresour Technol. 2001; 79(2):199-202.
63. Tiwari V, Maji S, Kumar S, Prajapati G. Yadav R. Use of kitchen waste based bio-organics for strawberry (*Fragaria* x *ananassa*Duch) production. Afr J Agric Res. 2016; 11(4):259-265.
64. Todeschini V, AitLahmidi N, Mazzucco E, Marsano F, Gosetti F, Robotti E *et al*. Impact of Beneficial Microorganisms on Strawberry Growth, Fruit Production, Nutritional Quality and Volatilome. Front Plant Sci. 2018; 9:1611. doi: 10.3389/fpls.2018.01611
65. Trejo-Tellez LI, Gomez-Merino FC. Nutrient Management in Strawberry: Effects on yield, quality and plant health. In: Strawberries. Editor: Nathan Malone. Nova Science Publishers, Inc. 2014, 239-267.
66. Tripathi VK, Jain A, Kumar S, Dubey V. Efficacy of bio-fertilizers and mulching on growth, yield and quality of strawberry. (Fragaria x ananassa) cv. Chandler. Indian J Agric Sci. 2017; 87(9):1179-1183.
67. Umar I, Wali VK, Kher R, Jamwal M. Effect of Fym, urea and *Azotobacter* on growth, yield and quality of strawberry Cv. Chandler. Not. Bot. Hort. Agrobot. Cluj. 2009; 37(1):139-143.
68. Verma J, Rao VK. Impact of INM on soil properties, plant growth, and yield parameters of strawberry cv. Chandler, 2013, Corpus ID: 87464638.
69. Wani RA, Hakeem SA, Bashir S, Geelani S, Mughal MN, Prasad VN. Impact of integrated nutrient management on growth, yield and quality of strawberry (*Fragaria* x *ananassa* Duch) cultivation in India. Nat Sci., 2015, 13(1).
70. Wani RA, Sheema S, Malik TH, Geelani S, Bashir S, Dar NA *et al*. Impact of integrated nutrient management on growth, yield and quality of strawberry (*Fragaria* x *ananassa* Duch) cultivation in India. Adv Hortic Sci. 2013; 27(4):147-151.
71. Webster GR. The effect of sawdust, straw, compost and manure on the yield and chemical composition of

strawberries on soil moisture, acidity and organic matter content. Can J Plant Sci., 1961, 41(1).
72. Welke SE. The effect of compost extract on yields of strawberries and the severity of Botrytis cenerea J Sustainable Agric. 2004; 25(1):57-68.
73. Wells AT, Chan KY, Cornish PS. Comparison of conventional and alternative vegetable farming systems on the properties of a yellow earth in New South Wales. Agric Ecosyst Environ. 2000; 80(1-2):47-60.
74. Yadav SK, Khokhar UU. Integrated nutrient management for strawberry cultivation. Publisher: LAP Lambert Academic Publishing, 2012.
75. Yadav SK, Khokhar UU, Yadav RP. Integrated nutrient management for strawberry cultivation. Indian J Hort. 2010; 64(4):445-449.
76. Yadav SK, Khokhar UU, Sharma SD, Kumar P. Response of strawberry to organic versus inorganic fertilizers. J Plant Nutr., 2016, 39(2). https://doi.org/10.1080/01904167.2015.1109115
77. Zargar MY, Baba ZA, Sofi PA. Effect of N, P and biofertilizers on yield and physico-chemical attributes of strawberry. Agro-Thesis. 2008; 6(1):3-8.