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Effect of inorganic and organic fertilizers on soil properties with vegetative growth and yield quality of sweet pepper (*Capsicum annuum* L.) in Bangladesh

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Abstract

A field experiment was conducted on sweet pepper for yield and quality of fruits using different types of organic and inorganic fertilizers at the farm of Patuakhali Science and Technology University. Inorganic and organic fertilizers treatments were tested on California variety of sweet pepper. The fertilization treatments were T1, (Urea +TSP+ MOP): (260+120+124) kg/ha; T2, Cow dung: 9 t/ha; T3, Poultry manure: 7 t/ha; T4, (Urea + cow dung): (195kg +2.5 t/ha); T5,(Urea + poultry manure): (180 kg + 2t/ha); T6, (Urea + cow dung): (130kg + 4.5 t/ha); T7, (Urea + poultry manure): (140kg +3 t/ha);T8, Control: no manure and fertilizer. Randomized complete block design (RCBD) with three replicates were used to conduct this experiment. Physiochemical properties of soil were increasing after harvesting of sweet pepper. Obtained results showed that urea with cow dung (130kg + 4 tons)/ha (T6) increased sweet pepper production. Combined application of urea with cow dung showed significant increase in leaves number per plant (174), Leaf area (48.6cm2), Root/canopy (15.2%), Plant fresh weight (378.5g), No. of fruits/plant (16.6), Fruit length (9.9cm), Fruit diameter (5.8cm), Average green fruit weight (142.1g), Average dry fruit weight (84.6g), yield/replicate (38.5Kg), no. of branching (10.6). Urea with cow dung influenced the total yield per replicate and extended the period of pepper fruit production compared to other treatments.

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Introduction

Sweet pepper or Bell pepper (*Capsicum annuum* L.) popularly known as "King of spices" belongs to family Solanaceae. It is an important spice cum vegetable crop and widely comparison of different organic amendments and used foods in the world; it was originated in the Mexico combined application of organic amendments, along with and Central America regions and Christopher Columbus in 1493. Sweet pepper is grown as an annual crop due to its sensitivity to frost and is actually herbaceous perennial and will survive and yield for several years in tropical climates (Kelley and Boyhan, 2009). Ideal growing conditions for bell peppers include warm soil, ideally 21 to 29°C (70 to 84°F) that is kept moist but not waterlogged. The fruits of capsicum peppers (Capsicum annum) are used extensively as in all local soups, stew and sauces (Grubben and El-Tahir, 2004). The nutritional quality of the fruits, especially as an excellent source of antioxidants- ascorbic acid, carotenoids and phenolic compounds makes the daily intake of pepper a health protecting factor in the prevention of chronic human degenerative and systemic sicknesses including cancer, diabetes, liver cirrhosis and cardio-vascular diseases (Navarro *et al*., 2006; Nwose, 2009). Sweet pepper is famous for its pleasant aromatic flavour, pungency and high colouring Substance. It is used very widely in culinary, pharmaceutical and beverage industries. There is no spice probably as popular as chilli and no other spice has become such an indispensable ingredient of the daily food of majority people of the world (Parvathi, S. and Yuruns, AHJ. 2000).

As agriculture technologies develops and becomes more intensive in its use of land and water resources in order to increase food production to meet the nutritional demand of vast growing population, its negative impacts on agricultural eco-systems was become more destructive (Millenium Ecosystem Assessment, 2005). Consequently, a great attention has been given to clean agriculture and application of eco-friendly practices. One of the most significant ways to achieve is using of organic and bio-fertilizers farming. Organic farming of vegetables is most appropriate as most of the vegetables are consumed in the fresh form and chemical residues have adverse effect on human health. Nitrogen is a major limiting nutrient for crop production. It can be applied through chemical or biological means. Over application can result in negative effects such as leaching, pollution of water resources, destruction of microorganisms and friendly insects. Due to the prohibitive cost of chemical fertilizers, majority of farmers who are mostly marginal and small, do not apply the recommended dose of fertilizers.

The use of organic fertilizers provides soil with essential nutrients and adsorbs nutrients against leaching. Also improve soil texture, increase ion exchange capacity of soil, increase soil microbial populations and activity, improve moisture-holding capacity of the soil and enhanced soil fertility (Arancon *et al*., 2005). Lower availability of plant nutrients in plots applied with organic amendments is expected due to slower release rates of nutrients from organic materials particularly during initial years of conversion to organic production (Gopinath *et al*., 2009). Farmers are using indigenous organic manures as sources of nutrients. These organics are bulky in nature but, contain reasonable amount of nutrients. Sweet pepper crop responds well to the application of both organic manures and inorganic fertilizers. The use of organic manures in INM helps in mitigating multiple nutrient deficiencies. The application of organics has also been shown to increase ascorbic acid content in chilli, which is one of the important quality parameters. Organic fertilizers are gaining importance because of their low cost, no residual toxicity and capacity to enrich soil fertility in addition to high returns under favourable conditions. There is greater demand in the international market for organically produced chilli. Application of inorganic fertilizers at the rate of 100:50:50kg N: P_2O_5: K_2O per ha produced highest fruit yield per vine (1.76kg/vine) and highest fruit yield per ha (117.33q/ha) in ridge gourd cv. DPL-RG-17 (Shinde *et al.* 2003). To determine the effects of foliar application of a novel organic liquid fertilizer on growth and yield in chilli (*Capsicum annum* L. var. Shama). The present investigation has revealed the consistent and significant results for growth parameters due to application of novel organic liquid fertilizer. Out of five different treatments, the 3% treatment resulted in maximum, plant height; number of branches per plant; leaf number; leaf area; fresh and dry weight of the plant; number of fruits per plant and total yield (Deore *et al*., 2010). Integrated nutrient management in chilli genotypes that the application of FYM @ 10 t ha-1 along with RDF increased oleoresin content and yield by 16.97 per cent and 124.23kg ha-1, respectively over 100 per cent RDF alone (14.53 per cent and 87.50 kg ha-1, respectively)(Santoshkumar and Shashidhara, 2006). Organic manures supply the major nutrients, micronutrients, besides improving soil properties. In the light of the above facts, a field experiment was conducted involving organic manure (cow dung), poultry manure and inorganic fertilizers as source of nutrients to find out the best combination of manures and fertilizers for obtaining the higher yield of sweet pepper.

Materials and methods

Experimental site

Present study was conducted in the farm of Patuakhali Science and Technology University, Patuakhali. Experiment was carried out during the year 2015/2016 season. The experimental field was located at 220 13/ and 23 04 N latitude and 890 55/ and 910 00/ E longitude with an elevation of 30 cm above sea level.

Soils

The soil of the experimental field belongs to the Barisal soil series of the Ganges tidal floodplain (Agro ecological Zone AEZ-13). The general soil type of the experimental field is silt loam. Topsoil is silt clay in texture. Organic matter content is very low and soil pH varies from 6.87 to 7.06. The land is above flood level and well drained. In order to determine the textural class and fertility status of the experimental area, the soil samples were collected randomly from each plot with the help of soil auger before sowing from the experimental field. Primary samples were mixed to prepare and composite soil sample from each replication was drawn to study physical and chemical properties of the experimental field. The data pertaining to various physical and chemical properties of soil before planting and after harvesting of sweet pepper have been presented in Table 2.

Climate

The climate of the experimental area was tropical in nature. It is characterized by high temperature, high humidity and heavy rainfall during the month of April to September and a scanty rainfall associated with moderately low temperature during the rest of the year. The annual precipitation of the site was 2152mm and potential vapor -transpiration was 1297mm. the average maximum temperature was 26.34°C. Temperature during the cropping period was ranged between 11.24°C to 27.2°C. The humidity varied from 70.22% to 77.219%.

Application of manure and chemical fertilizers

Required amounts of nitrogen, phosphorus and potassium fertilizers were applied in the whole plots as basal dose according to the fertilizers Recommendation Guide (BARC, 1997). Half of nitrogen and whole of potassium were applied during final land preparation in the form of urea and murate of potash (MOP), respectively .the fertilizers were mixed thoroughly with the soil and rest nitrogen applied after 30 days of planting. Half of cow dung, poultry manure ware applied at the time of final land preparation. Remaining amount of cow dung, poultry manure, and full amount of phosphorus was applied before one week of transplanting as per treatment. Nitrogen and potassium were applied in three equal installments 21, 35 and 50 days after transplanting (DAT) as ring method around the plants (Fertilizer Recommended Guide, 2012).

Experimental design and statistical analysis

The experiment was laid out in a Randomized Complete Block Design (RCBD) design. There were three replications and 7 doses of organic and inorganic fertilizers; the plot size was 2m x 1.5m = 3m^2 and maintaining a spacing of 75cm x 50cm and the plots were separated from each other by 0.5m bunds. The block to block and plot to plot distances were 0.5m and 1.0m, respectively. Plant to plant and row to row spacing were also 50 and 75cm. thus each unit plot accommodated 9 plants.

The collected data on various parameters under study were analyzed using the MSTAT statistical package program.

The means for all the treatments were calculated and analyses of variance for all the characters were performed by F test. The Least Significant Difference (LSD) for each parameter was done comparison among the treatment means was evaluated by the Duncan Multiple Range Test (DMRT) AT 5% level of probability.

Parameters measured

Number of leaves per plant

The number of leaves of the sample plants was counted at the time of final harvesting and the average number of leaves produced per plant was recorded.

Leaf area

Fifteen leaves were collected from each replication and their area was measured using a Portable Area Meter. Average leaf area were calculated.

Root per Canopy Percentage

Root per canopy fresh weight percentage was considered for five freshly harvested plants per replicate. Plants were removed from the beds, the roots washed with water, then separated from the crown of the plants using hand shears, weights were measured by digital scale balance for roots and canopies separately for each replicate and the root/ canopy fresh weight percentage was calculated.

Flowering

When plants began blooming, counting of the Flowering: When plants began blooming, counting of until 50 percent of the plants per replicate were in bloom, then the number of days from planting until blooming was observed.

Number of branching

The number of branches of the sample plants was counted at the time of different days after transplanting and the average number of branches produced per plant was recorded.

Plant Fresh and Dry Weight

The average weight were considered for the ten freshly harvested plants per replicate and then dried in an oven at 60°C to a constant weight (Leskinen *et al.*, 2002).

Number of Fruits per Plant

It was considered at the end of the experiment by dividing the total number of fruits for each replicate over the number of plants in that replicate.

Length and Diameter of fruit

The Length and Diameter of fruit of the five randomly selected plants were measured using centimeter scale and the mean value was calculated and was expressed in centimeter (cm).

Average green and dry fruit weight

Five bulbs were weighted separately in an electric balance and their average was considered as the individual green fruit weight. Five bulbs were weighted separately in an electric balance and their average was considered as the individual dry fruit weight.

Yield/replicate

This parameter was measured directly in the field by weighing the total freshly harvested fruits per replicate, using a digital scale balance. At the end of the experiment, all weights for each replicate were summed.

Results and discussion

Number of Leaves per Plant

In T6 treatment (Urea: 130kg + cow dung: 4 tons)/ha, the highest number of leaves per plant (174) was observed than other treatments and the lowest number of leaves per plant (142) was found in T8 treatment (control) (Table 4). Urea enhance the vegetative growth of plant and cow dung contain nitrogen and also some other essential plant nutrients.

Leaf area

The highest leaf area (46.3cm2) was obtained in T4 treatment (Urea: 195+ cow dung kg: 2.25 tons) which was significantly different from other treatments. On the contrary, the lowest leaf number (32.7cm2) was recorded in T8 treatment (control).

Root/canopy percentage

In T6 treatment (Urea: 130kg + cow dung: 4 tons)/ha, the highest Root/canopy percentage (15.2) was found while the lowest root/canopy percentage (7.9) was found in T8 treatment (control) (Table 4). These results indicate that, soil organic matter increased root growth and this is due to the fact that addition of organic matter (cow dung) improves soil physical conditions which in turn facilitate root growth and penetration. Moreover, the conventional treatment resulted in a large canopy with small roots, thus the root/canopy percentage was small, while the organic matter treatments produced small canopy with large roots and therefore the root/canopy percentage was larger.

Days of flowering

Days of flowering per plant was significantly on influenced by different combination of organic and inorganic fertilizer. Flowering date was accelerated by the use of organic and inorganic fertilizers. The earliest days of first flowering (28 days) was observed in T6 treatment (Urea: 130kg + cow dung: 4 tons)/ha while the latest onset of flowering was obtained by the T5 treatment which need 34 days to reach first flowering stage. Furthermore, significant differences present between the treatments. Blooming stage was accelerated by application of organic manures which may be due to continued decomposition of manures after application, resulting in increased temperature in the rhizosphere. This increase in temperature and the higher amounts of potassium in the soil may be responsible for the acceleration of the onset of flowering in the organically treated plants (Turemis, 2002). Again, earliest 50% Days of flowering (36 days) was recorded in T6 treatment (Urea: 130kg + cow dung: 4 tons)/ha and the latest 50% Days of flowering (41 days) was observed in T1 treatment (Table 4). Inorganic fertilizer application accelerated the appearance of first flower and treated plants flowered earlier than control. Nitrogen deficiency retarded the vegetative as well as reproductive growth, which re- sulted in longer periods needed to flowering and fruit setting. Similarly, the both inorganic and organic level of fertilizers also increased the day numbers up to flowering. It means integrated nutrient supply enhanced vegetative growth and days to flowering, which leads to early fruit setting that were in agreement with findings of Satpal and Saimbhi (2003) and Law-Ogbomo and Egharevba (2009).

Table 1. Experimental treatments and doses.

Treatments (T)	*Dose/ha*
Urea +TSP+ MOP (T_1)	(260+120+124) kg/ha
Cow dung (T_2)	9 t/ha
Poultry manure (T_3)	7 t/ha
Urea + cow dung(T_4)	(195 kg +2.5 t)/ha
Urea + poultry manure (T_5)	(180 kg + 2t)/ha
Urea + cow dung (T_6)	(130kg + 4.5 t)/ha
Urea + poultry manure (T_7)	(140 kg +3 t)/ha
Control (T_8)	No manure and fertilizer

Table 2. Physiochemical properties of soil before planting and after harvesting of sweet pepper.

	pH	EC (dS/m)	N (%)	OM (%)	P (ppm)	S (ppm)	K (me/100g soil)	Sand	Silt	Clay	Textural class
Before planting	6.87	1.02	0.11	0.97	56.24	25.23	2.01	25.5	55	19.5	Silt loam
After harvesting	7.06	1.17	0.17	1.34	68.23	45.54	2.83	25.5	55	19.5	Silt loam

Table 3. Pearson correlation coefficient of physiological properties of soils collected after harvest of sweet pepper.

	pH	EC	P	S	K	N	OM	Sand	Silt	Clay
pH	1									
EC	-0.26	1								
P	0.33	-0.4	1							
S	0.67	0.14	0.56	1						
K	0.31	0.31	0.31	0.05	1					
N	-0.53	0.27	-0.18	-0.75*	0.35	1				
OM	-0.12	0.12	-0.23	-0.54	0.74	0.69	1			
Sand	-0.32	0.27	-0.36	-0.15	-0.10	-0.12	-0.16	1		
Silt	0.16	0.20	-0.23	0.24	-0.24	-0.71	-0.41	0.66	1	
Clay	0.14	-0.60	0.41	-0.12	-0.02	0.07	-0.09	0.06	-0.001	1

* = Correlation is significant at the 0.05 level (two-tailed).

Table 4. Sweet pepper leaves number per plant, leaf area (cm^2), Root/canopy (%), Days of 1st flowering and 50% Days of flowering as affected by inorganic and organic fertilizers.

Treatments	Number of Leaves per plant	Leaf area (cm^2)	Root/canopy %	Days of 1st flowering	50% Days of flowering
T_1	163 cd**	43.1 ab	9.2 cd	31 ab	41 a
T_2	159 d	32.9 e	11.8 bc	29 bc	39 ab
T_3	171 ab	36.4 d	10.2 cd	33 ab	40 ab
T_4	168 bc	46.3 a	13.4 bc	32 ab	39 ab
T_5	165 cd	41.3 bc	12.3 bc	34 a	38 bc
T_6	174 a	48.6 a	15.2 a	28 bc	36d
T_7	154 e	39.3 bc	9.8 cd	32 ab	37 cd
T_8	142 f	32.7 e	7.9 e	33 ab	38 bc

**Means within each column having different letters are significantly different according to LSD at 5% level.

No. of branching

A significant variation was recorded in consideration of Number of branches per plant in different treatment combination (Table 5). Number of branches per plant was significantly on influenced by different combination of organic and inorganic fertilizer The highest no. branching (10.6) was obtained in T6 treatment (Urea: 130kg + cow dung: 4 tons)/ha whereas the lowest no. of branching (6.7) was found in T2 treatment (Cow dung: 9 t/ha).

The Number branching per plant of sweet pepper in the experiment shows the following gradation in the decreasing order: T6 >T7 >T5 >T1 >T3 > T4> T8 > T2. Revanappa (1993) observed significantly higher number of primary, (6.31), secondary (16.36) and tertiary (53.0) branches per plant with the application of 250:75:75kg NPK per ha. The increase in number of branches with enhancement of N was attributed to rapid meristematic activity in plants.

Plant fresh and dry weight

A significant variation was recorded in consideration of fresh and dry weight of plant in different combination of organic and inorganic fertilizer application and the result was presented in (Table.4.3). The highest plant fresh weight (378.5g) was recorded in T6 treatment (Urea: 130kg + cow dung: 4 tons)/ha and in T8 treatment (control), the lowest plant fresh weight (243.5g) was found. The plant fresh weight of sweet pepper in the experiment shows the following gradation in the decreasing order: T6 >T3 >T2 >T5 >T7 > T1> T4> T8. In case of plant dry weight, the highest dry weight (68.8g) was found in T3 treatment where the lowest dry weight (56.7g) was obtained in T8 treatment (control). The plant dry weight of sweet pepper in the experiment shows the following gradation in the decreasing order: T3 >T6 >T7 >T2 >T4 > T5> T1> T8. The present results showed in general a increase in vegetative growth of the inorganic and organic treatments compared to the control treatment; which could be due to the higher availability of nutrients in integrated treatment especially nitrogen (Palomaki *et al*., 2002).

No. of fruits/plant

From the present research it is observed that the no. of fruits/plant influence significantly by the application of different combination of organic and inorganic fertilizer application and shown in (Table 5). The highest no. of fruits/plant (16.6) was found in T6 treatment (Urea: 130kg + cow dung: 4 tons)/ha and the lowest one (8.8) was observed in T8 treatment (control).

The highest fruit numbers per plant were obtained in T6 treatment (Urea: 130kg + cow dung: 4 tons)/ha compared with others (Table 5), which were in agreement with findings of Solvadore *et al.* (1997), Guohua *et al.* (2001) and Olaniyi (2008). Ali and Kelly (1992) suggested that the maintenance of vigorous vegetative growth from flower bud formation throughout fruit development might ensure sufficient assimilate supply to alleviate stress on growing processes in the developing buds. Increase of soil fertility delayed at the beginning of flowering and fruit set of sweet pepper, but increased total fruit yield (Shrivastava, 1996).

Table 5. Sweet pepper no. of branching, Plant fresh weight (g), Plant dry weight (g), No. of fruits/plant, Fruit length (cm) and Fruit diameter (cm) as affected by inorganic and organic fertilizers.

Treatments	No. of branching	Plant fresh weight (g)	Plant dry weight (g)	No. of fruits/plant	Fruit length (cm)	Fruit diameter (cm)
T_1	9.1 ab**	298.1 cd	57.3 cd	14.2 ab	7.6 a	3.4 a
T_2	6.7 b	335.7 bc	61.3 bc	11.5 cd	7.5 a	5.2 a
T_3	9.1 ab	351.2 ab	68.8 a	9.5 d	8.2 a	4.3 a
T_4	8.3 ab	278.4 d	59.4 cd	13.2 ab	7.9 a	4.5 a
T_5	9.2 ab	332.3 bc	57.6 cd	12.1 bc	7.8 a	5.1 a
T_6	10.6 a	378.5 a	65.4 ab	16.6 a	9.9 a	5.8 a
T_7	9.6 ab	310.2 cd	62.6 bc	12.3 bc	6.4 a	4.8 a
T_8	7.1 b	243.5 e	56.7cd	8.8 d	5.6 a	4.2 a

**Means within each column having different letters are significantly different according to LSD at 5% level.

Fruit length and diameter

No significant variation was recorded in consideration of fruit length and diameter in different combination of organic and inorganic fertilizer application (Table 5).

Average green and dry fruit weight

The data of the average green and dry fruit weight had significant differences between all the used treatments (Table 6). The highest average green fruit weight (142.1g) and dry fruit weight (84.6 g) were recorded in T6 treatment (Urea: 130kg + cow dung: 4 tons)/ha. Fruit weight depends on the cultivar and temperature rather than on the culture system (organic or conventional) (Hortynski *et al.*, 1994). Also, only small and non-significant differences between organic and conventional systems in respect to fruit weight (Birkeland *et al.*, 2002). Data showed the highest fruit weigh (both green and dry weight) which were in agreement with Magdatena (2003), Akanbi *et al.* (2007) and Aujla *et al.* (2007).

Yield per Replicate

The results concerning the yield are shown in Table 6. The highest total yield per replicate (38.5kg) was found by the T6 treatment (Urea: 130kg + cow dung: 4 tons)/ha which significantly exceeded all other treatments, while the lowest total yield (21.3kg) was obtained by T8 treatment (control). The highest yield recorded by the T6 treatment could be due to the supply of both organic and inorganic fertilizers from cow dung and urea. Inorganic and organic fertilization significantly increased fruit number, yield per plant and total yield comparing to control, that were in agreement with Tumbare *et al.* (2004) and Law-Ogbomo and Egharevba (2009).

Table 6. Sweet pepper Average green fruit weight (g), Average dry fruit weight (g), Yield/replicate (kg) affected by inorganic and organic fertilizers.

Treatments	Average green fruit weight (g)	Average dry fruit weight (g)	Yield/replicate (kg)
T_1	121.2 cd**	67.4 ab	31.4 bc
T_2	134.6 ab	72.3 ab	29.4 cd
T_3	122.4 cd	68.3 ab	31.6 bc
T_4	132.9 ab	69.5 ab	34.5 ab
T_5	127.3 bc	68.5 ab	31.4 bc
T_6	142.1 a	84.6 a	38.5 a
T_7	125.2 bc	65.4 cd	28.7 cd
T_8	116.3 e	64.9 cd	21.3 d

**Means within each column having different letters are significantly different according to LSD at 5% level.

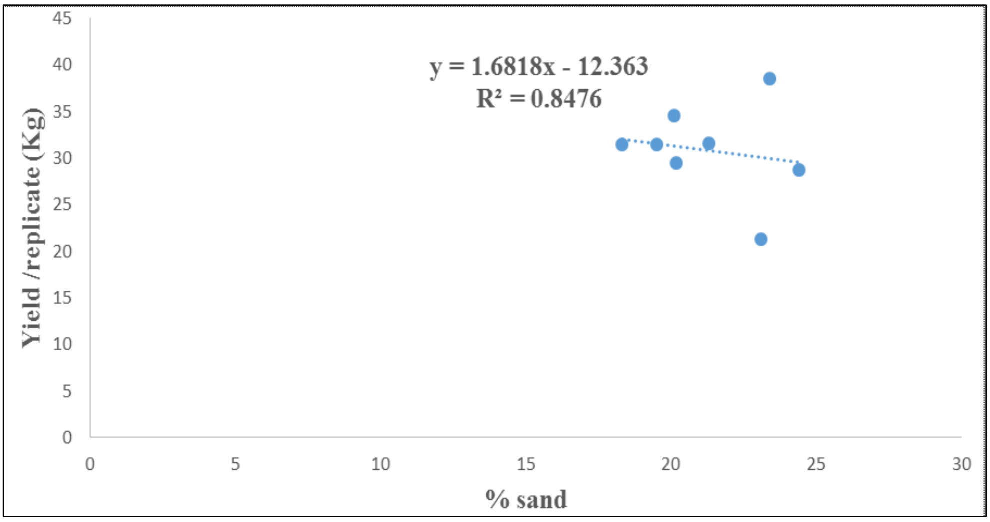

Fig. 1. Relationship between % sand and yield/replicate in sweet pepper cultivation.

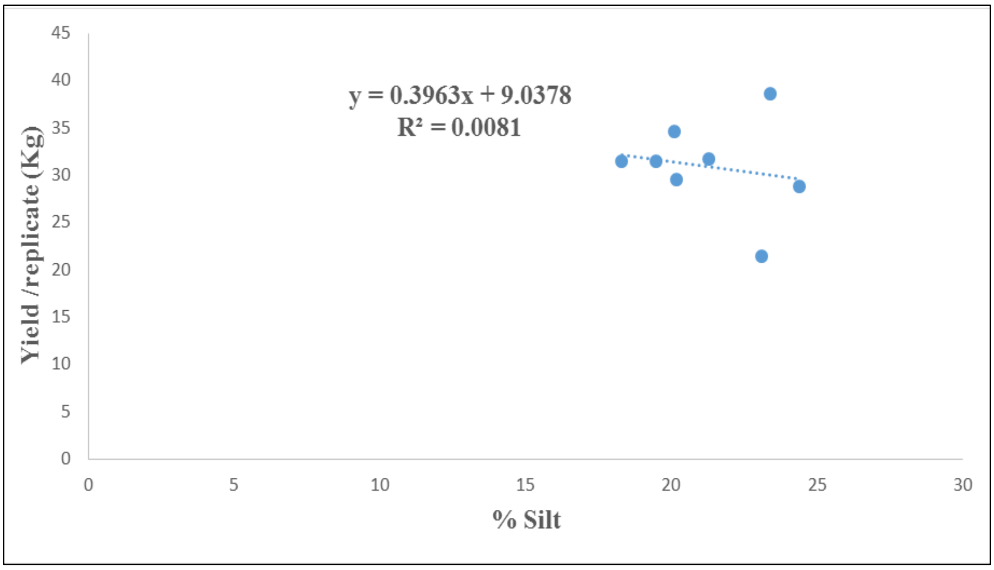

Fig. 2. Relationship between % silt and yield/replicate in sweet pepper cultivation.

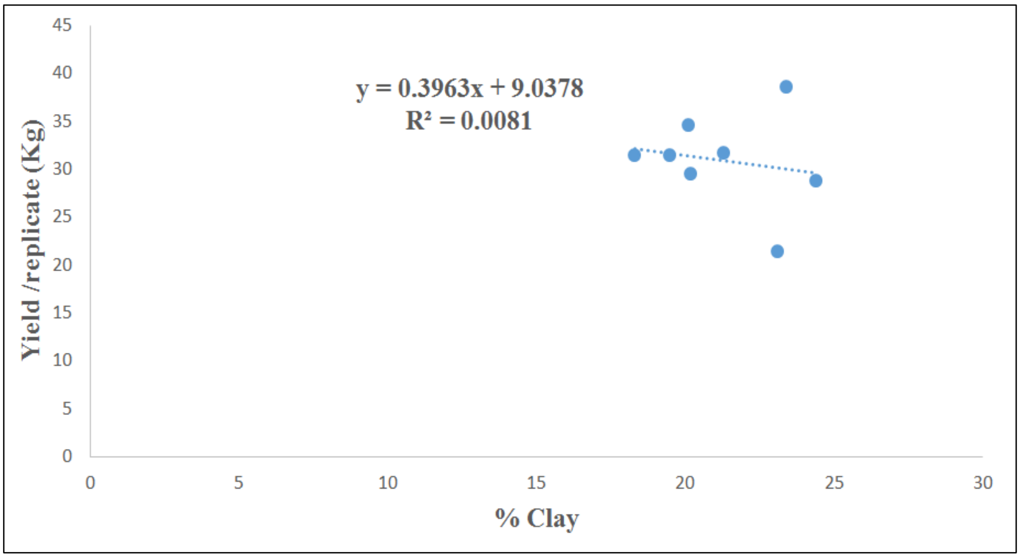

Fig. 3. Relationship between % clay and yield/replicate in sweet pepper cultivation.

Conclusions

On the context of above results it was found that integrated nutrient application (Urea: 130kg + cow dung: 4 tons)/ha increased plant growth; number of leaves/plant, leaf area, root/canopy, no. of branching, plant fresh weight, no. of fruits/plant, fruit length, fruit diameter, average green fruit weight and yield/replicate. Inorganic fertilizers increased plant growth and organic matter accelerated flowering stage. So integrated nutrient application in sweet pepper was most effective and efficient.

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