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Effect of organic sources of nutrients on n, p & k uptake, available n, p & k and yield of okra [*Abelomoschus esculentus* (L.) Moench] cv. GAO 5

SB Chaudhary, MV Patel, SG More, SS Chaudhary and SS Rabari

Abstract
The results revealed that significantly maximum yield per hectare and the nitrogen, phosphorous and potassium uptake were recorded significantly maximum with treatment of Vermicompost @ 5 t/ha + *Azospirilium* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha (T_{17}). The available Nitrogen, Phosphorous and Potassium were recorded significantly maximum with treatment of FYM @ 20 t/ha + *Azospirilium* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha (T_{16}).

Keywords: Organic source, N, P, K uptake, available, biofertilizers

Introduction
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. Okra requires heavy manuring for its potential production (Naik and Shrinivas, 1992) [6]. 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) [19, 2, 4]. 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, 8]. Organic manures not only balance the nutrient supply but also improve the physical and chemical properties of soil (Nair and Peter, 1990) [7]. 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 nutrition with vegetables is especially important as it provide quality food, which is very important for providing health security to people. Since the vegetables are mostly consumed as fresh or partially cooked, they should be devoid of residual effect of chemical fertilizers.

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 as well as the quality of crop produce. 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 was conducted.

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.

The soil of the field in which experiment was carried out was sandy loam, with good drainage condition. The mechanical and chemical analysis of the soil of field was under taken prior to initiation of the experiment to ascertain the nutritional status of the soil. The result obtained are as follow.

Physico-chemical properties of the experimental soil.

Sr. No.		Properties	Soil depth (15-30 cm)	Method employed
[A]		**Physical**		
	(a)	Sand (%)	75.63	International Pipette method (Piper, 1950)
	(b)	Silt (%)	18.42	
	(c)	Clay (%)	5.72	
	(d)	Textural classes	Sandy loam	
[B]		**Chemical**		
	(a)	Soil pH (1:2.5, soil: water ratio)	7.90	Potentiometric method (Jackson, 1973)
	(b)	Electrical conductivity (dSm^{-1}) (1:2.5, soil: water ratio)	0.27	Schofield method (Jackson, 1973)
	(c)	Organic carbon (%)	0.32	Walklely and Black's rapid titration method (Jackson, 1973)
	(d)	Available N (kg ha^{-1})	196	Alkaline permanganate method (Subbiah and Asija, 1956)
	(e)	Available P_2O_5 (kg ha^{-1})	37	Olsen method (Jackson, 1973)
	(f)	Available K_2O (kg ha^{-1})	82	Flame photometer method (Jackson, 1973)

The ratio of Nitrogen, Phosphorus and Potassium were 0.51:0.25:0.50 and 1.58:0.42:0.56 percentage respectively in FYM and Vermicompost.

The recommended dose of fertilizer is 100-50-50 kg/ha out of which half dose of the nitrogen and full dose of phosphorus and potassium were applied in the form of urea, single super phosphate and murate of potash, respectively. The remaining half dose of nitrogen was applied as top dressing in the form of urea at 30 days after sowing. Well rotten farm yard manure @ 20 t/ha and Vermicompost @ 5 t/ha was incorporated before sowing. 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 mean data were subjected to statistical analysis following analysis of variance technique (Panse, V.G. and Sukhatme, P.V. 1985) [9].

Results and discussion

Nitrogen, phosphorus and potassium uptake

Data presented in Table 1and graphically illustrated in Fig. 1 showed that the effect of organic sources of nutrients on uptake of nitrogen from pod and plant was significantly affected by various treatments. Significantly maximum uptake of N (74.36 kg/ha) 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) which was statistically at par with treatment T_1, T_{10}, T_{11}, T_{14}, T_{15} and T_{16}. Whereas, the minimum uptake of N (57.99 kg/ha) was recorded with treatment T_2 (FYM @ 20 t/ha). A similar result of uptake of nitrogen due to A*zospirillium* was reported in okra (Parvatham *et al.*, 1989) [10] through improving nitrogen availability in the rhizosphere, which facilitates better uptake of nitrogen.

Data presented in Table 1 and graphically illustrated in Fig. 2 showed that the effect of organic sources of nutrients on uptake of phosphorous from pod and plant was significantly affected by various treatments. Statistically maximum uptake of phosphorus (11.72 kg/ha) 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) which was at par with treatment T_1, T_{10}, T_{11}, T_{14}, T_{15} and T_{16}. Whereas, the minimum uptake of P (9.47 kg/ha) was recorded with treatment T_2 (FYM @ 20 t/ha). The reason for better uptake of phosphorus due to biofertilizer inoculation which accelerate enzymatic action of phosphobacter which increased the availability of native and applied phosphorus resulting in better absorption (Rohade and Patil, 1993) [12].

Data presented in Table 1 and graphically illustrated in Fig. 3 showed that the effect of organic sources of nutrients on uptake of potassium from pod and plant was significantly affected by various treatments. Statistically maximum uptake of potassium (53.97 kg/ha) 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) which was at par with treatment T_1, T_5, T_8, T_{10}, T_{11}, T_{12}, T_{13}, T_{14}, T_{15} and T_{16}. Whereas, the minimum uptake of potassium (40.91 kg/ha) was recorded with treatment T_2 (FYM @ 20 t/ha). The maximum uptake of potassium might be due to better root growth of plants with *Azospirillum* and phosphobacter which triggered the mechanism of potassium uptake. Subbiah (1991) [18] also found that application of *Azospirillum* to okra crop had beneficial effect in improvement potassium uptake.

Table 1: Effect of organic sources of nutrients on N, P & K uptake (kg/ha), Available N, P & K (kg/ha) and Yield (Per plant, per plot & per ha)

S. No.	Treatment	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Yield (q/ha)
T_1	Recommended dose of fertilizer (100:50:50 kg NPK/ha)	72.46	11.51	51.58	183.16	32.98	80.58	93.44
T_2	FYM @ 20 t/ha	57.99	9.47	40.91	198.18	40.75	92.04	69.06
T_3	Vermicompost @ 5 t/ha	63.05	9.48	43.24	188.79	36.72	82.70	75.85
T_4	FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha	64.92	9.60	46.47	220.24	41.22	93.22	78.78
T_5	FYM @ 20 t/ha + PSB @ 2.5 l/ha	65.37	9.76	47.76	203.63	44.75	92.64	86.19
T_6	FYM @ 20 t/ha+ KSB @ 2.5 l/ha	63.56	9.52	44.79	200.73	42.19	99.40	76.16
T_7	Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha	65.12	9.74	47.04	201.67	36.39	84.27	80.94
T_8	Vermicompost @ 5 t/ha + PSB @ 2.5 l/ha	65.47	9.79	47.78	193.82	39.12	80.60	86.34
T_9	Vermicompost @ 5 t/ha + KSB @ 2.5 l/ha	64.58	9.54	45.32	189.85	38.07	94.20	77.78
T_{10}	FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha	69.18	10.71	50.08	217.80	45.39	91.84	89.97
T_{11}	Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha	69.55	10.73	50.47	200.80	43.85	83.45	91.13
T_{12}	FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha + KSB @ 2.5 l/ha	65.48	10.00	47.80	221.41	43.19	98.70	86.57
T_{13}	Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + KSB @ 2.5 l/ha	65.78	10.21	48.30	206.52	37.61	94.11	88.81
T_{14}	FYM : 20 t/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha	66.78	10.47	48.65	203.31	45.70	99.95	89.58
T_{15}	Vermicompost @ 5 t/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha	67.62	10.56	49.46	188.75	41.28	91.92	89.80
T_{16}	FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha	71.35	11.18	51.43	222.08	48.51	100.60	93.13
T_{17}	Vermicompost @ 5 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha	74.36	11.72	53.97	208.02	42.94	94.72	101.08
	S.Em. (±)	2.74	0.46	2.28	8.61	2.70	4.80	5.13
	C.D. (P = 0.05)	7.89	1.33	6.57	24.80	7.78	13.83	14.76
	C.V. (%)	7.12	7.82	8.24	7.35	11.35	9.09	10.38

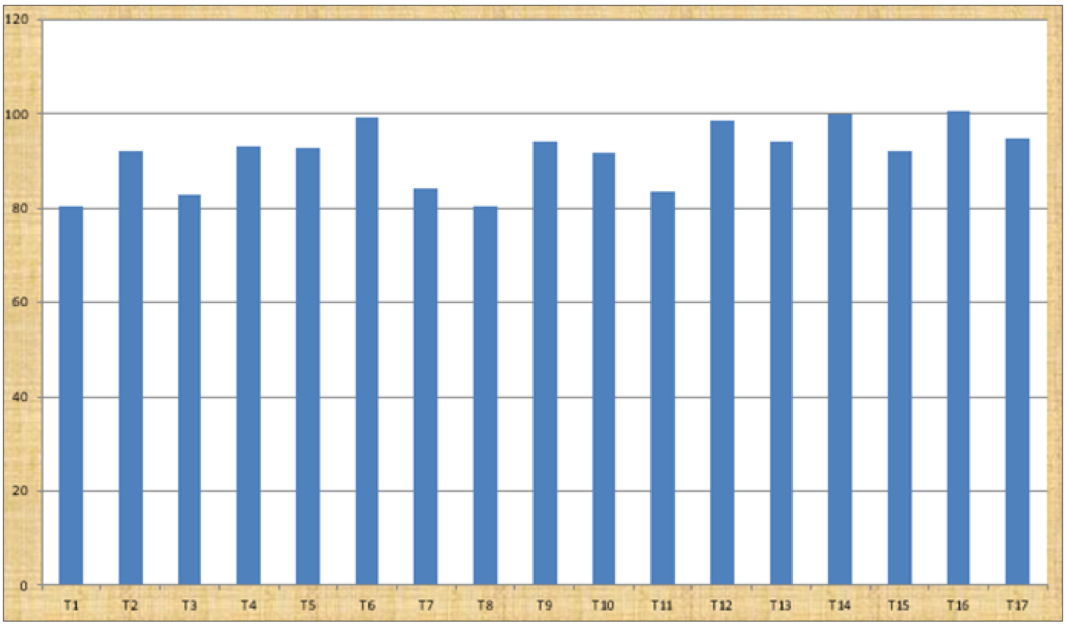

Fig 1: Effect of organic sources of nutrients on nitrogen uptake (kg/ha)

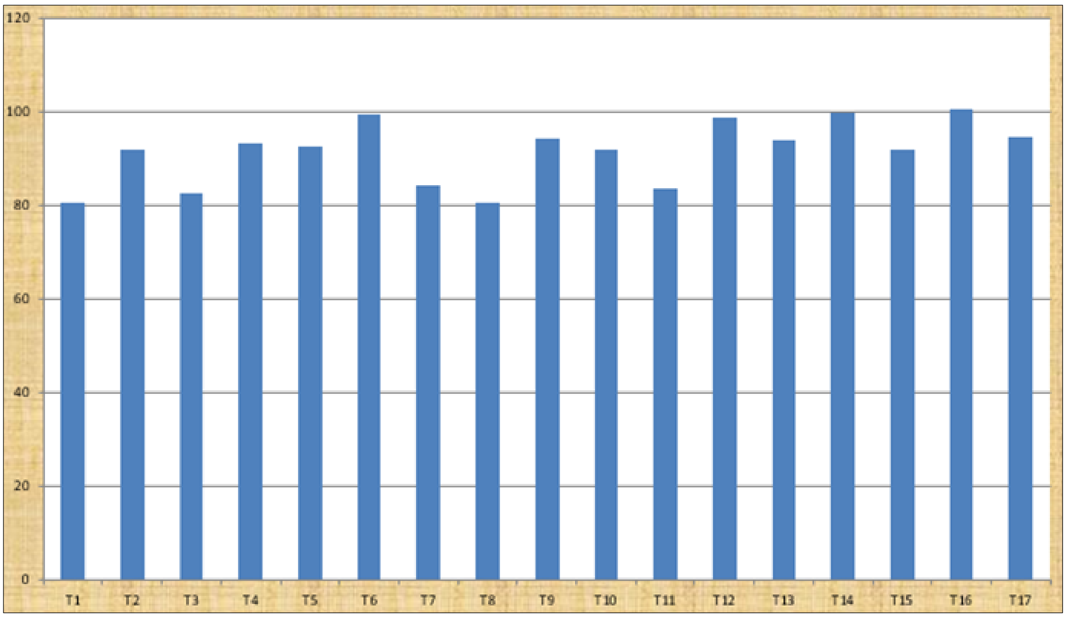

Fig 2: Effect of organic sources of nutrients on phosphorous uptake (kg/ha)

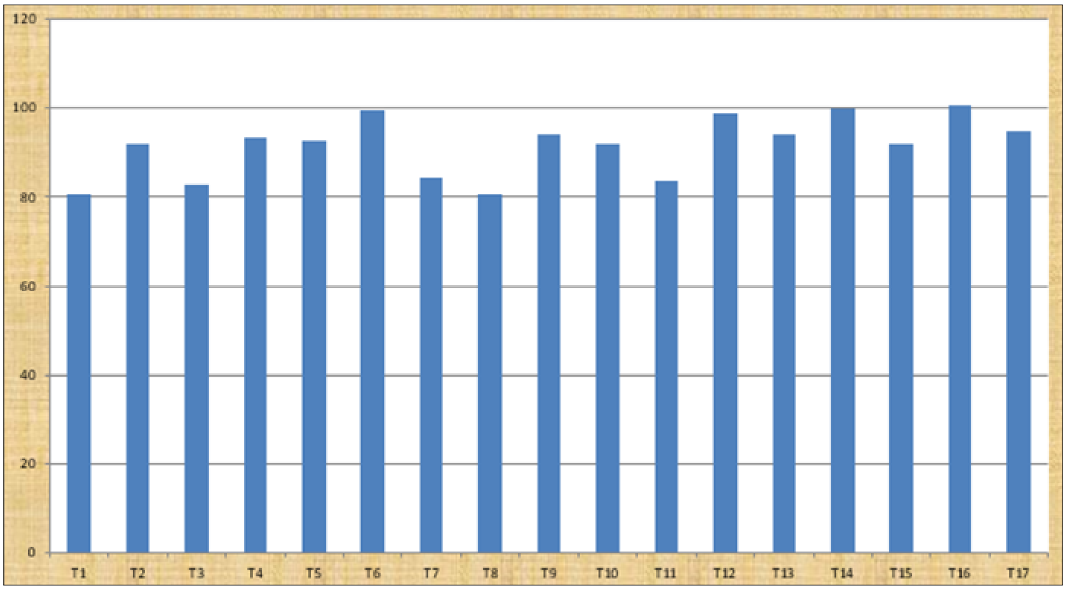

Fig 3: Effect of organic sources of nutrients on potassium uptake (kg/ha)

Soil analysis of nitrogen, phosphorus and potassium

Available nitrogen, phosphorus and potassium from the soil

Data presented in Table 1 and graphically presented in Fig. 4 showed that available nitrogen was significantly influenced by treatments containing various organic sources of nutrients. Statistically maximum available nitrogen (222.08 kg/ha) was found in treatment T_{16} (FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha) which was at par with treatment T_2, T_4, T_5, T_6, T_7, T_{10}, T_{11}, T_{12}, T_{13}, T_{14} and T_{17}. Whereas, the minimum available nitrogen (183.16 kg/ha) was found under treatment T_1 (Recommended dose of fertilizer 100:50:50 kg NPK/ha). Increase in available nitrogen due to better response of addition of organic manures in improving the nitrogen status of soil can be ascribed to its slow decomposition producing humic and amino acids which in turn increases nitrogen availability. Application of organic manure improves the nitrogen status of soil. Increase in available nitrogen with vermicompost or FYM application due to mineralization of nitrogen from organic manures in soil and greater multiplication of soil (Yaduvanshi, 2001) [21] and greater multiplication of soil microbes which could convert organically bound nitrogen to inorganic form (Bhardwaj and Omanwar, 1994) [1]. Enhancement in available nitrogen content of soil with use of organics (Sharma *et al.* 2009) [14]. These results are in conformity with the finding of Bhardwaj and Omanwar (1994) [1] and Sharma *et al.* (2009) [14] in onion.

Data presented in Table 1 and graphically presented in Fig. 5 showed that available phosphorous was significantly influenced by treatments containing various organic sources of nutrients. Statistically maximum available phosphorous (48.51 kg/ha) was found in treatment T_{16} (FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha) which was statistically at par with treatment T_2, T_4, T_5, T_6, T_{10}, T_{11}, T_{12}, T_{14}, T_{15} and T_{17}. Whereas, the minimum available phosphorous (32.98 kg/ha) was found under treatment T_1 (Recommended dose of fertilizer 100:50:50 kg NPK/ha). An increase in available phosphorus content of soil due to the incorporation of organic manures might be attributed to the direct addition of phosphorus as well as solublization of native phosphorus through various organic acids which released during the decomposition of organic matter. Similar results were also observed by Desai *et al*. (2009) [3] in rice and Sharma *et al*. (2005) [16] in French bean.

Data presented in Table 1 and graphically presented in Fig. 6 showed that available potassium was significantly influenced by treatments containing various organic sources of nutrients. Statistically maximum available potassium (100.60 kg/ha) was found in treatment T_{16} (FYM @ 20 t/ha + *Azospirillum* @ 2.5 l/ha + PSB @ 2.5 l/ha + KSB @ 2.5 l/ha) which was at par with treatment T_2, T_4, T_5, T_6, T_9, T_{10}, T_{12}, T_{13}, T_{14}, T_{15} and T_{17}. Whereas, the minimum available potash (80.58 kg/ha) was found under treatment T_1 (Recommended dose of fertilizer 100:50:50 kg NPK/ha). Increase in available potassium due to organic manures application may be attributed to the direct addition of potassium to the soil. The beneficial effect of vermicompost and farm yard manure on available potassium might also be attributed to the reduction in fixation and release of potassium due to interaction of organic matter with clay besides the direct potassium addition to the available potassium pool of soil. These results are in conformity with the finding of Santhy *et al*. (1998) [13] and Sharma *et al*. (2003) [15] in onion.

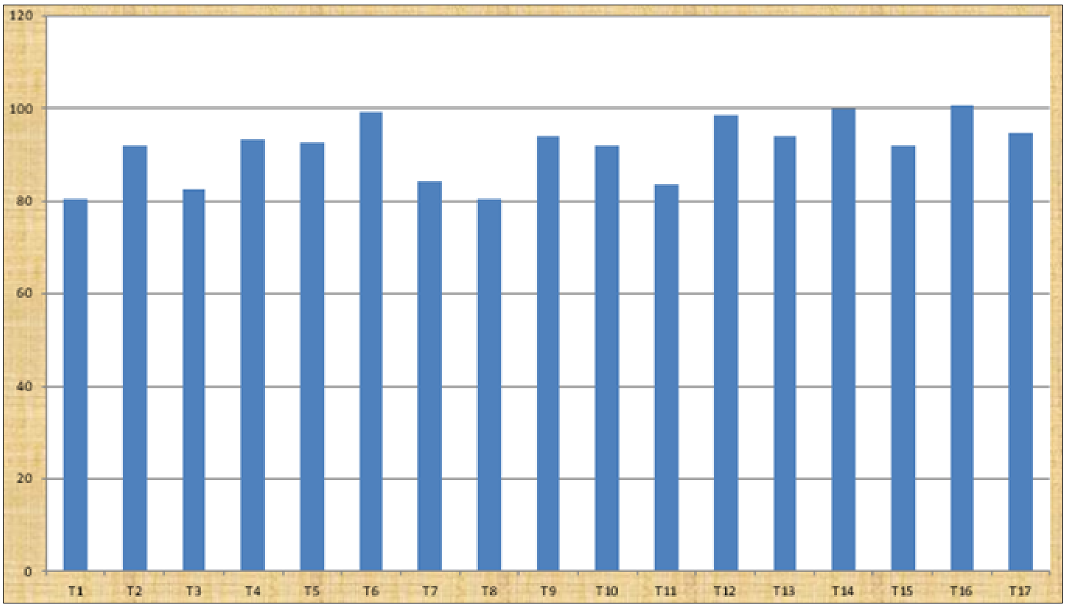

Fig 4: Effect of organic sources of nutrients on available nitrogen from the soil (kg/ha)

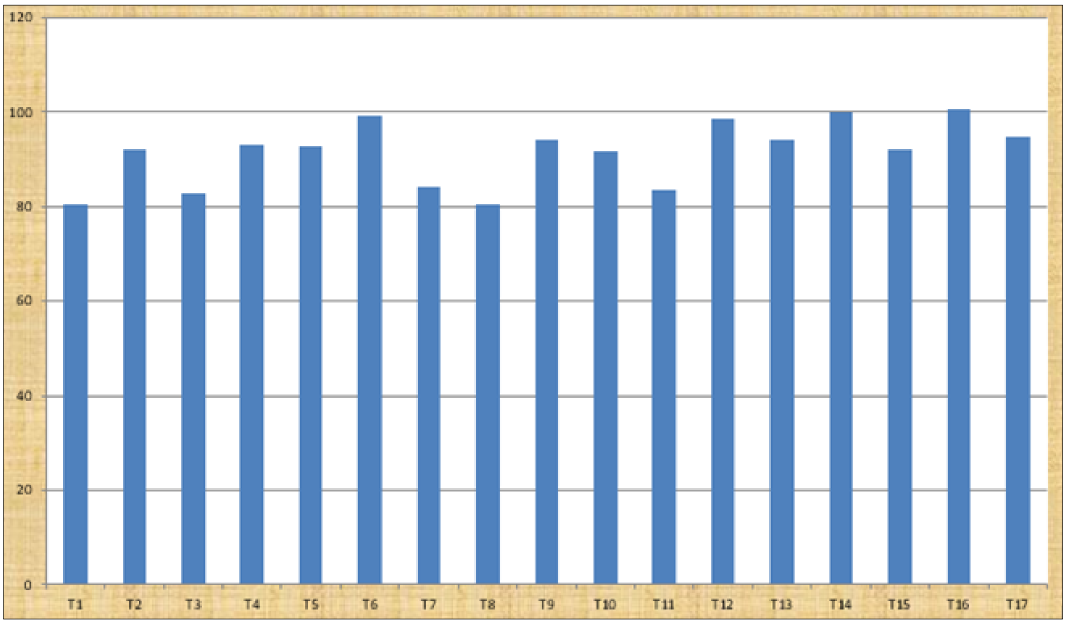

Fig 5: Effect of organic sources of nutrients on available phosphorus from the soil (kg/ha)

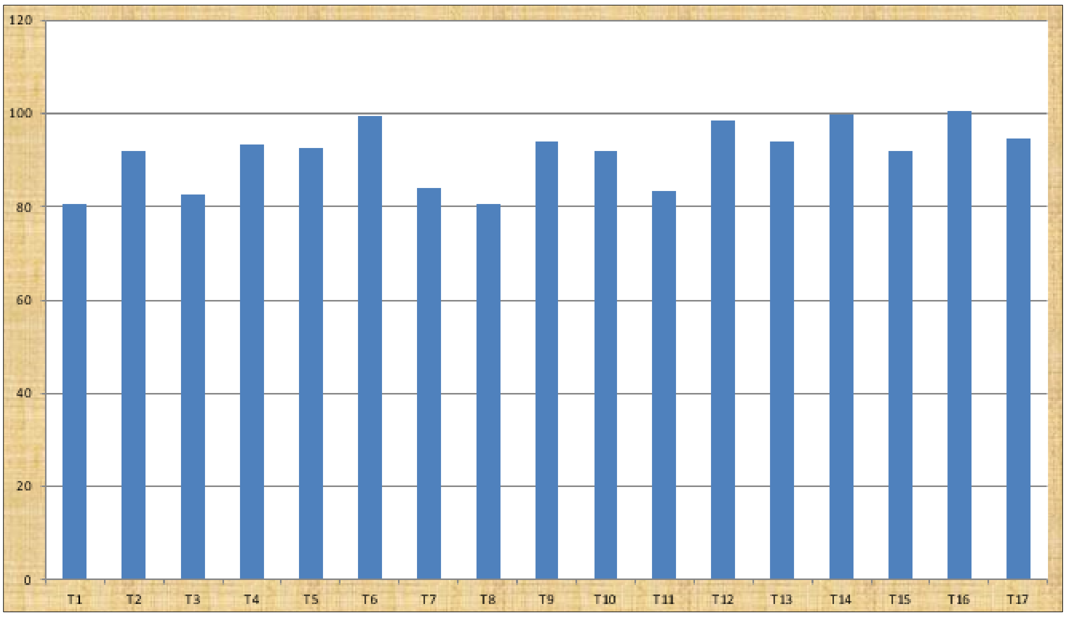

Fig 6: Effect of organic sources of nutrients on available potassium from the soil (kg/ha)

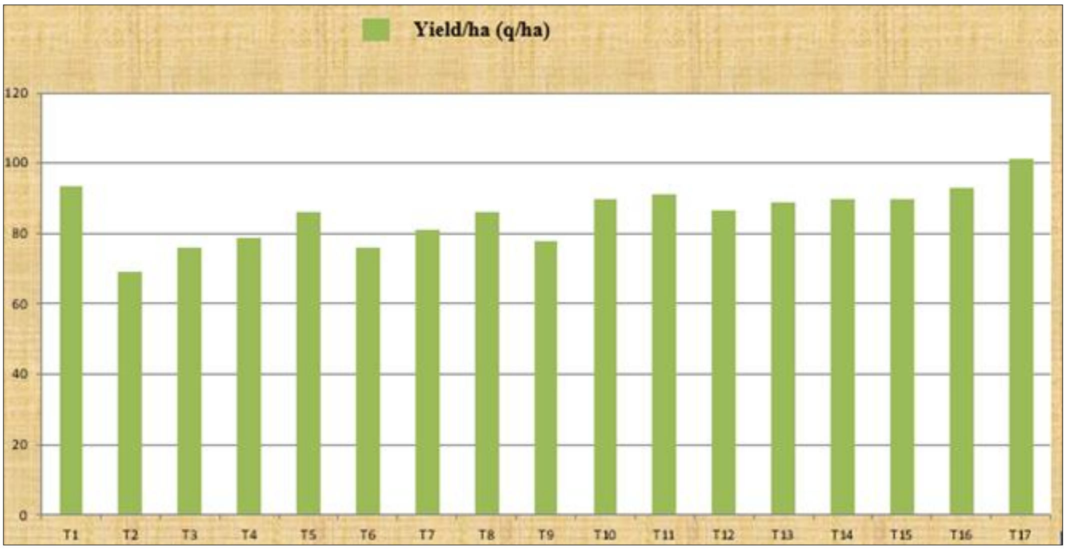

Fig 7: Effect of organic sources of nutrients on yield of okara

Yield per hectare (q)

The mean data on yield of okra are influenced by the effect of organic sources of nutrients which are presented in Table 1 and graphically depicted in Fig.7. Data revealed that the various treatments significantly influenced the yield per hectare (q). 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) which, was statistically at par with T_1, T_8, T_{10}, T_{11}, T_{12}, T_{13}, T_{14}, T_{15} and T_{16}. While, the lowest yield per hectare (69.06 q) was recorded with treatment T_2 (FYM @ 20 t/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) [17] and Tripathy and Maity (2009) [20].

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