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Yield Performance of Sweet Pepper *(Capsicum annuum)* Treated with Inorganic and Organic Fertilizer

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ABSTRACT

This experimental study aimed to determine the yield and growth of sweet pepper under varying soil conditions and to determine the performance of the different treatments. There were four treatments, replicated three times. The treatments were as follows: treatment 1 (control), treatment 2 (inorganic fertilizer), treatment 3 (organic fertilizer), and treatment 4 (combination of inorganic and organic fertilizers). The variety of sweet pepper used was SULTAN F1, a high-yielding conical, dark green hybrid sweet pepper with a good year-round adaptation. Fruits have a long shelf life and are marketable up to 7 days after harvest. This is an early maturing variety, harvestable at 55-60 d after transplanting. It has strong pest and disease tolerance to bacterial spot and bacterial wilt. After planting, each plot received different treatments based on the study. During production, the project encountered insects that can cause damage to some of the plant fruits. To mitigate this situation, a mixture of sterilized water, malathion, and effective microorganism (EM-5) was applied at a single application, following the recommended rate of application. In addition, results showed that the plant height and fruit weight in treatment 4 (T4) performed better than other treatments. However, in terms of replication or blocking of the experiments, no significant differences was observed. This shows that a combination of inorganicand organic fertilizer is effective for the yield performance of sweet pepper.

Keywords: Inorganic fertilizer, sweet pepper (*Capsicum annuum*), organic fertilizer, treatment combination (organic and inorganic), and yield performance

INTRODUCTION

Sweet pepper (*Capsicum annuum*) is a warm-season crop that belongs to the Solanaceae family. According to Wien (1997), pepper's family is a member of the Solanaceae crops, which include potato (*Solanum tuberosum*), eggplant (*Solanum melongena*), and cherry (*Solanum pseudocapsicum*). Sweet peppers are sensitive to light frost and grow poorly when temperatures are in the 40-60°F range. Extreme summer heat prevents fruit set inmost sweet peppers. A well-drained, sandy loam soil is ideal for pepper production. Peppers may be "hot" or "sweet". The fruit size varies from 1 to 30 cm in length, from thin to thick fleshed, conical to blocky or flattened, both yellow and green, at an immature stage, and with red, yellow, and brown mature fruits. This plant is a perennial in warm climates but grows as an annual in northern climates (Garton and Bodnar, 1991).

Pepper is commonly divided into two groups, pungent and non-pungent, which are also called hot and sweet pepper. Sweet pepper includes different cultivars, and the most frequently used ones, in greenhouse production, are hybrids that have bell-shaped (*Capsicum annuum L.*). According to Ramesh et al., (2005), organic fertilizers provide essential nutrients for plant development, improve the quality of vegetables, and enhance growth and yield when compared to sole reliance on chemical fertilizers. Organic fertilizers are essential for the proper development of plants, vegetables, flowers, and fruits, as they offer rapid growth with superior quality to all species. They have the nutrients necessary for better development (Zayed et al., 2013). In addition, the organic matter serves as nutrients and energy sources for soil microorganisms (Silva et al., 2012). The suitability and usefulness of organic fertilizers have been attributed to the high availability of NPK content (Waddington, 1998), which is capable of enhancing soil fertility (Thomas, 1997). They also act as a substrate for soil microorganisms, which leads to an increase in microbial activity. This will increase the rate of organic material decomposition and release nutrients for plant uptake. They improve the physical properties of the soil as well (Nasef et al., 2004; Palada et al., 2004; Khalid and Shafei, 2005).

According to Zhang et al. (2016), nitrogen dynamics and soil fertility under treatments that combined compost (organic) with inorganic chemical fertilizers shows that partially substituting chemical fertilizer with compost can maintain or increase yield while improving soil fertility and reducing nitrogen loss. Their usage makes clear that "chemical fertilizer" is equal to manufactured inorganic fertilizer supplying readily available nutrients.

Production of high-quality organic sweet pepper transplants is the first step in achieving optimum fruit production in year-round greenhouse production. However, organic regulations often restrict the use of liquid fertilizers for certified organic transplant production because the growing medium must provide the primary source of nutrients. This increases the challenge of producing healthy sweet pepper transplants with a balance between the shoot and the root within a small volume of growing medium, which contains a source of nutrients that is enough to last until final transplanting (Gagnon et al., 2007).

The germination of sweet pepper is slow if sown too early when soil temperatures are still too low, but seedling emergence accelerates as temperatures increase to between 24 and 30 °C (Bosland and Votava, 1999). The optimum soil temperature for germination is 29 °C (Anon., 2000). Low temperatures also slow down seedling growth, which leads to prolonged seedling exposure to insects, diseases, salt, or soil crusting, any of which can severely damage or kill off the seedlings (Bosland et al., 1999).

Generally, this study aimed to determine the yield performance of sweet pepper

treated with inorganic and organic fertilizers. This study aimed to boost the economy by encouraging farmers to engage in sweet pepper production through the use of inorganic and organic fertilizers in Purok Tambon, Barangay Don Salvador Lopez, Mati City, Davao Oriental. This may provide information to interested farmers who are willing to have an additional income with less investment.

METHODOLOGY

Description of the study

The study area of the proponent is Purok Tambon, Barangay Don Salvador Lopez, Mati City, Davao Oriental. The farm site is 1 km from the highway and 18 km from the public market. It is surrounded by trees, which would serve as windbreakers. Sweet pepper thrives best in areas with temperatures ranging from 25-30°C. The soil requirement of sweet pepper is relatively fertile, well-drained, sandy, with a pH of 5.5 to 6.8. The soil pH requirement of sweet pepper coincides with the soil pH of the area (PCARRD, 1989). The topography of the area is generally flat. It is accessible by any land transportation from Mati Poblacion, and has access to a reliable source of irrigation. The study area is 116m^2 and only 30 min to the public market of Mati. The seed stock of sweet pepper was procured in Mati City, where planting materials, fertilizers, and pesticides were available. The land preparation was completed before the seedlings were transplanted to the field. The field was plowed many times as necessary, followed by harrowing until a tilt was obtained.

Management aspect

During the pre–operating period, plans and schedules for all necessary activities were established for the operation and the establishment of a 116 m² production site at Purok Tambon, Barangay Don Salvador Lopez, Mati City, Davao Oriental. These activities were scheduled over several weeks as shown in Table 1. The first activity was the acquisition of funds needed during the operation. The proponent engages money as capital in the production. The next activity was the procurement of raw materials, supplies, and other farm inputs.The land preparation was done before the seedlings were transplanted to the field. The field was plowed many times as necessary, followed by furrowing until a tilt was obtained.

Operating activities

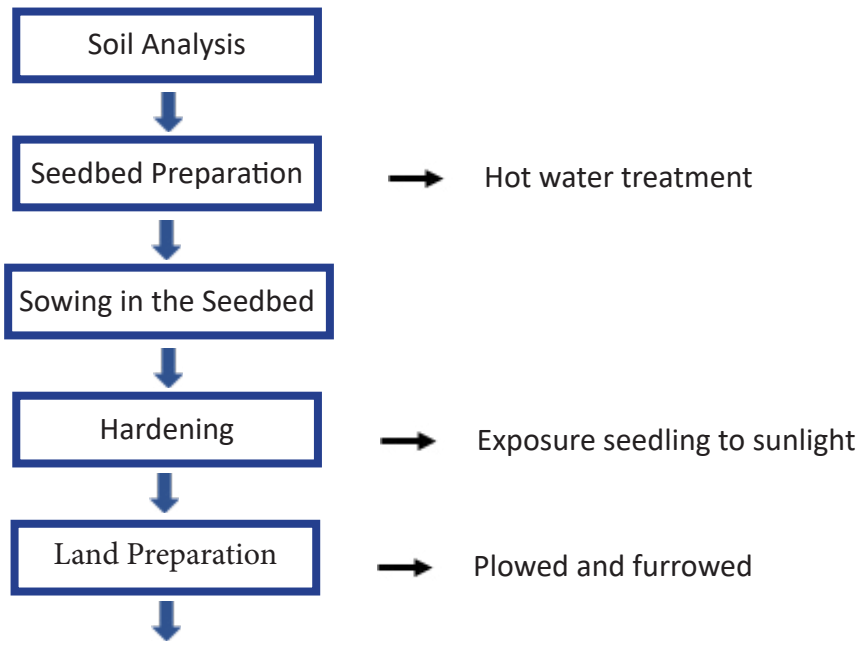
This activity includes seedling preparation, seedling management, and land preparation was followed after procuring all necessary materials needed for this study. Weeding was done first, slashing or clearing the area before the plot had been installed. After that, the plot was made with measurements of 3 m in length and 2 m in width, totaling 116 m² in area. After the plot was made, a canal was created to serve as drainage and prevent overflow. Fertilizer application is critical after the land preparation because it will enhance the growth of the plant. After that, transplanting took place. Seedlings were transplanted at four weeks from germination at a distance of 45 cm between hills and 50 cm between rows (PCARRD, 1989). Watering started right after transplanting. Hand weeding was practiced once or twice a week, or when weeding was visible, particularly in the soil. Fertilization of muriate of potash was done during the flowering stage for fruit development. When the fruit reached its full shape/s and size, harvesting took place. Fruits in yellow, orange, and red were harvested, including mature green fruits (PCARRD, 1989). Sweet pepper can be harvested at 3-to-5-day intervals. After harvesting, postharvest handling then followed. Harvested fruits were sorted according to their size and color, and damaged fruits were separated from good ones. Marketable fruits were packaged in smooth cellophane for the walk–in buyers who bought the products.

Taxonomy

Sweet Pepper (*Capsicum annuum)* belongs to the Solanaceae family (Bukas et al., 2007). It is one of the critical ingredients and seasonings used in food preparation. It comes from a woody herb or shrub native to tropical America. This plant is widely cultivated as a seasonal crop in the United States and Asia (Bosland et al., 2012). The fruit is large, bell-shaped, and has thick walls. Its color ranges from red to orange, yellow, or brown when ripe. An unripe sweet pepper is called a garden pepper. Raw sweet pepper can be stuffed or used in salads. The variety used for planting was SULTAN (F1), which had a high-yielding conical, dark green hybrid sweet pepper with a good year–round adaptation. Its large, smooth, and thick fruit flesh is ideal for canning and processing. Fruits are a dark green color when mature and glossy red when ripe. Due to its rounded shoulder and peduncle attachment, there are fewer incidences of fruit rot and damaged fruits. Fruits have a long shelf life and are more marketable up to seven (7) days after harvest. This is an early maturing variety, harvestable at 55 – 60 days after transplanting. It has strong resistance to pests and diseases, including bacterial wilt.

Production process

In the process of production, the proponent had conducted a soil analysis. The disinfection of soil in the seedling trays was done using hot water treatment. After cooling, seeds were sown in seedling trays at a distance of 1 cm between hills and 1 cm between rows. To maintain the moisture, watering was done. Hand weeding was practiced to keep the grown seeds free from weeds, to avoid competition for nutrients, and to support their growth. After three days of germination, pricking was done and was followed by hardening through a gradual exposure of the seedling to sunlight. Seedlings were transplanted to the fields, and these were done late in the afternoon to avoid wilting. The seedlings were planted 45 cm apart in hills and 50 cm apart in rows (Villamor et al., 2008). The Production flow chart indicates the step-by-step process of sweet pepper production, as shown below.



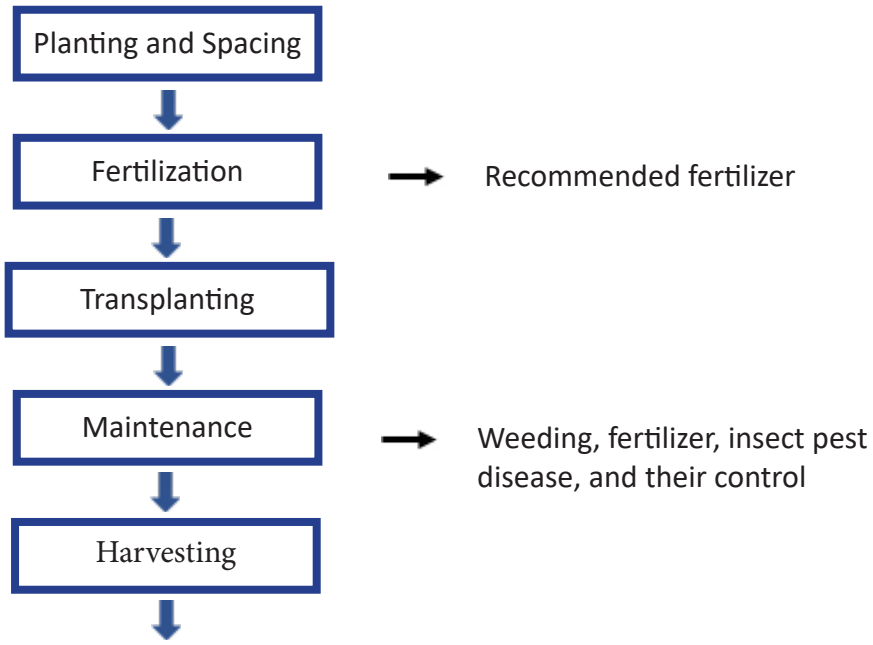


Figure 1. Production flow chart

Maintenance

A.) Weeding

Weeds are controlled to attain the minimum crop yield. Hand weeding was done to help absorb water and avoid competition for nutrients

B.) Watering

Watering was done to sustain the growth and development of the plant, especially during the dry season.

C.) Fertilization

To attain its maximum crop yield, the recommended fertilizer was applied to the plant. The first fertilizer application was the complete (14-14-14) ammonium sulfate (21-0-0), followed by muriate of potash (0-0-60), and finally, urea (46-0-0). If compost /organic fertilizer is available, apply the minimum rate recommended. The study by the proponent used inorganic and organic fertilizers, indicating that it is necessary for the plants' growth and development (Lorejo, 2009).

Experimental design

The design to be used in this study is RCBD, where similar experimental units are grouped into blocks or replicates. It is also used to control variation in an experiment by accounting for spatial effects in a certain field.

The four treatments were as follows;

- T1 – Control
- T2 – inorganic fertilizer (urea, complete, muriate of potash, and ammonium sulfate)
- T3 – organic fertilizer (chicken and goat manure)
- T4 – combination of Inorganic Fertilizer plus Organic Fertilizer

Fruit characterization

A.) Color of the fruit

Fruits are a dark green color when mature and glossy red when ripe. Fruits have a shelf life and are marketable up to seven (7) days after harvest, and are harvestable at fifty-five (55) to sixty (60) days after transplanting.

B.) Weight of the fruit

The weight of the fruits in each treatment differs, with the highest weight, T4 (combination of the two fertilizers), at 200 g in the first harvest. In contrast, the T2 (inorganic fertilizer) and T3 (organic fertilizer) were almost the same weight of 100 g, followed by T1 (control) of 50 g.) (Lorejo, 2009).

C.) Plant height (cm)

The plant height was measured from the base to the tip of the sweet pepper twice a month. Six plants were measured as a sample.

RESULTS AND DISCUSSION

As shown in Table 1, the parameters of sweet pepper plant height in replication 1 (Treatment 1 and Treatment 2) were measured every two weeks, with six random samples per treatment. Furthermore, the proponent determines the highest plant height among the treatments of T1 (control) and T2 (inorganic fertilizer). Thus, inorganic fertilizer (T2) had the highest average of plant height when compared to the control (T1). According to Bahuguna et al., (2015) the application shows of nitrogen, phosphorus, and potash fertilizers significantly enhanced the vegetative growth and yield attributes of sweet pepper plants. Comparing the alignment to the control (T1), the average plant height was the highest.

Table 1. Plant height of replication 1 (Treatments 1 and 2).

			Days from transplanting to harvesting (cm)				
Replications	Treatment	Sample	15	30	45	60	75
	T1	1	3.5	6.8	15.3	22.2	25.3
		2	3.3	6.6	14.8	22.5	25.7
		3	3.2	6.3	14.5	22.5	24.4
		4	3.3	5.9	15.2	23.5	24.3
		5	3.3	5.9	14.9	22.3	24.3
		6	3.2	6.1	15.8	23.7	25.3
R1		**Average**	**5.68**	**10.74**	**15.08**	**22.78**	**25.88**
	T2	1	4.2	8.3	17.1	25.6	32.2
		2	4.2	8.3	16.2	25.7	31.2
		3	4.3	8.5	16.9	28.6	32.4
		4	3.8	7.5	16.6	26.2	32.7
		5	3.5	7.1	17.4	26.9	32.4
		6	4.1	7.9	17.8	25.8	32.6
		Average	**4.02**	**7.93**	**17**	**26.47**	**32.25**

Table 2 shows the different treatments with exact replication. Treatment 3 (organic fertilizer) and treatment 4 (inorganic fertilizer plus organic fertilizer) were measured for plant height twice a month. And it presented that in treatment four, the initial measurement averaged 36.27 cm over 75 days, compared to the T3, which only had a 33.10 cm. Inorganic fertilizer applications can lead to increased plant height in sweet pepper cultivation (Bahuguna et al., 2015).

Table 2. Plant height of replication 1 (Treatments 3 and 4).

		Days from transplanting to harvesting (cm)					
Replications	Treatment	Sample	15	30	45	60	75
	T3	1	4.8	9.9	25.9	27.9	32.4
		2	5.5	11.7	23.9	26.3	33.2
		3	5.3	10.7	27.7	26.6	34.2
		4	5.2	10.5	23.7	27.5	32.9
		5	5.9	11.2	26.5	28.7	33.4
		6	5.5	11.7	26.2	28.5	32.5
R1		**Average**	**5.37**	**10.95**	**25.60**	**27.58**	**33.1**
	T4	1	6.1	11.6	26.0	34.3	36.3
		2	6.0	10.2	21.5	33.4	36.4
		3	5.8	10.5	28.3	32.2	36.1
		4	5.9	10.8	21.6	32.5	36.2
		5	6.2	11.8	25.6	34.5	36.4
		6	5.9	11.4	24.7	32.6	36.2
		Average	**5.98**	**11.05**	**24.62**	**33.25**	**36.27**

Table 3 shows the plant height of sweet pepper in replication 2 with the treatment of inorganic fertilizer (T3) and organic fertilizer (T4). However, this specified that treatment 3 (organic fertilizer) had higher growth, averaging 31.15, compared to treatment 2 (inorganic fertilizer), which gained 31.05 only in 75 days.

Table 3. Plant height of replication 2 (Treatments 2 and 3).

		Days from transplanting to harvesting (cm)					
Replications	Treatment	Sample	15	30	45	60	75
	T2	1	4.3	10.2	22.2	26.4	31.8
		2	4.3	10.5	25.5	26.3	31.3
		3	5.2	10.7	19.4	23.1	29.4
		4	5.3	10.9	23.5	27.3	31.9
		5	4.3	10.2	24.4	27.8	31.8
		6	4.2	10.4	25.7	26.7	30.1
R2		**Average**	**4.6**	**10.48**	**23.45**	**26.27**	**31.05**
	T3	1	5.5	11.7	23.6	26.8	30.4
		2	5.2	10.5	23.7	26.3	30.2
		3	5.3	10.7	27.7	26.9	30.5
		4	4.8	9.9	25.9	27.4	32.3

		5	5.5	10.8	26.1	27.2	31.1
		6	5.9	11.2	26.5	28.4	32.4
		Average	5.37	10.8	25.83	27.17	31.15

Table 4 indicates the different treatments, which are T4 (inorganic fertilizer plus organic fertilizer) and T1 (control), replication 2. The treatment 4 (inorganic fertilizer plus organic fertilizer) had the highest average of 35.50 compared to T1, which also had an average of 27.35 over a 75-day observation period. It found that combined nutrient application improved vegetative growth parameters more than single-source treatments or control (Islam et al., 2015).

Table 4. Plan height of replication 2 (Treatments 4 and 1).

			Days from transplanting to harvesting (cm)				
Replications	Treatment	Sample	15	30	45	60	75
	T4	1	6.1	11.6	26.0	30.3	35.4
		2	5.8	10.2	21.5	33.4	35.4
		3	6.0	11.4	27.5	33.1	35.3
		4	5.9	10.5	28,3	32.5	35.2
		5	5.9	10.8	21.6	34.2	35.5
		6	6.2	11.8	26.5	34.8	36.2
R2		**Average**	**5.98**	**11.05**	**24.62**	**33.05**	**35.5**
	T1	1	3.2	6.1	15.3	23.4	27.2
		2	3.2	5.9	14.5	24.5	27.3
		3	3.3	5.9	14.8	24.5	27.2
		4	3.2	6.3	15.2	24.8	27.5
		5	3.4	6.6	15.8	23.5	27.4
		6	3.2	6.8	15.2	24.3	27.5
		Average	**3.25**	**6.27**	**15.13**	**24.17**	**27.35**

Table 5 shows a different treatment in the plant height of sweet pepper in replication 3. All samples listed in the table were measured twice a month. Treatment 4 (inorganic fertilizer plus organic fertilizer) had an initial average of 36.78 over 75 days, compared to treatment 3 (organic fertilizer). The result of Islam et al. (2015) showed that combined inorganic–organic fertilization greatly improves vegetative growth characteristics in sweet pepper in comparison to control treatments, are consistent with this.

Table 5. Plant height of replication 3 (Treatments 3 and 4).

			Days from transplanting to harvesting (cm)				
Replications	Treatment	Sample	15	30	45	60	75
	T3	1	5.2	12.4	24.7	26.8	32.3
		2	4.9	11.5	24.6	26.4	32.3
		3	5.5	10.8	22.4	27.5	32.5
		4	5.3	10.6	22.5	28.4	32.4
		5	5.3	9.7	22.5	27.5	32.2
		6	6.2	10.4	25.7	27.8	32.3
R3		**Average**	**5.4**	**10.9**	**23.73**	**27.4**	**32.33**

	T4	1	8.5	15.2	26.3	34.5	36.3
		2	7.2	14.6	24.7	34.4	35.4
		3	8.3	15.5	26.7	34.3	36.4
		4	6.8	13.5	23.6	34.4	37.5
		5	6.5	13.3	25.3	34.5	37.5
		6	5.9	12.3	23.8	34.4	37.6
		Average	**7.2**	**14.07**	**25.07**	**34.42**	**36.78**

In replication 3, Table 6 shows the parameters of sweet pepper plant height in treatment 1 (control) and treatment 2, which shows that treatment 2 (inorganic fertilizer) has an initial measurement of 33.3 cm in sample 5 and the final average of 32.55%. In comparison, the initial measurement of treatment 1 was 27.8 cm in sample 3, and the final average was 27.58%. This indicated that treatment 2 (inorganic fertilizer) had a higher growth of 32.55% compared to treatment 1, which had only 27.58%.

Table 6. Plant height of replication 3 (Treatments 1 and 2).

			Days from transplanting to harvesting (cm)				
Replications	Treatment	Sample	15	30	45	60	75
	T1	1	3.9	8.1	19.5	23.4	27.5
		2	3.8	7.9	17.2	24.4	27.6
		3	3.9	8.9	22.5	26.5	27.8
		4	3.9	8.1	20.2	26.4	27.4
		5	4.1	8.0	19.3	24.5	27.6
		6	3.7	7.9	18.3	24.6	27.6
R3		**Average**	**3.88**	**8.15**	**19.5**	**24.97**	**27.58**
	T2	1	4.2	8.3	17.8	27.4	32.4
		2	4.2	8.5	17.4	26.5	32.4
		3	4.3	7.5	16.6	27.4	32.5
		4	3.5	7.1	16.2	28.4	32.4
		5	4.1	7.9	17.1	28.9	33.3
		6	3.8	8.3	16.9	28.3	32.3
		Average	**4.02**	**7.93**	**17**	**27.82**	**32.55**

Sweet pepper is one of the two distinct classes of pepper that can be found and cultivated here in the Philippines. It is known as *Capsicum annuum*, which belongs to the Solanaceae family. “Atsal” is the local term for sweet pepper. Its fleshy fruit is an excellent source of Vitamin A, iron, phosphorus, and niacin. Its green leaves are also an excellent source of. It can be used in making salads and pickles as a garnish, and as an ingredient in many Filipino dishes.

Table 7 below shows the information and observation of sweet pepper that applied with inorganic fertilizer plus organic fertilizer produce earlier flowering (T4) in forty-two (42) days while other treatments applied with inorganic fertilizer (T2) and organic fertilizer (T3) flower early at an average of 43 days compared to control which flowered late at 45 days after planting .

Table 7. Number of days from transplanting to flowering stage (days).

	Replications				
Treatment	I	II	III	Treatment Total	Treatment Means
T1	45	45	45	135	45
T2	43	43	43	128	43
T3	43	43	43	128	43
T4	42	42	42	126	42
Replication total (R)	**168**	**173**	**173**		
Grand total (G)				**514**	
Grand mean					**171.34**

Sweet pepper treated with different products or materials yielded highly significant results on plant height, as shown in Table 8. In every treatment, T4 (a combination of inorganic fertilizer plus organic fertilizer) resulted in the tallest plant height at 108.55 cm. On the other hand, other treatments of sweet pepper were also found to have heights of 96.58 cm (T3) and 95.85 cm (T2), compared to the control, which had the shortest height at 79.81 cm. In the analysis of variance, Table 8 shows that the plant height (cm) revealed a highly significant difference among the treatments (T4 – a combination of inorganic fertilizer plus organic fertilizer) at 5% level. However, in terms of replication or blocking of the experiments, no significant difference is observed.

Table 8. Plant height (cm) of sweet pepper using different fertilizers.

	Replications				
Treatment	I	II	III	Treatment Total	Treatment Means
T1	24.88	27.35	27.58	79.81	26.60
T2	32.25	31.05	32.55	95.85	31.95
T3	33.10	31.15	32.33	96.58	32.19
T4	36.27	35.50	36.78	108.55	36.18
Replication total (R)	**126.50**	**125.05**	**29.24**		
Grand total (G)				**380.79**	
Grand mean					**31.73**

Sweet pepper treated with different fertilizers showed a highly significant result in fruit weight, as shown in Table 8. T4 treated with a combination of Inorganic fertilizer plus Organic fertilizer obtained the heaviest weight of the fruit at an average of 445 g. Furthermore, different treatments were found to have heavier fruit, with T3 weighing an average of 320 g and T2 weighing 310 g, compared to control T1, which weighed 250 g. The weight of fruits shown in Table 9 shows highly significant differences at the 5% level for T4, which is a combination of Inorganic fertilizer plus Organic fertilizer, compared to other treatments.

Table 9. Weight of the fruit (grams) of sweet pepper using different fertilizers.

	Replications				
Treatment	I	II	III	Treatment Total	Treatment Means
T1	60	90	100	250	83.33
T2	100	100	110	310	103.33
T3	110	110	100	320	106.67
T4	120	150	175	445	148.33
Replication total (R)	**390**	**450**	**485**		
Grand total (G)				**1325**	
Grand mean					**110.46**

CONCLUSION

Based on the foregoing results, it can be concluded that T4, which is a combination of inorganic fertilizer plus organic fertilizer, had the best perofrmance in terms of plant height and fruit weight compared to the other treatments. Furthermore, the statistical analysis also revelead a highly significant difference in plant height and fruit weight.

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