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Effect of organic sources of nutrients on yield, quality and economics of okra [*Abelmoschus esculentus* (L.) Moench] cv. GAO 5

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Abstract
The results revealed that significantly the maximum number of pods per plant (12.47), maximum yield per plant (181.99 g), per plot (4.37 kg), per hectare (101.08 q), maximum number of picking (17.23), length of pod (14.38 cm), thickness of pod (14.91 mm) and crude protein content of pod (15.06%) were found significant with treatment of Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha (T_{17}). The nitrogen uptake (74.36 kg/ha), phosphorous uptake (11.72 kg/ha) and potassium uptake (53.97 kg/ha) was recorded significantly maximum with treatment of Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha (T_{17}). The available Nitrogen (222.08 kg/ha), Phosphorous (48.51 kg/ha) and Potassium (100.60 kg/ha) was recorded significantly maximum with treatment of FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha (T_{16}). On the basis of results obtained from present investigation, it could be concluded that okra cv. GAO 5 should be fertilized with recommended dose of fertilizer (100:50:50 kg NPK/ha) to obtain higher yield with better quality and economic return. Further, for organic production of okra, application of Vermicompost @ 5 t/ha as a organic manure along with biofertilizers *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha gave maximum yield with better quality and higher net return.

Keywords: Pusa Naveen, bottle gourd, nitrogen, organic sources, biofertilizers, yield, economics

Introduction
Okra or Bhendi [*Abelmoschus esculentus* (L.) Moench] commonly known as lady's finger, belongs to the family *Malvaceae.* It is one of the important *kharif* and summer vegetable grown widely in sub-tropical region of the world for its tender pods. Okra is one of the most important vegetable crop grown extensively throughout the country during rainy and summer season due to its high adaptability over a wide range of environmental conditions. It is one of the economically important vegetable crop grown almost all parts of India. It is widely adapted vegetable in Indian kitchens and can be grown through-out the year. As a vegetable in tender stage, okra is nutritious and it finds an important place in the Indian dietary. Besides the utility of its tender green fingers as a vegetable, it is also used in soups and curries. Green pods are rich source of Iodine, Vitamin A, B and C. The stems and roots of okra can also be used in paper industry.

Okra requires heavy manuring for its potential production (Naik and Shrinivas, 1992) [8]. However, the use of expensive commercial fertilizers as per requirements of the crop is not much affordable to the average farmers. Therefore, the application of plant nutrients through organic sources like compost, farm yard manure and biofertilizers remains the alternative choice of the growers for maintaining its sustainable production (Subbiah *et al.*, 1982; Dart, 1986 and Gaur, 1990) [15, 4, 5]. Nutritional imbalance in the soil causes instability in productivity and hidden hunger of nutrients besides results in poor nutritional quality of the vegetables. To maintain sustainability in production through integrated use of different sources may also help to maintain the fertility of the soil, avoids depletion of soil organic matter and plant nutrients besides suppression of some insect-pests and diseases (Gaur, 2001 and Palaniappan and Annadurai, 2000) [6, 10]. Organic manures not only balance the nutrient supply but also improve the physical and chemical properties of soil (Nair and Peter, 1990) [9]. Okra requires proper and sufficient N, P & K for regular fruiting and subsequent pickings (Premsekhar and Rajashree, 2009) [12]. Farming with organic manures gains potential importance because it is claimed that the crops grown with organics, taste well and are more nutritious, thereby increasing export potential (Prabhu *et al.*, 2003) [11].

Organic manures generally improve the soil physical, chemical and biological properties along with conserving the moisture holding capacity of soil and thus resulting in enhanced crop productivity.

A considerable scientific data was generated recently to show that the produce obtained from organic farming is nutritionally superior with good taste, lusture and better keeping qualities. Integrating organic manures in the nutrient management system also paves way for reducing the amounts of inorganic fertilizers in okra production, thus reducing the harsh environment that the chemical fertilizers leave back due to their long term residual effects. Organic farming strategy is growing rapidly all over the world to conserve human health and the environment. Bio-fertilizers are formulations of beneficial microorganisms, which upon application can increase the availability of nutrients by their biological activity and help to improve the soil health for increasing soil fertility with objective of increasing the number of such microorganisms and to accelerate certain microbial processes. Bio fertilizers are low cost, effective and renewable source of plant nutrients to supplement chemical fertilizers. In addition to their role in enhancing the growth of the plants, bio fertilizers can also act as bio control agents in the rhizosphere at the same time. This synergistic effect, when present, increases the role of application of bio-fertilizers in the sustainable agriculture. Biofertilizers play an important role in increasing availability of nitrogen and phosphorus. They increase the biological fixation of atmospheric nitrogen and enhance phosphorus availability to the crop. They are helpful in reducing the application dose of macronutrients especially N and P. Accordingly, it is necessary to know that up to which level, the RDF can be reduced if applied with biofertilizers. This practice have been prooved successful in several crops including okra. But under North Gujarat condition, no much information is available, hence the present experiment on Effect of organic sources of nutrients on yield, quality and economics of okra [*Abelmoschus esculentus* (L.) Moench] cv. GAO 5.

Material and methods

The investigation was conducted at the College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan (Gujarat). The different organic manures *viz.* farmyard manure and vermicompost with biofertilizer i.e. *Azospirillum*, PSB, KSB were tested during the *kharif* season of the year 2017. The experiment was laid out in a Randomized Block Design with seventeen treatments were employed and replicated thrice.

Table 1: Detail of different treatment

T_1	Recommended dose of fertilizer (100:50:50 kg NPK/ha)
T_2	FYM @ 20 t/ha
T_3	Vermicompost @ 5 t/ha
T_4	FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha
T_5	FYM @ 20 t/ha + PSB @ 2.5 l/ha
T_6	FYM @ 20 t/ha+ KSB @ 2.5 l/ha
T_7	Vermicompost @ 5t/ha + *Azospirillum* @ 2.5 l/ha
T_8	Vermicompost @ 5t/ha + PSB @ 2.5 l/ha
T_9	Vermicompost @ 5t/ha + KSB @ 2.5 l/ha
T_{10}	FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha
T_{11}	Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha
T_{12}	FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha + KSB @ 2.5 l/ha
T_{13}	Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + KSB @ 2.5 l/ha
T_{14}	FYM @ 20 t/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha
T_{15}	Vermicompost @ 5 t/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha
T_{16}	FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha
T_{17}	Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha

Note: Biofertilizer are applied after mixing well with organic manures and then incorporated in soil before sowing.

To raise the crop recommended package of practices were followed. The treatments were evaluated on the basis of plant growth and flowering behavior from ten randomly selected tagged plants at different stages. The mean data were subjected to statistical analysis following analysis of variance technique (Gomez and Gomez, 1984).

Results and Discussion

Yield and yield attributes

The data recorded pertaining to number of pods per plant were influenced by different treatments are presented in Table 2, graphically illustrated in Fig. 1. It was observed from the data that numbers of pods per plant were significantly influenced by different treatments. Among different treatments, maximum number of pods per plant (12.47) was recorded with T_{17} (Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha). This might be due to gradual and steady release of nutrient during the growth period as well as enhanced biological activity and proper nutrition to crop, availability of micro-organism in soil which enhance growth of pod and number of pods per plant. These results are in conformity with the findings of Chattoo *et al.* (2011) [2] and Hisham *et al.* (2014) [7] in okra.

The mean data on pod yield of okra are influenced by the effect of organic sources of nutrients which are presented in Table 3 and graphically depicted in Fig. 2. Significantly maximum yield per plant (181.99 g) was obtained under T_{17} (Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha). The maximum yield per plot (4.37 kg) was obtained under treatment T_{17} (Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha). The maximum yield per hectare (101.08 q) was obtained under treatment T_{17} (Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha). The increased in yield might be due to better root proliferation, more photosynthesis efficiency, enhanced food accumulation, increased availability of atmospheric nitrogen and soil phosphorus by microbial inoculants and synthesis of plant growth hormones at all the essential stage of growth and development by the combined application of biofertilizers and organic manure. These results are in accordance with the findings of Singh *et al.* (2008) [14], Tripathy and Maity (2009) [16] and Bairwa *et al*. (2004) [1].

Data pertaining to periodical observations on total number of pickings of okra are influenced by different organic source of nutrients and biofertilizers which are presented in Table 2 and graphically depicted in Fig. 2. Significantly maximum total number of pickings (17.23) was obtained in treatment T_{17} (Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha). This results supported the findings of Premsekhar and Rajshree (2009) who reported that organic manures promote root growth and activity of okra plants and generally the plant having a better root system can absorb more water and support for photosynthesis.

Quality parameters

The data recorded in respect to length of pod was influenced by the effect of organic sources of nutrients, which are presented in Table 2 and graphically illustrated in Fig. 4. Among all the treatments, significantly maximum length of pod (14.38 cm) was recorded with T_{17} (Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha). The length of pod was directly influenced by the enhanced vegetative growth the plants which resulted in increase in the height and number of green branches of plants. This might have accumulated more carbohydrates, resulting into increased length of pod which is the storage organ. These results were in agreement with those reported by Yadav and Yadav (2010) and Chattoo *et al.* (2011) [2] in okra. The mean data on thickness of pod of okra are influenced by the effect of organic sources of nutrients are presented in Table 2, graphically depicted in Fig.5. Significantly maximum thickness of pod (14.91 mm) was obtained in treatment T_{17} (Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha. This might be due to gradual and steady release of nutrients during the growth period as well as enhanced biological activity and proper nutrition to crop which are similar with the findings of Chattoo *et al.* (2011) [2] and Choudhary *et al.* (2015) [3] in okra.

The mean data on crude protein content of fruits (%) in okra as influenced by effect of organic sources of nutrients are presented in Table 2 and its graphically representation is in Fig. 6. Data presented in Table 2 clearly indicated that statistically maximum crude protein content (15.06%) was obtained in treatment T_{17} (Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha). Organic manures are capable of supplying adequate macro and micro plant nutrients which play major role in quality improvement through desirable enzymatic changes taking place during growth. The increase in crude protein content of okra may be due to increase in photosynthesis and also due to some improved physiological and biochemical activities in plant system under the influence of organic matters. These results are consequences with the findings of Tripathy *et al.* (2004) [17], Sharma *et al.* (2010) [13] and Chattoo *et al.* (2011) [2] in okra.

Economics

Effect of organic sources of nutrients on net return and benefit cost ratio in okra are presented in Table 3. Data revealed that maximum gross realization was obtained in treatment T_{17} (Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha) but highest net returns and BCR were obtained in T_1 (Recommended dose of fertilizer 100:50:50 kg NPK/ha) due to low cost of cultivation. While lowest yield, net return along with BCR was observed in treatment T_2 (FYM @ 20 t/ha).

Table 2: Effect of organic sources of nutrients on no. of pods per plant, yield (g/plant), yield (kg/plot), yield (q/ha), total no. of pickings, length of pod (cm), thickness of pod (mm), crude protein (%)

Sr. No.	Treatment	Number of pods/ plant	Yield (g /plant)	Yield (kg/plot)	Yield (q/ha)	Total No. of pickings	Length of pod (cm)	Thickness of pod (mm)	Crude protein (%)
T_1	Recommended dose of fertilizer (100:50:50 kg NPK/ha)	12.43	170.85	4.04	93.44	17.22	13.88	14.86	14.47
T_2	FYM @ 20 t/ha	9.10	124.29	2.98	69.06	14.64	11.36	12.29	12.74
T_3	Vermicompost @ 5 t/ha	10.00	136.50	3.28	75.85	14.77	11.53	12.46	12.79
T_4	FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha	10.41	141.89	3.40	78.78	14.86	11.84	13.31	13.11
T_5	FYM @ 20 t/ha + PSB @ 2.5 l/ha	11.36	155.02	3.72	86.19	15.22	12.50	13.70	13.60
T_6	FYM @ 20 t/ha+ KSB @ 2.5 l/ha	10.23	137.19	3.29	76.16	14.83	11.57	12.59	12.80
T_7	Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha	10.82	147.75	3.50	80.94	15.14	12.37	13.56	13.49
T_8	Vermicompost @ 5 t/ha + PSB @ 2.5 l/ha	11.45	155.35	3.73	86.34	15.43	12.63	13.74	13.77
T_9	Vermicompost @ 5 t/ha + KSB @ 2.5 l/ha	10.28	140.09	3.36	77.78	14.85	11.81	13.20	12.96
T_{10}	FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha	12.05	163.95	3.89	89.97	16.71	13.22	14.32	14.38
T_{11}	Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha	12.15	164.45	3.94	91.13	16.82	13.55	14.64	14.40
T_{12}	FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha + KSB @ 2.5 l/ha	11.58	155.82	3.74	86.57	15.61	12.66	13.91	13.91
T_{13}	Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + KSB @ 2.5 l/ha	11.66	161.21	3.84	88.81	16.00	13.06	14.09	14.07
T_{14}	FYM 20 t/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha	11.83	161.25	3.87	89.58	16.01	13.07	14.28	14.14
T_{15}	Vermicompost @ 5 t/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha	11.88	162.01	3.88	89.80	16.40	13.14	14.29	14.34
T_{16}	FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha	12.28	167.66	4.02	93.13	17.18	13.56	14.82	14.74
T_{17}	Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha	12.47	181.99	4.37	101.08	17.23	14.38	14.91	15.06
	S.Em. (±)	0.65	9.16	0.22	5.13	0.64	0.62	0.56	0.45
	C.D. (P = 0.05)	1.86	26.39	0.64	14.76	1.85	1.78	1.62	1.31
	C.V. (%)	9.90	10.27	10.38	10.38	7.03	8.41	7.05	5.70

Table 3: Effect of organic sources of nutrients on economics and benefit cost ratio

Treatments	Gross realization (□/ha)	Total cost of cultivation (□/ha)	Net returns (□/ha)	Benefit Cost Ratio
T_1	186880	35840	151040	5.21
T_2	138120	50850	87270	2.72
T_3	151700	50850	100850	2.98
T_4	157560	51100	106460	3.08
T_5	172380	51100	121280	3.37

T_6	152320	51100	101220	2.98
T_7	161880	51100	110780	3.17
T_8	172680	51100	121580	3.38
T_9	155560	51100	104460	3.04
T_{10}	179940	51350	128590	3.50
T_{11}	182260	51350	130910	3.55
T_{12}	173140	51350	121790	3.37
T_{13}	177620	51350	126270	3.46
T_{14}	179160	51350	127810	3.49
T_{15}	179600	51350	128250	3.50
T_{16}	186260	51600	134660	3.61
T_{17}	202160	51600	150560	3.92

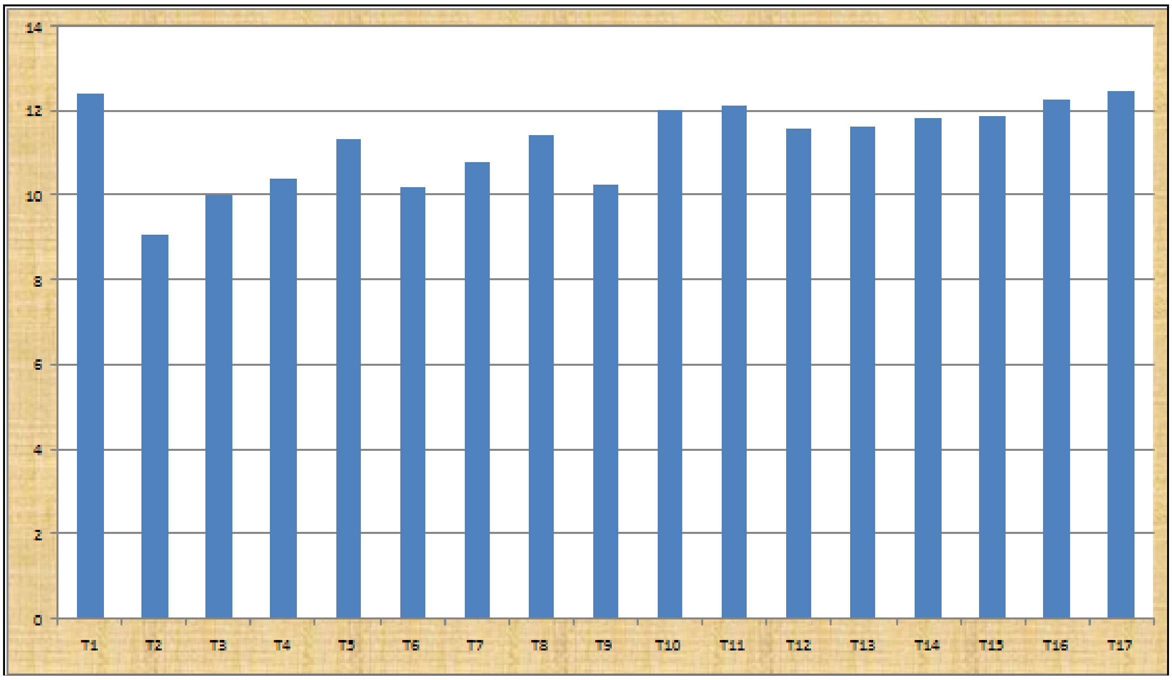

Fig 1: Effect of organic sources of nutrients on number of pods per plant

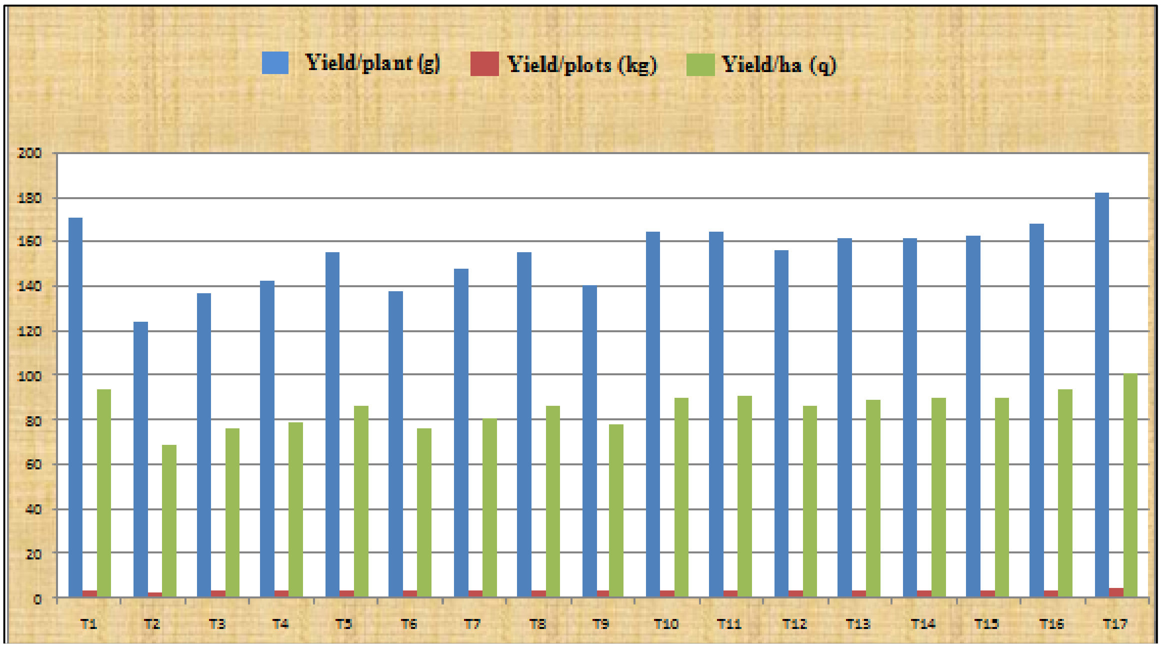

Fig 2: Effect of organic sources of nutrients on yield of okra

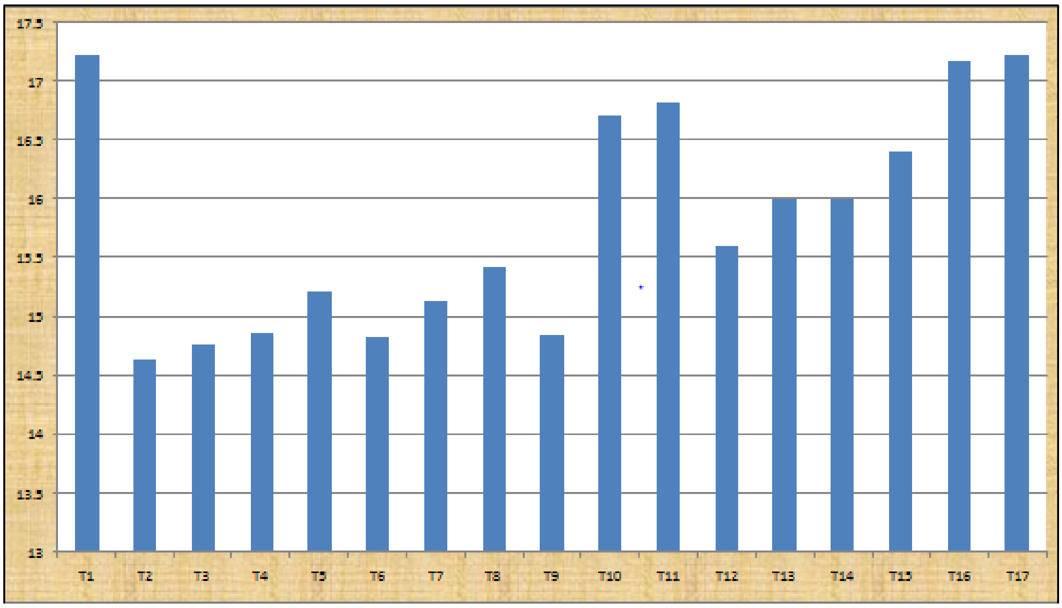

Fig 3: Effect of organic sources of nutrients on total number of pickings

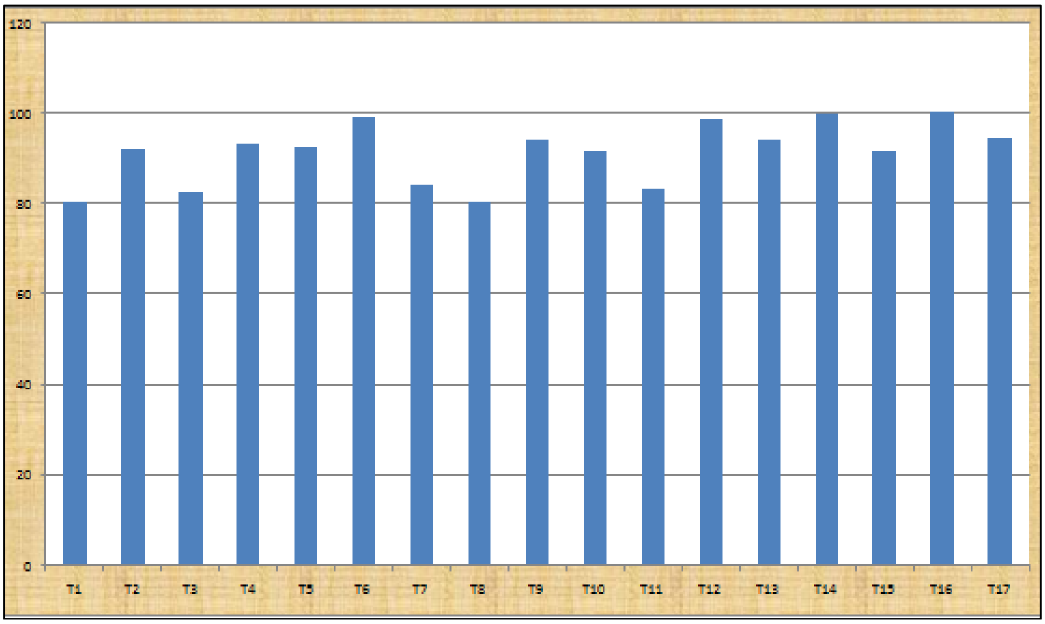

Fig 4: Effect of organic sources of nutrients on length of pod (cm)

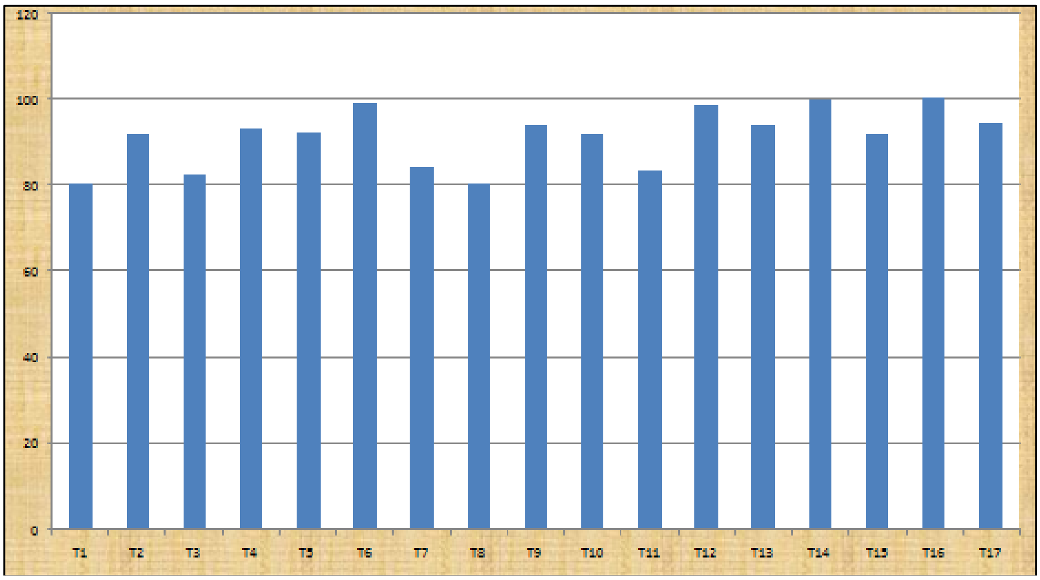

Fig 5: Effect of organic sources of nutrients on thiclmess of pod (mm)

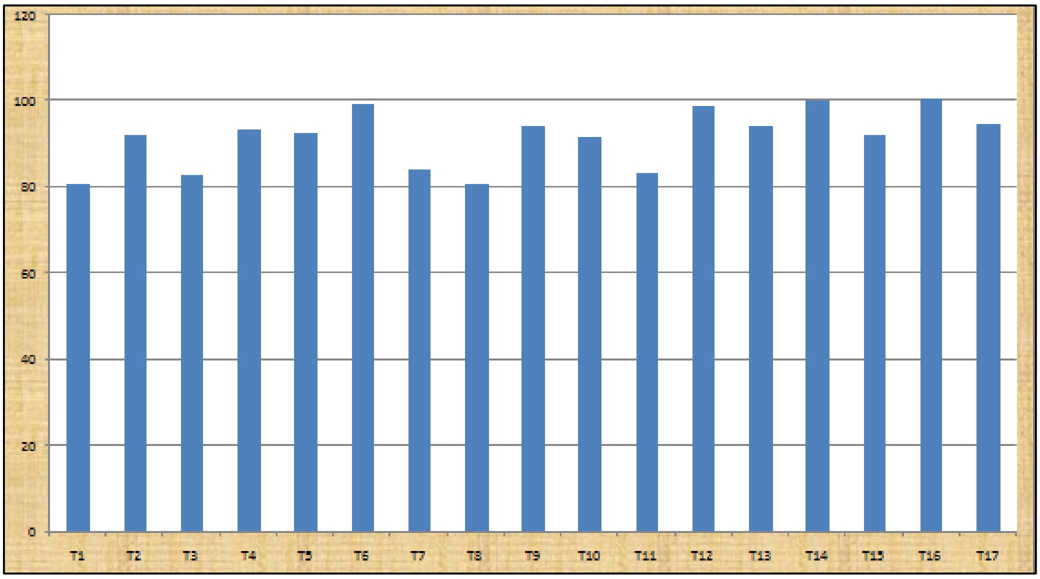

Fig 6: Effect of organic sources of nutrients on crud protein content (%)

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