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Efficiency of Integrated Nutrient Management to Improve Eggplant Production in Intercropping Systems

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ABSTRACT

Eggplant is a vegetable that is widely cultivated in Indonesia. Fertilization is one of the most influential factors to increase eggplant productivity. The research to improve the eggplant productivity through the application of various nitrogen nutrient sources in an integrated nutrient management system and an intercropping system with cabbage was carried out from June to December 2019 in Wonorejo, Poncokusumo-Malang. The study was conducted using a randomized block design (RBD) with 21 treatments and was repeated 3 times. The treatments were D0 = Control (180 kg N) and (D1–D20), which were various combinations of inorganic N fertilizers, manure, and microbes (EM and PGPR). Observations included the number of leaves and stem diameter of eggplant, number of cabbage leaves, number of fruit per plant, fruit weight (per plant, per hectare, and per fruit), and Land Equivalent Ratio (LER), soil analysis before and after the research. The results showed that the combination of 75% inorganic fertilizer + 20–30 $t \cdot ha^{-1}$ manure + 10–20 $ml \cdot l^{-1}$ microbe (EM / PGPR) in the eggplant – cabbage intercropping system increased the growth and yield of eggplant, with fruit weights ranging 1.86–2.35 $kg \cdot plant^{-1}$ or 40.88–53.17 $t \cdot ha^{-1}$, and LER value was 1.94–2.04.

Keywords: inorganic N, integrated nutrient management, intercropping system, manure, microbes.

INTRODUCTION

Eggplant is a representative of the Solanaceae family which is widely consumed by the public. Eggplant has a delicious taste and high nutritional content (Thingujam et al., 2016). According to El-Nemr et al. (2015), eggplant fruit is known to have low calories and contains lots of carbohydrates, protein, and several minerals that are beneficial to humans. Eggplant also contains several phytochemicals from the phenol group, flavonoids, alkaloids, and glycosides. In addition, eggplant contains quite a lot of anthocyanins and high antioxidants (Adamczewska-Sowinska and Krygier, 2013). Jagatheeswari (2013) suggests that consuming eggplant can lower cholesterol, and is suitable to regulate high blood pressure. On the basis of the nutritional content and benefits of consuming eggplant, the need for eggplant in the future will increase. The growth, yield, and yield quality of eggplant are mainly influenced by fertilization factors. Fertilization is the main limiting factor for the growth and productivity of eggplant (El-Nemr et al., 2015). According to Agbo et al. (2012) stated that eggplant is an annual plant. The growth and yield of eggplant can be hampered due to the inadequate supply of nutrients and the fast absorption of nutrients. On low fertility soils, eggplant plants need 150–200 kg $N \cdot ha^{-1}$, 100–150 kg $P_2O_5 \cdot ha^{-1}$ and 60–100 kg $K_2O \cdot ha^{-1}$. The growth and development of eggplant plants are influenced by the availability of nutrients, especially nitrogen and phosphorus (Sharma and Brar, 2008). Nitrogen is a nutrient that is needed by the eggplant. Aminifard et al. (2010) stated that eggplant plants are very responsive to N fertilization. Nitrogen is the main constituent of all amino acids in proteins and lipids which act as chloroplast structural compounds. The availability of nitrogen is one of the limiting factors for plant growth (Direkvandi et al., 2008). This is because element N is easily lost through leaching. Lack of nitrogen can reduce crop yields and quality (Sendi et al., 2011). Therefore, efforts are needed to increase the efficiency of N fertilizers by utilizing various nutrient sources.

The application of an integrated nutrient management system can increase the production of eggplant in sustainable agriculture. Rather et al. (2018) explained that the application of inorganic fertilizers becomes more efficient when combined with organic and biological fertilizers. The application of organic fertilizers, such as manure, increases the physical and chemical properties of the soil, e.g. soil texture, and water holding capacity, creating good soil aeration and reducing the pH value so that nutrients become more available for plants (Dawa et al., 2015). Meanwhile, microbial inoculation can increase plant growth by regulating the balance of nutrients and hormones, producing plant growth regulators, dissolving nutrients, and encouraging resistance to soil nematodes (Li et al., 2017). The results of the research by Ananda Kumar et al. (2018) showed that the application of inorganic, organic, and biological fertilizers had a major effect at all stages of eggplant plants. Through the application of a combination of various nutrient sources due to the balance of the C/N ratio, increased decomposition, mineralization, and nutrient availability (Rather et al., 2018).

Manure is a good organic fertilizer to increase plant growth and yield. Organic fertilizers provide nutrient needs, reduce plant pest populations as well as increase the yield and quality of agricultural crops in the same way as inorganic fertilizers (Islam et al., 2017). Piravena and Seran (2012) explained that organic fertilizers increase the macro and micronutrient content in the soil, water holding capacity, pH, and soil structure. The role of manure lies in its role as a soil repairer, improving physical conditions and biological activity parameters to increase soil productivity (Saravaiya et al., 2010). Microbes are an important part of integrated nutrient management. Various biological fertilizer products have been sold on the market. In general, commercial biological fertilizers contain several types of live microorganisms that play an important role in increasing plant growth and yield (Meena et al., 2017). The biofertilizer products that can be used in an integrated nutrient management system include EM and PGPR. Biofertilizer solutions generally contain several types of microbes. According to Olle and Williams (2013), EM consists of a mixture of beneficial microorganisms such as photosynthetic bacteria, Lactobacillus, yeast, and Actinomycetes. Meanwhile, PGPR is a biological fertilizer product containing the microbes of *Azotobacter, Azospirillum, Aspergillus, Pseudomonas,* and *Bacillus.* Soil microorganisms play an important role in regulating the dynamics of decomposition of organic matter and nutrient availability for plants (Maghfoer, 2018). Muhammad et al. (2017) explained that biological fertilizers have been developed as an important part of an integrated nutrient management system. The entire agricultural system depends on microbial activity, with microbes having a key role in increasing crop yields.

The efficiency of nutrient management in eggplant can be improved through intercropping systems. Ouma and Jeruto (2010) explain that intercrops with short morphology plants can be used as ground cover so that the soil temperature is lower. This prevents the evaporation of organic matter in the soil and the loss of nutrients. Planting plants with short roots among plants with long roots can also complement each other to increase the plant nutrient uptake (Yildirim and Turan, 2013). According to Gebru (2015), differences in root systems make plants grown in an intercropping system absorb more nutrients than in a monoculture system. The plants with shallow root systems can help increase soil aeration and break down soil hardness so that penetration of plant roots with longer roots becomes easier. This condition will increase nutrient uptake and increase plant growth (Qosim et al., 2013).

On the basis of the description above, it is hoped that the application of an integrated and intercropping nutrient management system can reduce the use of inorganic fertilizers, thereby increasing the growth and yield of eggplant sustainably.

MATERIALS AND METHODS

The research was conducted in andosol soil, Wonorejo – Poncokusumo, Malang Regency from June to December 2019. The altitude was

625 m.asl., the average temperature was 26–27°C, and the average rainfall was 2000–3000 mm $year^{-1}$. The materials used were mulch and eggplant seeds variety of Hijau Kuat and cabbage seeds variety of Grand 11, PGPR, and EM4. Fertilizers used were goat manure and inorganic fertilizers (Urea and Phonska). Control of weeds, pests, and diseases using herbicides (Roundup and Gramaxone), insecticides (Furadan, Calicron, Samite, Curacrop, and Libero), and fungicides (Antracol, Goneb), acaricides (Agrept and Benzim), molluscicides (Toxiput).

The study was conducted using a randomized block design with three replications. The treatments were D0 = control (180 kg N), D1 = 75% inorganic N fertilizer + manure 20 $t \cdot ha^{-1}$ + without microbes, D2 = 75% inorganic N fertilizer + manure 20 $t \cdot ha^{-1}$ + EM 10 $ml \cdot l^{-1}$, D3 = 75% inorganic N fertilizer + manure 20 $t \cdot ha^{-1}$ + EM 20 $ml \cdot l^{-1}$, D4 = 75% inorganic N fertilizer + manure 20 $t \cdot ha^{-1}$ + PGPR 10 $ml \cdot l^{-1}$, D5 = 75% inorganic N fertilizer + manure 20 $t \cdot ha^{-1}$ + PGPR 20 $ml \cdot l^{-1}$, D6 = 50% inorganic N fertilizer + 20 $t \cdot ha^{-1}$ manure + no microbes, D7 = 50% inorganic N fertilizer + manure 20 $t \cdot ha^{-1}$ + EM 10 $ml \cdot l^{-1}$, D8 = 50% inorganic N fertilizer + manure 20 $t \cdot ha^{-1}$ + EM 20 $ml \cdot l^{-1}$, D9 = 50% inorganic N fertilizer + manure 20 $t \cdot ha^{-1}$ + PGPR 10 $ml \cdot l^{-1}$, D10 = 50% inorganic N fertilizer + manure 20 t ha^{-1} + PGPR 20 $ml \cdot l^{-1}$, D11 = 75% inorganic N fertilizer + manure 30 t ha^{-1} + without microbes, D12 = 75% inorganic N fertilizer + manure 30 $t \cdot ha^{-1}$ + EM 10 $ml \cdot l^{-1}$, D13 = 75% inorganic N fertilizer + manure 30 $t \cdot ha^{-1}$ + EM 20 $ml \cdot l^{-1}$, D14 = 75 % inorganic N fertilizer + manure 30 $t \cdot ha^{-1}$ + PGPR 10 $ml \cdot l^{-1}$, D15 = 75% inorganic N fertilizer + manure 30 $t \cdot ha^{-1}$ + PGPR 20 $ml \cdot l^{-1}$, D16 = 50% inorganic fertilizer + manure 30 $t \cdot ha^{-1}$ + without microbes, D17 = 50% inorganic N fertilizer + manure 30 $t \cdot ha^{-1}$ + EM 10 $ml \cdot l^{-1}$, D18 = 50% inorganic N fertilizer + manure 30 $t \cdot ha^{-1}$ + EM 20 $ml \cdot l^{-1}$, D19 = 50% inorganic fertilizer + manure 30 $t \cdot ha^{-1}$ + PGPR 10 $ml \cdot l^{-1}$, D20 = 50% inorganic fertilizer + manure 30 $t \cdot ha^{-1}$ + PGPR 20 $ml \cdot l^{-1}$. The plot size was 2.4 × 4 m.

Eggplant fertilization was carried out three times, i.e. 7, 28, and 42 days after planting (DAP), with a dose of 1/5 dose at 7 DAP, and 2/5 doses, at 28 and 42 DAP, respectively. Inorganic fertilizers for eggplant plants used urea and phonska, with the recommended dosage of 180 kg $N \cdot ha^{-1}$, 90 kg $P_2O_5 \cdot ha^{-1}$ and 90 kg $K_2O \cdot ha^{-1}$ (196 kg urea ha^{-1} and 600 kg $phonska \cdot ha^{-1}$). Inorganic fertilizers for cabbage used urea and phonska fertilizers at a dose of 75% of the recommended dosage, with the recommended dosage being 120 kg N, 105 kg P_2O_5 and 105 kg K_2O (700 $kg \cdot ha^{-1}$ phonska fertilizer and 33 $kg \cdot ha^{-1}$ urea fertilizer). The application of inorganic fertilizers on cabbage was applied 3 times, i.e. 7, 28, and 42 DAP, with a dose of 1/3 for each. The manure used was goat manure at a dose according to treatment. Manure application was carried out during soil cultivation by spreading it on the ground and then mixing it with the soil. The types of commercial microbes used were PGPR and EM4. EM4 and PGPR were given 4 times, i.e. when the eggplant and cabbage plants were 7, 2, 35, and 49 DAP. Giving EM4 and PGPR according to treatment. The dosage of EM and PGPR for each application was 30 ml per plant, by splashing it around the stems of eggplant and cabbage plants.

Growth observations on eggplant and cabbage were carried out 4 times, starting from 14 until 56 DAP with an interval of 14 days. Growth observations included the number of leaves and stem diameter of eggplant, as well as the number of cabbage leaves. Yield observations included eggplant fruit weight per plant and per hectare, eggplant weight per fruit, and eggplant fruit weight per plant. Land productivity assessments were carried out by calculating LER, as well as soil analysis before and after the research. The data collected were analyzed using analysis of variance, followed by the LSD 5% test.

RESULTS AND DISCUSSION

Growth

The utilization of organic and biological sources of nutrients could reduce the use of inorganic N fertilizers. In Tables 1 and 2, it was known that the reduction in the dosage of inorganic N fertilizers was 25 and 50% and replaced with 20–30 $t \cdot ha^{-1}$ of manure and 10–20 $ml \cdot l^{-1}$ EM or PGPR (K2, K3, K4, K5, K7, K8, K9, K10, K12, K13, K14, K15, K17, K18, K19, and K20) increased the growth of eggplant plants to a greater extent than in the plants fertilized with 100% inorganic N (K0) or inorganic fertilizer + manure treatment without the addition of microbes. These results indicated that the use of manure and biological (microbial) manure in an integrated nutrient management system could provide nutrients more efficiently than with 100% inorganic N fertilization. Manure and biological fertilizer (EM or PGPR) increase the availability of plant nutrients directly or indirectly. Directly by providing nutrients for plants, and indirectly by improving soil properties. The results of soil analysis after the research showed that the plants fertilized with 50–75% inorganic N fertilizer + 20–30 t·ha^{-1} manure + microbes 10–20 ml·l^{-1} (EM or PGPR) increased soil CEC and improved soil texture from clay into sandy loam. Changes in soil properties increased the efficiency of nutrient uptake for the better, thereby increasing the growth of eggplant plants to be better for plants fertilized with 100% inorganic fertilizers. Siringoringo and Siregar (2011) explain that the value of CEC is an indicator to determine soil quality and productivity. The higher the soil CEC, the more base cations the soil can hold so that the soil has a higher fertility rate. Conversely, if the CEC is low, then the soil is unable to hold the nutrients properly so the nutrients in the soil are easily washed by water and the availability of nutrients is lower. In turn, changing the soil texture from loam to sandy loam will increase water infiltration and drainage, air infiltration, and allow deeper roots. In fine-textured clay, the long-term use of organic matter can glue small clay particles into larger pieces or aggregates, creating large pore spaces (Louisa and Taguiling, 2013). Increased nutrient availability and improved soil properties due to the combination treatment of various nutrient sources resulted in better nutrient uptake and increased the growth of eggplant plants.

The higher the reduction in the dosage of inorganic N fertilizers. the greater the addition of N from other nutrient sources was required. In Tables 1 and 2, it was known that the reduction in the dosage of inorganic N fertilizer was 25% and replacing it with manure by 20–30 t·ha^{-1} and microbes of 10–20 ml·l^{-1} (K2, K3, K4, K5, K12, K13, K14, and K15) increased the growth of eggplant plants better than the treatment of 100% inorganic N fertilizer (K0). Meanwhile, a 50% reduction in N fertilizer required a larger

Table 1. The average number of leaves of eggplant in the eggplant – cabbage intercropping system as a result of a combined application of various N sources at various observation ages

Treatment	Number of leaves at age (DAP)			
	14	28	42	56
K0 (180 kg N)	4.92 a	5.96 a	21.00 a	43.67 a
K1 (75% N + 20 t Mn + 0 M)	5.18 abcd	6.53 abcd	24.33 abcd	50.67 abcd
K2 (75% N + 20 t Mn + EM 10 ml)	5.63 cdefg	7.08 cdefg	28.17 bcdefg	64.50 efgh
K3 (75% N + 20 t Mn + EM 20 ml)	5.76 cdefg	7.27 defg	29.33 defg	69.67 fghi
K4 (75% N + 20 t Mn + PGPR 10 ml)	5.71 cdefg	7.21 cdefg	29.00 cdefg	65.50 efghi
K5 (75% N + 20 t Mn + PGPR 20 ml)	5.79 defg	7.33 defg	29.67 efg	71.00 ghi
K6 (50% N + 20 t Mn + 0 M)	4.95 ab	6.04 ab	23.67 ab	44.67 ab
K7 (50% N + 20 t Mn + EM 10 ml)	5.25 abcde	6.67 abcde	25.33 abcdef	53.33 abcd
K8 (50% N + 20 t Mn + EM 20 ml)	5.58 bcdefg	6.96 cdefg	27.83 bcdefg	58.50 de
K9 (50% N + 20 t Mn + PGPR 10 ml)	5.46 abcdef	6.75 abcdef	25.67 abcdefg	54.67 bcde
K10 (50% N + 20 t Mn + PGPR 20 ml)	5.59 cdefg	7.00 cdefg	28.17 bcdefg	59.33 def
K11 (75% N + 30 t Mn + 0 M)	5.21 abcd	6.60 abcde	24.67 abcde	51.33 abcd
K12 (75% N + 30 t Mn + EM 10 ml)	5.88 efg	7.40 defg	30.00 fg	72.33 hi
K13 (75% N + 30 t Mn + EM 20 ml)	5.92 fg	7.58 fg	30.50 fg	74.33 hi
K14 (75% N + 30 t Mn + PGPR 10 ml)	5.90 fg	7.43 efg	30.33 fg	73.33 hi
K15 (75% N + 30 t Mn + PGPR 20 ml)	6.17 g	7.67 g	30.83 g	75.50 i
K16 (50% N + 30 t Mn + 0 M)	5.13 abc	6.33 abc	24.00 abc	47.00 abc
K17 (50% N + 30 t Mn + EM 10 ml)	5.48 abcdef	6.88 bcdefg	26.33 bcdefg	56.00 cde
K18 (50% N + 30 t Mn + EM 20 ml)	5.63 cdefg	7.03 cdefg	27.83 bcdefg	60.67 defg
K19 (50% N + 30 t Mn + PGPR 10 ml)	5.54 abcdefg	6.96 cdefg	27.50 bcdefg	57.50 cde
K20 (50% N + 30 t Mn + PGPR 20 ml)	5.64 cdefg	7.04 cdefg	28.67 bcdefg	61.17 defg
LSD 5%	0.64	0.88	5.31	10.84

Note: numbers in the same column accompanied by the same letter showed no significant difference in the 5% LSD test, Mn – manure, M – microbe.

Table 2. The average stem diameter of eggplant in the eggplant – cabbage intercropping system as a result of the combination application of various N sources at various control ages

Treatment	Eggplant stem diameter at age (DAP)			
	14	28	42	56
K0 (180 kg N)	0.30 a	0.66 a	1.34 a	1.58 ab
K1 (75% N + 20 t Mn + 0 M)	0.33 abc	0.74 abc	1.43 abcd	1.66 abcd
K2 (75% N + 20 t Mn + EM 10 ml)	0.37 bcdef	0.79 bcde	1.55 bcdefg	1.79 bcdefg
K3 (75% N + 20 t Mn + EM 20 ml)	0.39 cdef	0.80 bcde	1.58 cdefg	1.83 cdefg
K4 (75% N + 20 t Mn + PGPR 10 ml)	0.38 bcdef	0.80 bcde	1.57 cdefg	1.80 bcdefg
K5 (75% N + 20 t Mn + PGPR 20 ml)	0.39 cdefg	0.80 bcde	1.60 defg	1.85 cdefg
K6 (50% N + 20 t Mn + 0 ml)	0.31 a	0.67 a	1.38 ab	1.42 a
K7 (50% N + 20 t Mn + EM 10 ml)	0.34 abcd	0.75 abc	1.44 abcd	1.70 bcde
K8 (50% N + 20 t Mn + EM 20 ml)	0.35 abcdef	0.77 abcd	1.49 abcde	1.74 bcdef
K9 (50% N + 20 t Mn + PGPR 10 ml)	0.34 abcd	0.76 abcd	1.45 abcd	1.72 bcde
K10 (50% N + 20 t Mn + PGPR 20 ml)	0.35 abcdef	0.78 bcd	1.50 abcdef	1.75 bcdefg
K11 (75% N + 30 t Mn + 0 M)	0.33 abc	0.74 abc	1.44 abcd	1.69 bcde
K12 (75% N + 30 t Mn + EM 10 ml)	0.40 def	0.82 bcde	1.62 defg	1.87 defg
K13 (75% N + 30 t Mn + EM 20 ml)	0.41 ef	0.87 de	1.68 fg	1.96 fg
K14 (75% N + 30 t Mn + PGPR 10 ml)	0.40 def	0.84 cde	1.64 efg	1.91 efg
K15 (75% N + 30 t Mn + PGPR 20 ml)	0.41 f	0.89 e	1.71 g	1.98 g
K16 (50% N + 30 t Mn + 0 M)	0.32 ab	0.73 ab	1.41 abc	1.63 abc
K17 (50% N + 30 t Mn + EM 10 ml)	0.34 abcd	0.77 abcd	1.46 abcde	1.72 bcde
K18 (50% N + 30 t Mn + EM 20 ml)	0.36 abcdef	0.78 bcd	1.52 bcdef	1.75 bcdefg
K19 (50% N + 30 t Mn + PGPR 10 ml)	0.35 abcde	0.77 abcd	1.47 abcde	1.73 bcdef
K20 (50% N + 30 t Mn + PGPR 20 ml)	0.36 abcdef	0.79 bcde	1.54 bcdefg	1.76 bcd
LSD 5%	0.06	0.11	0.18	0.24

Note: numbers in the same column accompanied by the same letter showed no significant difference in the 5% LSD test, Mn – manure, M – microbe.

proportion of other nutrient sources. The combination that is suitable for increasing plant growth when reducing inorganic N fertilizer by 50% was 50% inorganic N fertilizer + 30 t·ha^{-1} + EM / PGPR with a concentration of 10–20 ml·l^{-1} (K17. K18. K19 and K20) or a combination of 50% inorganic N fertilizer + 20 t·ha^{-1} + 20 ml·l^{-1} EM / PGPR (K8 and K10). This was to produce good eggplant growth. Large amounts of N are needed. A lack of N nutrients would inhibit the growth of eggplant. Therefore. any reduction in the dosage of inorganic N fertilizers must be balanced with an increase from other N nutrient sources (Sharma and Brar. 2008). According to Kumar et al. (2011), in implementing an integrated nutrient management system, it is necessary to know the optimal dose of each nutrient source used in order to obtain increased soil fertility, soil microbes and nutrient balance. This is due to the different characteristics and releases characteristics of chemicals, organic and biological fertilizers. Each type of nutrient source has its own advantages and disadvantages related to plant growth and soil fertility (Chen, 2006).

The intercropping of eggplant with cabbage increases the growth of the cabbage plant. In Tables 1, 2 and 3 it can be observed that each increase in the number of leaves of the cabbage increased the number of leaves and the stem diameter of the eggplant. This was because the greater the number of cabbage leaves formed, the more closed the surface area of the land around the eggplant plants, reducing the temperature and increasing soil moisture. Decreasing soil temperature and increasing soil moisture would increase nutrient efficiency and reduce nutrient losses due to evaporation. The increase in nutrient uptake would ultimately increase plant growth in the intercropping system higher than the monoculture. According to Rajii and Merdeh (2014), faster closure of land surface areas by planting intercrops will increase humidity and reduce the soil temperature better than monoculture. Increasing moisture and decreasing soil temperature will

Table 3. Average number of leaves of cabbage in the eggplant – cabbage intercropping system as a result of the application of a combination of various N sources at various observation ages

Treatment	Number of leaves of cabbage at age (DAP)			
	14	28	42	56
K0 (180 kg N)	4.07 a	7.17 a	11.92 a	15.00 a
K1 (75% N + 20 t Mn + 0 M)	4.42 abcd	7.83 abcd	12.58 abcd	16.25 abc
K2 (75% N + 20 t Mn + EM 10 ml)	5.08 cdef	9.08 def	14.58 efghi	19.50 defgh
K3 (75% N + 20 t Mn + EM 20 ml)	5.17 def	9.00 def	15.25 fghi	20.17 efgh
K4 (75% N + 20 t Mn + PGPR 10 ml)	5.17 def	9.00 def	14.50 defghi	19.42 defgh
K5 (75% N + 20 t Mn + PGPR 20 ml)	5.17 def	9.17 def	14.83 fghi	20.00 efgh
K6 (50% N + 20 t Mn + 0 ml)	4.25 ab	7.25 ab	12.25 ab	16.08 ab
K7 (50% N + 20 t Mn + EM 10 ml)	4.58 abcde	8.17abcde	13.33 abcdef	18.00 bcdef
K8 (50% N + 20 t Mn + EM 20 ml)	4.92 bcdef	8.75 cdef	14.17 bcdefghi	18.67 bcdef
K9 (50% N + 20 t Mn + PGPR 10 ml)	4.67 abcdef	8.33 abcde	12.67 abcdef	17.92 bcde
K10 (50% N + 20 t Mn + PGPR 20 ml)	5.00 bcdef	8.83 def	14.08 bcdefgh	18.42 bcdef
K11 (75% N + 30 t Mn + 0 M)	4.50 abcde	8.08 abcd	12.67 abcde	16.67 abcd
K12 (75% N + 30 t Mn + EM 10 ml)	5.22 ef	9.58 ef	15.83 ghi	20.83 fgh
K13 (75% N + 30 t Mn + EM 20 ml)	5.42 f	9.83 f	16.08 i	22.08 h
K14 (75% N + 30 t Mn + PGPR 10 ml)	5.37 f	9.58 ef	15.58 ghi	20.75 efgh
K15 (75% N + 30 t Mn + PGPR 20 ml)	5.42 f	10.00 f	16.00 hi	21.75 gh
K16 (50% N + 30 t Mn + 0 M)	4.33 abc	7.33 abc	12.33 abc	16.17 abc
K17 (50% N + 30 t Mn + EM 10 ml)	4.83 bcdef	8.67 bcdef	14.00 bcdefg	18.33 bcdef
K18 (50% N + 30 t Mn + EM 20 ml)	5.00 bcdef	8.92 def	14.25 cdefghi	19.25 defgh
K19 (50% N + 30 t Mn + PGPR 10 ml)	4.83 bcdef	8.67 bcdef	13.90 bcdefg	18.25 bcdef
K20 (50% N + 30 t Mn + PGPR 20 ml)	5.08 cdef	9.00 def	14.17 bcdefghi	19.00 cdefg
LSD 5%	0.75	1.42	1.93	2.85

Note: numbers in the same column accompanied by the same letter showed no significant difference in the 5% LSD test, Mn – manure, M – microbe.

reduce nutrient evaporation and increase plant nutrient uptake. In the intercropping system, the two plants will balance each other by utilizing environmental factors so as to increase the growth of the two plants (Belel et al., 2014).

Eggplant fruit yield

The combination of various nutrients in appropriate proportions increased the fruit weight per plant and per hectare. Fruit yields per plant and per hectare were higher through the application of fertilizer 75% + 20–30 $t \cdot ha^{-1}$ + 10–20 $ml \cdot l^{-1}$ EM / PGPR (K2, K3, K4, K5, K12, K13, K14, and K15) with fruit weights ranging from 1.86 to 2.35 kg per plant or 40.88–53.17 $t \cdot ha^{-1}$ (Table 4). The fruit weights per plant and per hectare resulted were higher in this treatment, because the eggplant plant needs its nutrients from the beginning of growth. The utilization of various nutrient sources increased nutrient efficiency in eggplant plants. Utilization of inorganic N fertilizers by 75% of the recommended dosage could meet the nutrient needs of eggplant. Meanwhile, manure plays an important role in providing most of the nutrients needed by plants and increasing the solubility of some nutrients (Najm et al., 2010). In the results of soil analysis after the study (Table 6), it was known that increasing the dose of manure increased the P and K content in the soil. Increasing the availability of P and K elements in the soil increased the number and weight of fruit, which in turn increased the fruit weight per plant and per hectare (Table 5). The application of manure also improved the physical, Chemical, and biological properties of the soil, thereby increasing the availability of nutrients for plants (Maerere et al., 2001). This can be seen in the results of soil analysis after the research which shows that the soil CEC and soil texture were changing for the better. The improvement of CEC and soil properties would improve the soil ability to hold the elements. thereby increasing the growth and yield of eggplant. According to Kanaujia and

Table 4. Average fruit yields of eggplant in the eggplant – cabbage intercropping system as a result of a combination application of various N sources at various observation ages

Treatment	Fruit weight			Fruit number per plant
	kg per plant	Ton per hectare	g per fuit	
K0 (180 kg N)	1.27 a	25.98 a	156.95 a	8.04 a
K1 (75% N + 20 t Mn + 0 M)	1.53 abc	32.31 abcd	173.10 abc	8.77 ab
K2 (75% N + 20 t Mn + EM 10 ml)	1.86 cdefg	40.88 defgh	188.87 cde	9.90 bcd
K3 (75% N + 20 t Mn + EM 20 ml)	1.97 defghi	44.17 fghi	193.22 cde	10.22 bcde
K4 (75% N + 20 t Mn + PGPR 10 ml)	1.91 cdefgh	41.82 efgh	193.58 cde	10.01 bcde
K5 (75% N + 20 t Mn + PGPR 20 ml)	2.02 efghi	44.87 fghi	190.21 cde	10.64 cde
K6 (50% N + 20 t Mn + 0 ml)	1.36 ab	28.78 ab	162.95 ab	8.46 ab
K7 (50% N + 20 t Mn + EM 10 ml)	1.57 abcd	33.37 abcde	177.11 abcd	9.11 abc
K8 (50% N + 20 t Mn + EM 20 ml)	1.71 bcdef	36.94 bcdef	176.29 abcd	9.58 abcd
K9 (50% N + 20 t Mn + PGPR 10 ml)	1.61 abcde	33.92 abcde	174.89 abc	9.19 abc
K10 (50% N + 20 t Mn + PGPR 20 ml)	1.75 bcdefg	37.67 bcdef	181.27 abcde	9.62 abcd
K11 (75% N + 30 t Mn + 0 M)	1.54 abc	32.56 abcd	173.85 abc	9.11 abc
K12 (75% N + 30 t Mn + EM 10 ml)	2.12 fghi	47.69 hi	197.91 cde	10.71 cde
K13 (75% N + 30 t Mn + EM 20 ml)	2.31 hi	52.38 i	204.85 e	11.26 de
K14 (75% N + 30 t Mn + PGPR 10 ml)	2.13 ghi	47.54 ghi	202.00 de	10.91 cde
K15 (75% N + 30 t Mn + PGPR 20 ml)	2.35 i	53.17 i	197.40 de	11.84 e
K16 (50% N + 30 t Mn + 0 M)	1.50 abc	30.82 abc	179.50 abcd	8.56 ab
K17 (50% N + 30 t Mn + EM 10 ml)	1.62 abcde	34.76 abcde	174.33 abc	9.32 abc
K18 (50% N + 30 t Mn + EM 20 ml)	1.76 bcdefg	38.50 cdefg	187.82 bcde	9.79 abcd
K19 (50% N + 30 t Mn + PGPR 10 ml)	1.69 bcde	36.21 bcdef	176.82 abcd	9.55 abcd
K20 (50% N + 30 t Mn + PGPR 20 ml)	1.77 bcdef	38.63 cdefgh	181.62 abcde	9.84 abcd
LSD 5%	0.42	9.13	25.31	1.85

Note: Numbers in the same column accompanied by the same letter showed no significant difference in the 5% LSD test, Mn – manure, M – microbe.

Singh (2015), the application of inorganic fertilizers + manure + biological fertilizers increases the availability of P_2O_5 and K_2O. This was because the application of manure reduces the solubility of Al and Fe, as well as improves the soil cation exchange capacity and increases the resistance of K in interchangeable forms. Meanwhile. the use of microbes such as EM and PGPR increases eggplant production because microbial inoculation helps the proliferation of better root growth and increased nutrient absorption, which in turn increases the weight of the resulting fruit (Vani et al., 2014). Therefore, fertilized eggplant plants with a combination of inorganic N fertilizer + manure and biological fertilizer produced eggplant weight per plant and per hectare higher than fertilization using 100% inorganic N fertilizer or a combination of organic N fertilizer + manure without the addition of biological fertilizers.

The higher the reduction of inorganic N fertilizers requires the addition of nutrients from other sources. In Table 4, it was shown that the reduction in inorganic N fertilizer by 50% resulted in a higher number of fruit and weight per fruit when combined with manure as much as 30 t ha^{-1} and biological fertilizer (EM or PGPR) with a concentration of 30 $ml \cdot l^{-1}$, compared to the situation when it was combined with 20 $t \cdot ha^{-1}$ manure + biofertilizer (EM or PGPR) with a concentration of 20 $ml \cdot l^{-1}$. This was because eggplant requires large amounts of nutrients due to continuous fruit picking, so that a 50% reduction in the inorganic N dose must be balanced with an increase in the number of nutrients from other nutrient sources. Availability of sufficient amounts of nutrients throughout its life would result in a larger number of fruits with a larger size. Through a combination of nutrient sources with appropriate proportions. It would increase the balance of the C/N ratio, the amount of organic matter, efficient microbial activity, better root proliferation, increased supply and availability of nutrients from the soil and more nutrients are absorbed to synthesize protoplasmic proteins. and other compounds (Rather et al., 2018). The use of biological fertilizers in an integrated nutrient management system plays an important role in increasing eggplant yields. Inoculation of beneficial microorganisms can substitute the chemical fertilizers and as biocontrol agents (Kee and Kremer, 2007). In Table 4, it was shown that reducing the dose of inorganic N fertilizer by 25–50% and combined with manure at a dose of 20–30 t·ha^{-1} (K1, K6, K11, and K16) without adding biological fertilizers resulted in fruit weight per plant and per plant, hectares, weight per fruit and number of fruit per plant were lower than that the eggplant fertilized with a combination of organic N fertilizer + manure + biological fertilizer (PGPR or EM). This was because the process of releasing nutrients from manure was slow to release, so it required the addition of microbes to accelerate the release of nutrients. The application of manure without the addition of biological fertilizers resulted in slower availability of nutrients so that the number and weight of fruit produced were lower than plants fertilized with inorganic fertilizers + manure + biological fertilizers (PGPR or EM). According to Mboubda et al. (2013), beneficial microbial inoculation can increase the mineralization of organic matter and accelerate the availability of nutrients for plants. Moreover. the addition of biological fertilizers can improve physical. chemical and biological properties of the soil, thereby increasing the absorption of nutrients from the soil. However, at the same dose of inorganic N fertilizer and manure as well as the concentration of biological fertilizer, the type of biological fertilizer did not significantly affect the eggplant yield. This was because the two types of biological fertilizers were tested. Both PGPR and EM contain photosynthetic bacteria and phosphate solvents, so that they have no different effectiveness in increasing eggplant yield.

Intercropping system of eggplant and cabbage could increase the eggplant production and land productivity. In Table 5 it was shown that eggplant planted in the intercropping system with cabbage produced higher fruit production per hectare than in the monoculture system. This was because the intercropping system could increase nutrient efficiency by improving

Table 5. Average yields of eggplant and cabbage in the intercropping system – monoculture, as well as NKL as a result of a combination application of various N sources

Treatment	Fruit weight of eggplant (ton ha^{-1})		Head weight of cabbage (ton ha^{-1})		LER
	Intercropping	Monoculture	Intercropping	Monoculture	
K0 (180 kg N)	25.98	19.78	11.64	21.56	1.85
K1 (75% N + 20 t Mn + 0 M)	32.31	23.76	12.93	23.25	1.92
K2 (75% N + 20 t Mn + EM 10 ml)	40.88	29.66	16.79	29.87	1.94
K3 (75% N + 20 t Mn + EM 20 ml)	44.17	31.78	17.89	31.08	1.97
K4 (75% N + 20 t Mn + PGPR 10 ml)	41.82	29.07	16.40	29.29	2.00
K5 (75% N + 20 t Mn + PGPR 20 ml)	44.87	31.29	17.58	30.60	2.01
K6 (50% N + 20 t Mn + 0 ml)	28.78	21.19	11.98	22.01	1.90
K7 (50% N + 20 t Mn + EM 10 ml)	33.37	24.82	13.86	25.50	1.89
K8 (50% N + 20 t Mn + EM 20 ml)	36.94	27.10	14.79	27.06	1.91
K9 (50% N + 20 t Mn + PGPR 10 ml)	33.92	24.64	13.83	25.06	1.93
K10 (50% N + 20 t Mn + PGPR 20 ml)	37.67	26.69	14.79	26.96	1.96
K11 (75% N + 30 t Mn + 0 M)	32.56	23.99	13.08	23.69	1.91
K12 (75% N + 30 t Mn + EM 10 ml)	47.69	33.31	19.62	33.69	2.01
K13 (75% N + 30 t Mn + EM 20 ml)	52.38	36.99	20.83	35.54	2.00
K14 (75% N + 30 t Mn + PGPR 10 ml)	47.54	33.41	19.25	33.13	2.00
K15 (75% N + 30 t Mn + PGPR 20 ml)	53.17	36.63	20.56	35.16	2.04
K16 (50% N + 30 t Mn + 0 M)	30.82	22.69	12.71	23.12	1.91
K17 (50% N + 30 t Mn + EM 10 ml)	34.76	26.27	14.51	26.58	1.87
K18 (50% N + 30 t Mn + EM 20 ml)	38.50	27.62	15.78	28.44	1.95
K19 (50% N + 30 t Mn + PGPR 10 ml)	36.21	25.40	14.45	26.31	1.97
K20 (50% N + 30 t Mn + PGPR 20 ml)	38.65	27.54	15.52	28.01	1.96

Note: Mn – manure, M – microbe.

Table 6. Soil analysis before and after the research as a result of the application of a combination of various sources of N in the intercropping system for eggplant and cabbage

Treatment	N total	P-Bray	K	Na	Ca	Mg	KTK	Texture
Before research:	0.11 l	120 vh	0.40 m	0.18 l	5.4 l	0.77 l	22.29 m	L
K0 (180 kg N)	0.10 l	118 vh	0.61 h	0.26 l	4.0 l	0.32 vl	21.26 m	L
K1 (75% N + 20 t Mn + 0 M)	0.12 l	128 vh	0.62 h	0.28 l	4.2 l	0.33 vl	21.95 m	L
K2 (75% N + 20 t Mn + EM 10 ml)	0.12 l	135 vh	0.70 h	0.29 l	4.8 l	0.66 l	23.85 m	SL
K3 (75% N + 20 t Mn + EM 20 ml)	0.12 l	143 vh	0.71 h	0.31 l	4.9 l	0.80 l	24.81 m	SL
K4 (75% N + 20 t Mn + PGPR 10 ml)	0.12 l	134 vh	0.68 h	0.32 l	4.7 l	0.65 l	23.53 m	L
K5 (75% N + 20 t Mn + PGPR 20 ml)	0.12 l	138 vh	0.71 h	0.33 l	4.9 l	0.67 l	24.60 m	SL
K6 (50% N + 20 t Mn + 0 ml)	0.11 l	117 vh	0.62 h	0.34 l	4.0 l	0.32 vl	21.77 m	L
K7 (50% N + 20 t Mn + EM 10 ml)	0.12 l	292 vh	0.65 h	0.34 l	4.4 l	0.47 l	22.18 m	L
K8 (50% N + 20 t Mn + EM 20 ml)	0.12 l	133 vh	0.67 h	0.35 l	4.6 l	0.65 l	23.44 m	L
K9 (50% N + 20 t Mn + PGPR 10 ml)	0.12 l	128 vh	0.63 h	0.36 l	4.3 l	0.34 vl	22.17 m	L
K10 (50% N + 20 t Mn + PGPR 20 ml)	0.12 l	131 vh	0.65 h	0.37 l	4.4 l	0.50 l	23.27 m	L
K11 (75% N + 30 t Mn + 0 M)	0.13 l	149 vh	0.74 h	0.41 m	5.2 l	0.96 l	25.74 h	SL
K12 (75% N + 30 t Mn + EM 10 ml)	0.13 l	279 vh	0.81 h	1.27 vh	6.7 m	1.58 m	28.12 h	SL
K13 (75% N + 30 t Mn + EM 20 ml)	0.15 l	283 vh	0.91 h	1.39 vh	7.7 m	1.69 m	29.53 h	SL
K14 (75% N + 30 t Mn + PGPR 10 ml)	0.13 l	226 vh	0.80 h	1.25 vh	6.1 m	1.36 m	27.56 h	SL
K15 (75% N + 30 t Mn + PGPR 20 ml)	0.14 l	292 vh	0.84 h	1.36 vh	7.2 m	1.64 m	28.99 h	SL
K16 (50% N + 30 t Mn + 0 M)	0.13 l	148 vh	0.73 h	0.38 l	5.1 l	0.96 l	25.09 h	SL
K17 (50% N + 30 t Mn + EM 10 ml)	0.13 l	157 vh	0.78 h	0.39 l	5.6 l	1.14 m	26.17 h	SL
K18 (50% N + 30 t Mn + EM 20 ml)	0.13 l	210 h	0.79 h	1.20 vh	5.9 l	1.31 m	27.38 h	SL
K19 (50% N + 30 t Mn + PGPR 10 ml)	0.13 l	155 vh	0.75 h	0.39 l	5.5 l	1.11 m	26.08 h	
K20 (50% N + 30 t Mn + PGPR 20 ml)	0.13 l	160 vh	0.79 h	0.39 l	5.6 l	1.18 m	27.17 h	

Note: vl – very low, l – low, m – moderate, h – high, vh – very high, L – loam, S – sandy loam, Mn – manure, M – microbe.

the microclimate and soil properties, so as to increase plant growth, which in turn increases plant production. Zafaranieh and Valizadeh (2015) explained that the intercropping system could reduce soil temperature and increase soil moisture, water use efficiency as well as canopy relative humidity. The improvement of the microclimate would reduce the risk of losing nutrients. especially N due to evaporation. In addition. the intercropping system could reduce the risk of nutrient loss through leaching and increase nutrient absorption efficiency. Qasim et al. (2013) explained that planting two types of plants with different root types both for controlling soil erosion and for sustainable crop production. Penetration of the roots into the soil will break the hardness of the soil and create soil pore spaces. Shallow roots bind to the surface soil, thereby helping to reduce erosion and increase soil aeration thus reducing nutrient loss and increasing nutrient uptake. Increased nutrient efficiency through the intercropping system in turn increases eggplant production.

The intercropping system could increase land productivity higher than the monoculture. In Table 5 it was known that all treatments of various combinations of N sources resulted in higher eggplant production per hectare in the intercropping system than in the monoculture system. This shows that the intercropping system could increase eggplant production to a higher level. In addition, the intercropping system could also increase land productivity to a higher level with LER values ranging from 1.85 to 2.04. Begum et al. (2015) explained that the intercropping system was more profitable than monoculture planting because the intercropping system could increase the total productivity of the plant and reduce the risk of planting. Increased land productivity was not only obtained from increased eggplant production but also increased yields from intercropping. Therefore, the intercropping system could not only increased the efficiency of plant nutrient uptake but also increase land productivity and reduce the risk of failure, so that it is more profitable for farmers.

CONCLUSIONS

Various combinations of inorganic fertilizers + manure + microbes (EM and PGPR) resulted in higher growth and yields of eggplant in the eggplant – cabbage intercropping system compared to 100% inorganic N fertilization. The combination of 75% inorganic fertilizer + 20–30 t·ha^{-1} manure + 10–20 ml·l^{-1} microbe (EM / PGPR) in the eggplant – cabbage intercropping system increases the growth and yield of eggplant plants higher than other treatments, with fruit weights ranging from 1.4 to 1.65 kg per plant or 31.55 to 37.98 t·ha^{-1}. Land productivity increases to a higher level with LER values of 1.85–2.04.

REFERENCES

1. Adamczewska-Sowińska K., Krygier M. 2013. Yield quantity and quality of field cultivated eggplant in relation to its cultivar and the degree of fruit maturity. Acta Scientiarum Polonorum, Hortorum Cultus, 12(2), 13–23.
2. Agbo C.U., Chukwudi P.U., Ogbu A.N. 2012. Effects of rates and frequency of application of organic manure on growth, yield and biochemical composition of *Solanum melongena* L.(cv.'Ngwa local') fruits. Journal of Animal and Plant Sciences, 14(2), 1952–1960.
3. Aminifard M.H., Aroiee H., Fatemi H., Ameri A., Karimpour S. 2010. Responses of eggplant (*Solanum melongena* L.) to different rates of nitrogen under field conditions. Journal Central European Agriculture, 11(4), 453–458.
4. Ananda Kumar D., Sivakumar K., Mariyappan E. 2018. Comparative studies on the growth and yield of brinjal (*Solanum melongena* L.) var PLR 2 based on bioinculants and inorganic fertilizers. International Journal of Research and Scientific Innovation, 5(3), 191–193.
5. Begum S.A., Zaman M.S., Khan A. 2015. Intercropping of root crops with chilli in Charlands of Mymensingh. Progressive Agriculture, 26, 109–114.
6. Belel M.D., Halim R.A., Rafii M.Y., Saud H.M. 2014. Intercropping of corn with some selected legumes for improved forage production: A Review Journal of Agricultural Science, 6(3), 48–62.
7. Chen J.H. 2006. The combined use of chemical and organic fertilizers and/or biofertilizer for crop growth and soil fertility. In International workshop on sustained management of the soil-rhizosphere system for efficient crop production and fertilizer use, 16(20), 1–11.
8. Dawa K.K.A., Al-Gazae T.M., Abdel-Fatah A.M. 2013. Effect of chicken manure combined with bio-fertilizers, mineral fertilizer and some foliar application on: 1-Vegetatif growth and some chemical constituents of tomato leaves. Journal of Plant Production, 4(10), 1555–1570.
9. Direkvandi S.N,. Ansari N.A., Dehcordie F.S. 2008. Effect of different levels of nitrogen fertilizer with two types of bio-fertilizers on growth and yield of two cultivars of tomato (*Lycopersicon esculentum* Mill). Asian Journal of Plant Sciences, 7(8), 757–761.
10. El-Nemr M.A., El-Bassiony A.M., Tantawy A.S., Fawzy Z.F. 2015. Responses of eggplant (*Solanum melongena* var. esculenta L.) plants to different foliar concentrations of some bio-stimulators. Middle East Journal of Agriculture Research, 4(4), 860–866.
11. Gebru. H. 2015. A review on the comparative advantage of intercropping systems. Journal of Biology, Agriculture and Healthcare, 5(7), 28–38.
12. Guvenc I., Yildirim E. 2006. Increasing productivity with intercropping systems in cabbage production. Journal of Sustainable Agriculture, 28(4), 29–44.
13. Islam M.A., Islam S., Akter A., Rahman M.H., Nandwani D. 2017. Effect of organic and inorganic fertilizers on soil properties and the growth, yield and quality of tomato in Mymensingh, Bangladesh. Agriculture, 7(3), 18.
14. Jagatheeswari D. 2013. Effect of vermicompost on growth and yield of eggplant (*Solanum melongena* L.). Indian Streams Research Journal, 3(4), 1–7.
15. Kanaujia S.P. Singh P.K. 2015. Integrated nutrient management for quality production of cauliflower in acid alfisol of Nagaland. Karnataka Journal of Agricultural Sciences, 28(2), 244–247.
16. Kee C.P., Kremer R.J. 2007. Effects of a biological properties and microbial diversity in soils receiving different organic amendments. Korean Journal of Soil Science and Fertilizer, 40(4), 234–241.
17. Kirimi J.K., Itulya F.M., Mwaja V.N. 2011. Effects of nitrogen and spacing on fruit yield of tomato. African Journal of Horticultural Science, 5, 50–60.
18. Kumar A.M., Gowda N.N., Shetty G.R., Karthik M.N. 2011. Effect of organic manures and inorganic fertilizers on available NPK, microbial density of the soil and nutrient uptake of brinjal. Research Journal of Agricultural Sciences, 2(2), 304–307.
19. Li T., Liu T., Zheng C., Kang C., Yang Z., Yao X., Song F., Zhang R., Wang X., Xu N., Zhang C. 2017. Changes in soil bacterial ommunity structure as a result of incorporation of Brassica plants compared with continuous planting eggplant and chemical disinfection in greenhouses. PLoS One, 12(3), 1–7.
20. Maerere A.P., Kimbi G.G., Nonga D.L.M. 2001. Comparative effectiveness of animal manures on soil chemical properties, yield and root growth of amaranthus (*Amaranthus cruentus* L.). African Journal of Science and Technology, 1(4), 14–21.

21. Maghfoer M.D. 2018. Tehnik Pemupukan Terung Ramah Lingkungan. UB Press.
22. Mbouobda H.D., Fotso, Djeuani C.A., Fai K., Omokolo N.D. 2013. Impact of effective and indigenous microorganisms manure on *Colocassia esculenta* and enzymes activities. African Journal of Agricultural Research, 8(12), 1086–1092.
23. Meena M.L., Gehlot V.S., Meena D.C., Kishor S., Kumar S., Meena J.K. 2017. Intercropping enhances productivity and maintains the most soil fertility properties relative to sole cropping. Journal of Pharmacognosy and Phytochemistry, 6(4), 1579–1583.
24. Muhammad A., Shahid U., Ahmadi I., Zainubi B., Shah K. 2017. Effect of biofertilizer and plant spacing on growth, yield and fruit quality of brinjal (*Solanum melongena* L.). Journal of Natural Sciences Research, 7(19), 56–62.
25. Najm A.A., Hadi M.H.S., Fazeli F., Darzi M.T., Shamorady R. 2010. Effect of utilization of organic and inorganic nitrogen source on the potato shoots dry matter, leaf area index and plant height, during middle stage of growth. International Journal Of Agricultural and Biosystems Engineering, 4(11), 852–855.
26. Olle M., Williams, I.H. 2013. Effective microorganisms and their influence on vegetable production–a review. The Journal of Horticultural Science and Biotechnology, 88(4), 380–386.
27. Ouma G., Jeruto, P. 2010. Sustainable horticultural crop production through intercropping: The case of fruits and vegetable crops: A review. Agriculture and Biology Journal of North America, 1(5), 1098–1105.
28. Piraveena S., Seran T. 2013. The effect of cattle manure enriched with ERP fertilizer on seed yield of soybean (*Glycine max*) in sandy regosol. Journal of Food and Agriculture, 3(1–2), 24–30.
29. Qasim S.A., Anjum M.A., Hussain S. Ahmad S. 2013. Effect of pea intercropping on biological efficiencies and economics of some non-legume winter vegetables. Pakistan Journal of Agricultural Sciences, 50(3), 399–406.
30. Rajaii M., DahMardeh M. 2014. The evaluation of corn and peanut intercropping on efficiency of use the environmental resource and soil fertility. Journal of Agricultural Science, 6(4), 99–108.
31. Rather A.M., Jabeen N., Bhat T.A., Parray E.A., Hajam M.A., Wani M.A., Bhat I.A., 2018. Effect of organic manures and bio-fertilizers on growth and yield of lettuce. The Pharma Innovation, 7(5, Part B), 75.
32. Saravaiya S.N., Patel N.B., Ahir M.P., Patel N.M., Desai K.D., Patel, J.B. 2010. Integrated Nutrient Management (INM) approach for brinjal (*Solanum melongena* L.) and other solanaceous vegetables-A review. Agricultural Reviews, 31(2), 79–92.
33. Sharma S.P., Brar J.S. 2008. Nutritional requirements of brinjal (*Solanum melongena* L.) – A Review. Agricultural Reviews, 29(2), 79–88.
34. Siringoringo H.H., Siregar C.A. 2011. pengaruh aplikasi arang terhadap pertumbuhan awal *Michelia montana* blume dan perubahan sifat kesuburan tanah pada tipe tanah latosol. Jurnal Penelitian Hutan dan Konservasi Alam, 8(1), 65–85.
35. Thingujam U., Pati S., Khanam R., Pari A., Ray K., Phonglosa A., Bhattacharyya K. 2016. Effect of integrated nutrient management on the nutrient accumulation and status of post-harvest soil of brinjal (*Solanum melonngena* L.) under nadia conditions (West Bengal). India. Journal of Applied and Natural Science, 8(1), 321–328.
36. Vani M.S., Hindumathi A., Bhumi N.R. 2014. Arbuscular mycorrhizal fungi associated with rhizosphere soils of brinjal cultivated in Andhra Pradesh, India. International Journal of Current Microbiology and Applied Sciences, 3(5), 519–529.
37. Yildirim E., Turan M. 2013. Growth, yield and mineral content of broccoli intercropped with lettuce. The Journal of Animal and Plant Sciences, 23(3), 919–922.
38. Zafaranieh M., Valizadeh J. 2015. Investigating light absorption and some canopy properties in monocultures and intercropping culture of safflower and chickpea. International Journal of Agriculture Innovations and Research, 3(4), 1182–1187.