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Effect of organic sources of nutrients on growth and flowering behavior of okra [*Abelmoschus esculentus* (L.) Moench] cv. GAO 5

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Abstract
A study was conducted at the farm of College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan (Gujarat) during *kharif* season 2017 to study the response of organic sources of nutrient on growth and flowering behavior of okra. The experiment was laid out in randomised block design with seventeen treatments using three replications. Significant variations were observed for maximum plant height at 45 days after sowing (34.43 cm), maximum number of leaves at 45 days after sowing (9.79) and maximum stem thickness at 45 days after sowing (10.12 mm) were found in treatment of recommended dose of fertilizer : 100:50:50 kg NPK/ha (T_1) to obtain significantly maximum plant height at 90 days after sowing (73.49 cm), maximum number of leaves at 90 days after sowing (16.78) and maximum stem thickness at 90 days after sowing (15.70 mm) were found in treatment of Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha (T_{17}). The maximum Leaf area per plant at 60 days after sowing (1817.67 cm2), minimum days taken for initiation of first flower after sowing (39.00) and minimum days taken for first picking (46.35) was recorded not significant with treatment of recommended dose of fertilizer: 100:50:50 kg NPK/ha (T_1). While, minimum days taken for flower initiation to edible maturity (6.21) was recorded not significant and highest days for last picking (104.06) was 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}).

Keywords: Organic Source, Biofertilizers, Growth, flowering behaviour

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. India ranks first in okra in the world with a production of 3.5 million tonnes (70 % of the total world production) from an area of 0.35 million ha. The area under okra cultivation in Gujarat was about 76,029 ha with total production of 908676.75 MT in 2016-17 with an average productivity of 11.95 t/ha and especially in Mehsana district cultivation of okra in 2016-17 was about 2,055 ha with the total production of 28461.75 MT with an average productivity of 13.85 t/ha (Anon., 2017) [1].

Okra requires heavy manuring for its potential production (Naik and Shrinivas, 1992). 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) [21, 3, 6]. 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 helps 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) [5, 14]. Organic manures not only balance the nutrient supply but also improve the physical and chemical properties of soil (Nair and Peter, 1990) [12].

Okra, being a short duration vegetable crop, its growth is largely influenced by the application of fertilizers. It requires proper and sufficient N, P & K for regular fruiting and subsequent pickings (Premsekhar and Rajashree, 2009) [16]. 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) [15]. 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 growth and flowering behavior of okra and to device a proper and balanced combination and scheme of fertilizers.

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.

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) [7].

Results and Discussion

Growth parameters

The data pertaining to the effect of organic sources of nutrients on plant height at 45 and 90 days after planting are presented in Table 1 and graphically illustrated in Fig. 1. Significantly maximum plant height at 45 DAS (34.43 cm) was observed with treatment T_1 (Recommended dose of fertilizer 100:50:50 kg NPK/ha) Readily available N from inorganic fertilizers was responsible for promoting better plant height and same was reported by Ray *et al.* (2005) [17] and Naidu *et al.* (1999) [11] in okra. The maximum plant height at 90 DAS (73.49 cm) was observed with treatment T_{17} (Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha). An increase in plant height in T_{17} might be due to enhanced availability of nutrients and production of growth promoting substances that might have caused cell elongation and cell multiplication. These results are in conformity with the finding of Singh *et al.* (2008) [19], Mal *et al.* (2013) [9] and Dademal and Dongale (2004) [2] in okra.

The data presented to the effect of organic sources of nutrients on number of leaves at 45 and 90 days after sowing are presented in Table 1 and graphically illustrated in Fig.2. Significantly maximum number of leaves (9.79) was recorded with treatment T_1 (Recommended dose of fertilizer (100:50:50 kg NPK/ha). Readily available N from inorganic fertilizers was responsible for promoting better plant growth and same was reported by Ray *et al.* (2005) [17] and Naidu *et al.* (1999) [11] in okra. The significantly maximum number of

leaves at 90 DAS (16.78) was recorded with treatment T_{17} (Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha). Increase in number of leaves might be due to higher metabolic activity because of the higher N supply resulting in higher production of carbohydrates and phytohormones which were manifested in the form of enhanced growth. Vermicompost is reported to be a very good source of macro and micro elements, growth hormones, vitamins and micro flora. Production of growth promoting substances and vitamins by vermicompost and biofertilizers and their favourable influences in increasing the leaf number. These results are in conformity with the finding of Nuruzzaman *et al*. (2003) [13], Mal *et al*. (2013) [9] and Sharma *et al*. (2014) [18] in okra.

Influence of various treatments on stem thickness at 45 and 90 days after sowing are summarized in Table 1 and graphically illustrated in Fig. 3. Significantly the maximum stem thickness (10.12 mm) was recorded with T_1 (Recommended dose of fertilizer (100:50:50 kg NPK/ha). Rapid elongation of cells because of adequate nitrogen seems to have favourable influence on plant growth. These results are in conformity with findings of Barani and Anburani (2004) in okra. The stem thickness at 90 DAS was significantly the highest (15.70 mm) in treatment T_{17} (Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha). Maximum stem thickness might be due to the enhanced availability of nutrients and growth promoting substances that might have caused cell enlargement and cell multiplication which is directly correlated to the plant height and number of leaves. These results are in conformity with the finding of Muoneke *et al*. (2003) [10], Singh *et al.* (2004) [20] in onion and Farooqui *et al.* (2009) [4] in garlic.

Data pertaining to observation on leaf area per plant of okra at 60 days after sowing are not influenced by the effect of organic sources of nutrients are presented in Table 1. The presented data clearly indicated not significant difference among the treatments. However, numerically maximum leaf area (1817.67 cm^2) was obtained in treatment T_1 (Recommended dose of fertilizers (100:50:50 kg NPK/ha). The observations on days taken for initiation of first flower after sowing of okra are not influenced by the effect of organic source of nutrients, which are presented in Table 1. The presented data clearly exhibited the not significant difference among treatments. However, numerically lowest days taken for initiation of first flower after sowing *i.e.*, 39.00 was obtained in treatment T1 (Recommended dose of fertilizer : 100:50:50 kg NPK/ha).

Data pertaining to observation on days taken for flower initiation to edible maturity of okra are not influenced by the effect of organic sources of nutrients, which are presented in Table 1. Data clearly indicated the non significant difference among the treatments. However the numerically minimum days taken for flower initiation to edible maturity (6.21) 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). Data pertaining to observation on days taken to first picking of okra are not influenced by the effect of organic sources of nutrients which are presented in Table 1. The data clearly indicated the not significant difference among the treatments. Whereas, numerically minimum days 46.35 to first picking was obtained in treatment T_1 (Recommended dose of fertilizer: 100:50:50 kg NPK/ha).

The observations on days taken to last picking of okra are influenced by organic sources of nutrients which are presented in Table 1 and graphically depicted in Fig 4. Significantly the highest days 104.06 to last picking 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 may be due to the fact that organics are known to enhance microbial activity which might have helped and improved availability of nutrients through mineralization and eventually leading to better canopy coverage, higer photosynthesis and translocation of photosynthates from source to sink (Jeevansab, 2000) [8].

Table 1: Effect of organic sources of nutrients on plant height (cm), leaves per plant, stem thickness, leaf area (cm^2), initiation of 1st flower after sowing, days taken for edible maturit y, days taken to first picking and days taken to last picking.

Sr. No.	Treatment	Plant height		Leaves /plant		Stem thickness		Leaf area (cm^2)	Initiation of 1st flower after sowing	Days taken for edible maturity	Days taken to first picking	Days taken to last picking
		45 DAS	90 DAS	45 DAS	90 DAS	45 DAS	90 DAS					
T_1	Recommended dose of fertilizer (100:50:50 kg NPK/ha)	34.43	69.60	9.79	16.72	10.12	15.52	1817.67	39.00	6.26	46.35	103.57
T_2	FYM @ 20 t/ha	27.59	57.57	7.47	13.96	7.34	13.06	1395.44	43.83	7.09	50.98	95.80
T_3	Vermicompost @ 5 t/ha	27.73	58.33	7.60	14.22	7.37	13.33	1399.71	43.60	6.94	50.62	95.81
T_4	FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha	28.21	59.94	7.94	14.52	7.65	13.65	1484.47	42.85	6.63	49.52	96.75
T_5	FYM @ 20 t/ha + PSB @ 2.5 l/ha	29.65	61.33	8.05	15.23	7.78	13.97	1557.71	42.22	6.61	49.31	97.26
T_6	FYM @ 20 t/ha+ KSB @ 2.5 l/ha	28.04	58.53	7.61	14.28	7.48	13.38	1423.42	43.18	6.78	50.07	95.83
T_7	Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha	28.87	60.67	8.03	14.58	7.69	13.77	1489.64	42.48	6.62	49.42	97.20
T_8	Vermicompost @ 5 t/ha + PSB @ 2.5 l/ha	29.78	59.33	8.20	15.24	7.89	14.23	1563.03	41.79	6.60	49.30	97.69
T_9	Vermicompost @ 5 t/ha + KSB @ 2.5 l/ha	28.07	59.33	7.90	14.32	7.50	13.41	1450.00	43.14	6.66	49.80	96.28
T_{10}	FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha	33.50	65.50	8.56	15.83	8.81	15.20	1707.06	40.63	6.32	48.61	99.15
T_{11}	Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha	33.51	58.53	8.86	15.93	8.92	15.24	1707.40	39.60	6.31	47.25	99.57
T_{12}	FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha + KSB @ 2.5 l/ha	30.54	61.47	8.27	15.26	8.20	14.31	1629.41	41.43	6.47	49.29	97.71
T_{13}	Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + KSB @ 2.5 l/ha	31.57	62.39	8.37	15.36	8.24	14.56	1661.47	41.13	6.44	49.17	98.20
T_{14}	FYM 20 t/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha	32.10	62.67	8.39	15.48	8.64	14.59	1683.82	41.11	6.40	49.03	98.64
T_{15}	Vermicompost @ 5 t/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha	32.96	64.07	8.40	15.60	8.66	14.60	1701.74	41.10	6.33	48.74	98.86
T_{16}	FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha	33.53	66.77	9.03	16.47	8.94	15.26	1753.07	39.49	6.27	46.86	103.51

T_{17}	Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha	34.14	73.49	9.07	16.78	9.06	15.70	1778.24	39.07	6.21	46.43	104.06
	S.Em. (±)	1.60	3.00	0.42	0.62	0.51	0.60	100.23	1.26	0.33	2.10	1.93
	C.D. (P = 0.05)	4.60	8.64	1.20	1.80	1.46	1.71	NS	NS	NS	NS	5.56
	C.V. (%)	8.96	8.34	8.65	7.08	10.64	7.19	10.85	5.24	8.67	7.44	3.39

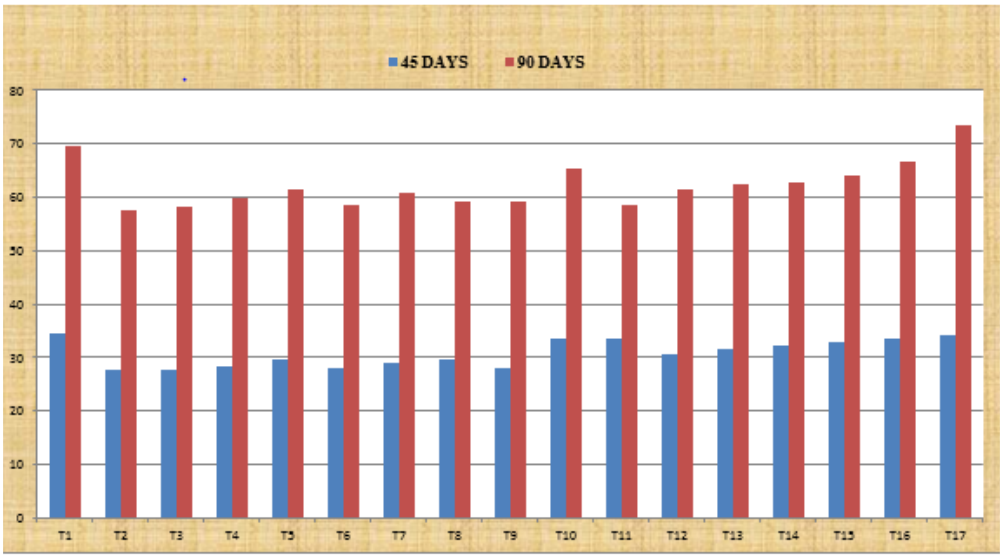

Fig 1: Effect of organic sources of nutrients on plant height (cm)

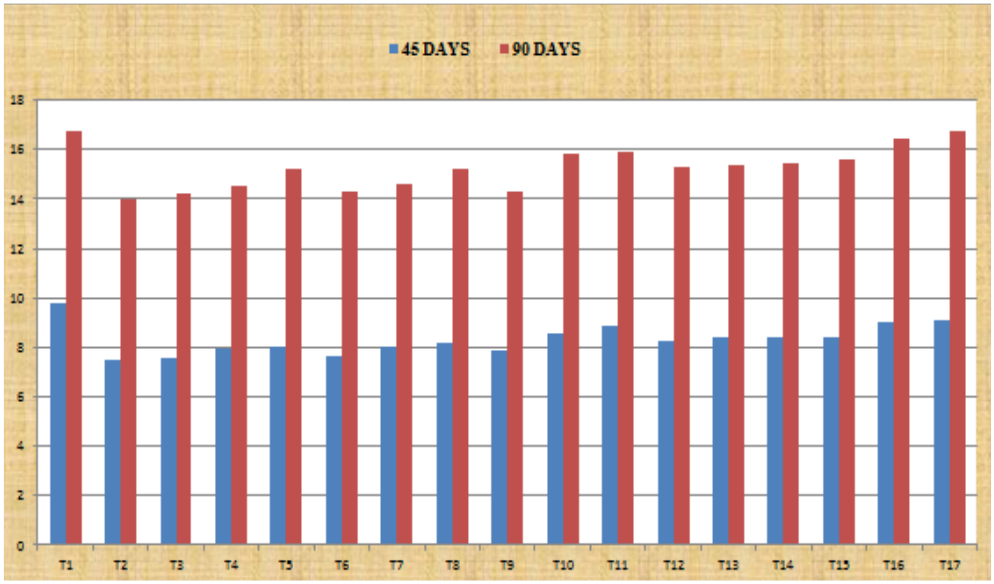

Fig 2: Effect of organic sources of nutrients on number of leaves per plant

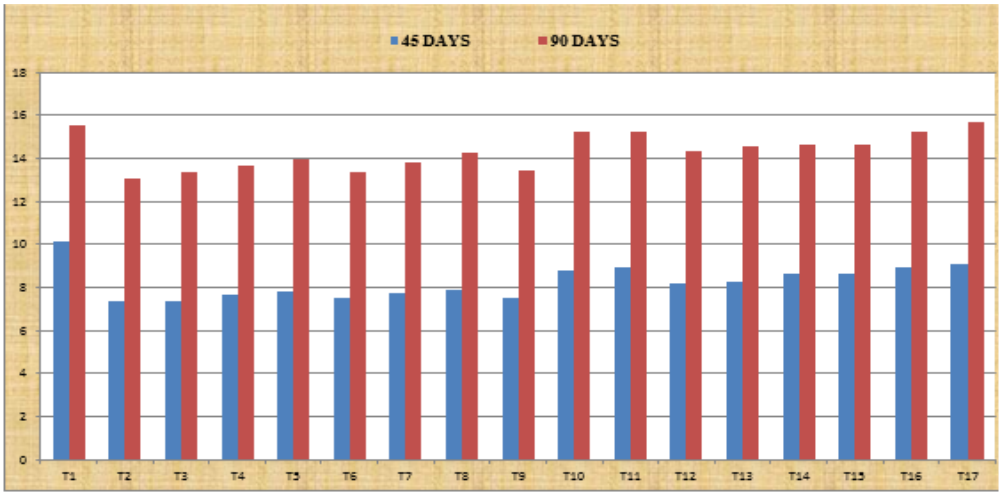

Fig 3: Effect of organic sources of nutrients on stem thickness (mm)

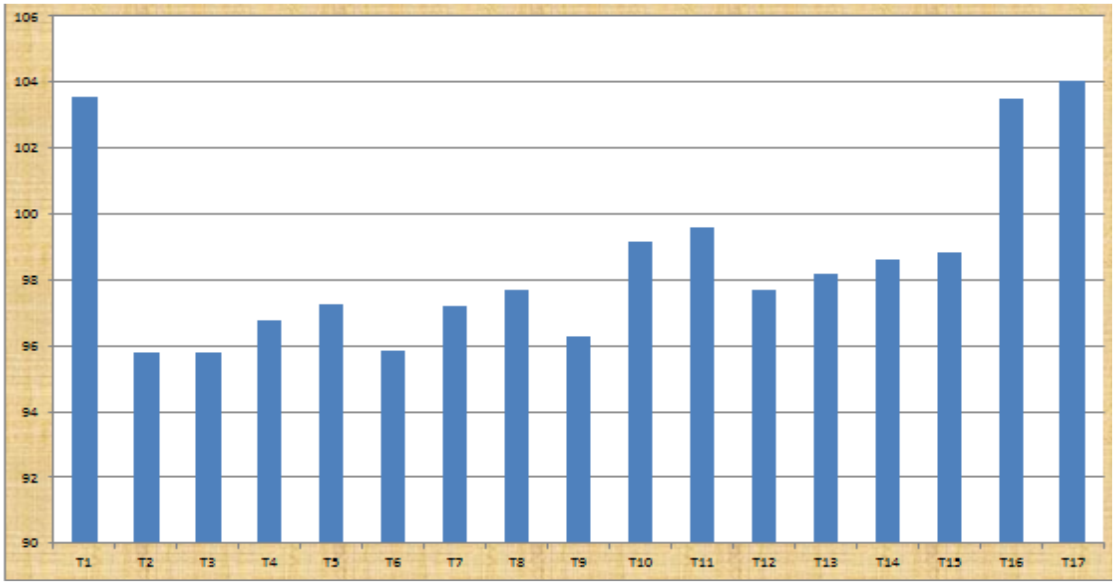

Fig 4: Effect of organic sources of nutrients on days taken to last Picidng

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