Performance of *Abelmoschus esculentus* L. *cv Arka Anamika (IIHR Sel 10)* grown in New Alluvail Region of West Bengal, India with different locally available Organic Manures

Amitava Rakshit

Institute of Agricultural Science, Banaras Hindu University, UP, India
Email: amitavabhu@gmail.com

Abstract

Field experiments were set up in an acid alluvial sandy loam soil to evaluate relative efficacy of organic manures in improving productivity and pest tolerance of an okra crop *cv* Arka Anamika (IIHR Sel 10). Three commercial manures, processed municipality waste (PMW), vermicompost (VC) and oil cake pellets (OCP), were assessed in relation to farmyard manure (FYM) alone and in combination with microbial culture (FYM+MC). All were compared to commercial fertilizer (CF). Among the organic manures tested, FYM produced maximum fruit and shoot yield. The uptake of N, P and K and micro-nutrient in FYM treatment was significantly superior to all other commercial manuring and CF. Increase in fruit yield with FYM application was attributed to higher retentivity of soils for water and nutrients, and higher uptake of major and minor nutrients. However, the tolerance of crop-plants to attack by pests in terms fruit yield was highest in the treatment with FYM. The quantity and the proportion of N, P and K coupled with minor elements available from nutrient sources were mainly responsible for differences among nutrient sources. Varying influence of organic manures on soil properties also caused differences in the performance of nutrient sources.

Keywords: Alluvail soil, Okra, organic manures, fruit yield, and pest

Introduction

Sustainability of agriculture has become a major global concern since the 1980s. Soil organic matter is very important in the functions of soil inasmuch as it is a good indicator of soil quality because it mediates many of the chemical, physical, and biological processes controlling the capacity of a soil to perform successfully. A comparison of cultivated and uncultivated soils has demonstrated a reduction in soil organic matter with cultivation (Mann 1986). Soil organic matter properties (e.g., C:N ratio and macroorganic matter) have been proposed as diagnostic criteria for soil health and performance. However, the importance of organic matter to crop production receives less emphasis, and its proper use in soil management is sometimes neglected or even forgotten. Moreover, understanding nutrient supply or agricultural systems is essential for maintaining long-term productivity.

Among all farming systems, organic farming is gaining wide attention among farmers, entrepreneurs, policy makers and agricultural scientists for varied reasons such as it minimizes the dependence on chemical inputs (fertilizers; pesticides; herbicides and other agro-chemicals) thus safeguards/improves quality of resources, and environment. Organic materials such as compost, animal manures, crop residues and municipal wastes when used as primary sources of plant nutrients, are part of a management system often referred as organic farming. Organic farming is not new to

Indian farming community. Several forms of organic farming are being successfully practiced in diverse climate, particularly in rainfed, tribal, mountains hill and resource poor areas of the country. The food produced through such farming is commonly termed as organic food and is relatively free from toxic residues. Information regarding influence of manures on resistance and tolerance by crop-plants to insect-pests and disease-pathogens is very important to farmers engaged in organic farming. The other concern has been the quality of organic manures, which depends upon the content and availability of N, P, K, and minor elements.

The organic manures show considerable diversity in physical, chemical and biological properties (Fauci *et al*. 1999; Sikora *et al*., 2001) and their efficacy in crop production. Field experiments conducted during 2003 and 2004 aimed at investigating the influence of various organic manures on the performance of okra in an acid alluvial soil.

Materials and Methods

The experiment with okra (*Abelmoschus esculentus* L.) *Var Arka Anamika (IIHR Sel 10)* was conducted during the spring in the year 2003 and 2004 in a farmers plot in new alluvial region of West Bengal, India ($pH_{(H2O)}$ 5.6, organic C 3.9g kg^{-1}, contained 16% clay, 24% silt and 7.3 ppm P (Bray.1). The layout of the experiment followed a split plot design with three replications. The main plots accommodated two levels of pest control i.e., no pest control (NPC) and chemical pest control (CPC), while sub-plots included: processed municipality waste (PMC), vermicompost (VC), oil cake pellets (OCP) all commercial, were assessed in relation to locally available farmyard manure (FYM) and inorganic fertilizer, respectively. Organic manures under different treatments were applied to supply recommended level of 120 kg N ha^{-1} although P and K supplied by them varied depending upon their nutrient composition (Table 1). Chemical fertilizers (CF), were applied at the recommended levels of 120 N, 60 P_2O_5 and 50 K_2O kg ha^{-1}, respectively.

The total quantity of the organic manure treatments was incorporated 15 days before sowing while 25 % of the dose of inorganic fertilizer N and the total dose of P_2O_5 and K_2O were applied basal. The remaining 75 % of inorganic N fertilizer was applied in three equal splits as top dressing at 25, 45, 65 days after sowing.

Observations on pests attack were recorded at fortnightly intervals. For taking observations, each plot was divided into four quadrants of 6 m^2 (3 x 2 m) each. From each quadrant, 10 plants were randomly selected and thoroughly searched for individual insect pests and pathogens attack. Per cent fruits affected by individual insect-pests were then calculated. Fruit yield was recorded randomly for 10 non infested fruits at every picking.

Soil physical properties such as bulk density, (core method) and water retention characteristics (pressure plate apparatus) were determined. Available N, P and K were estimated using standard procedures (Jackson, 1973). To analyze soil for available Fe, Mn, Cu and Zn, diethylene triamine penta acetic acid (DTPA) extraction method was used and estimated using atomic absorption spectrophotometer (AAS) (Piper, 1966).

Plant and fruit samples collected for chemical analysis were properly washed with distilled water and air dried. Thereafter the samples were oven dried at 60 ^oC temperatures and finely ground in a hammer mill. Estimation was done following the method described by (Ranganna 1979).

The data recorded from the field experiments were subjected to statistical analysis using analysis of variance technique described by (Gomez and Gomez 1984). Treatment differences were tested at 5 per cent of significance by F test.

Results

Insects – Pest

Shoot and fruit borer was the major insect-pest attacking and damaging the okra crop. At the final harvest, per cent shoot and fruit borer affected plants as influenced by pest control, nutrient sources and their interaction is presented in (Table 2). Pest control measures had significant influence on suppression of shoot and fruit borer. The per cent of affected plants were significantly lower in chemical pest control (CPC) treatment over no pest control (NPC), a trend that was observed in both the years. Application of chemical fertilizer resulted in significantly higher per cent of affected plants as compared to all treatments with organic nutrient sources except OCP. Suppression of shoot and fruit borer was significantly lower in FYM treatment compared to all commercial manure treatments except VC. The second year also followed similar general trend. The interaction effect of nutrient sources and pest control had significant influence on crop suppression of shoot and fruit borer .It was observed (Table 2) that nutrient sources such as OCP and CF had profound interactive influence while FYM+MC and PMW had an average interactive effect with pest control measure on the per cent affected plants. However, in FYM, VC treatments and UC, the variation observed in per cent affected plants due to attack by borer was small between NPC and CPC as compared to other treatments.

Shoot and Fruit Yield

Both fruit and shoot yield were significantly influenced by pest control measures (Table.3). Significantly higher fruit and shoot yield was recorded in CPC compared to NPC. Fruit yield recorded in UC was lowest and significantly inferior to other nutrient sources. Although shoot yield in CF was lower than in all commercial manures, statistically they were not different. Among the commercial organic sources (PMW, VC & OCP), only PCW was significantly superior in fruit yield compared to CF, while others were at par. FYM treatment was responsible for significantly higher fruit yield compared to commercial nutrient sources and at par with FYM+MC. This trend did not change in the second year.

Interaction effect of pest control and nutrient sources significantly influenced fruit yield although variation in shoot yield was not significant (Table 3). All commercial manures, except OCP showed statistically higher fruit yield compared to CF where pest control measures were not undertaken (NPC), a trend that was similar in the second year. However under CPC, the fruit yield obtained with application of FYM was significantly higher than treatments with all commercial manure except PCW, which was comparable. Fruit yield observed during the first year in OCP and VC and CF were comparable when chemical pest control measures were adopted (CPC), while PMW produced significantly higher fruit yield compared to other commercial manures and CF, in the both years. On comparing FYM and FYM+MC, under NPC fruit yield in FYM was superior to FYM+MC in the first year while it was significantly higher during second year. Although FYM in combination with MC under CPC produced higher fruit yield over FYM alone, it remained statistically comparable during both the years. The fruit yield recorded in certain nutrient sources such as OCP and CF showed profound interactive influence with pest control measures, while FYM+MC and PMW showed moderate interactive. However in FYM, VC and UC the variation in fruit yield between NPC and CPC was small and statistically not different.

Nutrient Uptake

It can be seen from the (Table 4) that pest control and nutrient sources significantly influenced uptake of all major nutrients at maturity, while interaction between pest control and nutrient sources was not significant. N, P and K uptake was significantly higher in CPC over NPC treatment during both the years.

It was observed that uptake of all major nutrients, N, P and K, was significantly lower in UC (Table 4). Among the commercial manures, only PMW showed superior N and P uptake over CF for CPC. However, other commercial manures were at par with CF. Regarding K uptake, CF was at par with OCP but showed significantly lower uptake in comparison to other commercial manures. A comparison of commercial manures with FYM would show that FYM was significantly better in respect to major nutrient uptake compared to commercial manures. However, uptake of N, P and K estimated in FYM+MC was statistically similar with FYM treatment. The trend of N and K uptake was similar in both the years. As regards P uptake, there was no significant difference between VC and CF treatments in the second year.

It can be observed from the (Table 5) that there was significant variation in uptake of Fe, Mn, Cu and Zn due to pest control and nutrient sources. Significantly higher uptake of micronutrients was estimated in CPC treatment over NPC. Uptake of all the micronutrients was significantly lower in UC compared to all others. The Fe and Zn uptake in CF treatment was comparable with OCP while the uptake in treatment with other commercial manures were significantly higher. In terms of Cu uptake, only PCW among commercial manures showed significantly higher uptake compared to CF, while other commercial manure treatments were at par. As regards Mn uptake, all commercial manures showed significantly higher uptake of Mn over CF. Fe and Mn uptake estimated in FYM treatment was significantly higher compared to commercial manures while Cu and Zn uptake was at par with PCW. However, Cu and Zn uptake in other commercial manures was significantly lower than observed in FYM treatment. In the subsequent year, similar general trend was observed.

Nutrient Availability

The availability of N, P and K was significantly higher then the all-commercial manures (Table 6). However, the N availability in FYM was at par with treatments with commercial manures. The availability in FYM and FYM+MC treatments showed that N and K availability was comparable between them while P availability was significantly higher in FYM+MC over FYM alone. As regards micronutrients, Fe and Mn availability was significantly higher in FYM treatment over commercial manure treatments. In the case of Cu availability, FYM was at par with all commercial manures except PCW, which was significantly superior. Zn availability estimated in FYM treatment was observed to be at par with all commercial manures except OCP, which was significantly lower. There was no significance difference in the availability of micro nutrients between FYM and FYM+MC. In the second year, the availability of macro and micronutrients in FYM were comparable with FYM+MC while Zn availability in FYM was significantly higher over commercial manure VC (Table 6).

Soil Properties

The bulk density decreased (Figure 1) in treatments with organic nutrient sources as compared to treatments with CF and UC. The decrease in bulk density following treatments with organic nutrient sources was higher in the second year. Water content in treatments with organic nutrient sources was higher at all metric potentials compared to CF and UC.

Discussion

The shoot and fruit yield of okra. were higher following FYM treatment compared to treatments with commercial manures and CF when chemical pest control measures was adopted. Among the commercial manures, PMW emerged as a potential alternative to FYM as edible fruit yield of okra was statistically comparable between them. All these manures were applied on a recommended N equivalent basis. However, these manures supply different levels of P_2O_5 and K_2O (Table 1) based on their nutrient content. The quantity of P_2O_5 supplied by these different manures ranged from 42.4 to 85.9 Kg ha^{-1} (average of two years). Treatment with VC could provide lowest the P_2O_5 ha^{-1} while OCP treatment provided the highest quantity. With respect to K_2O, FYM provided the highest quantity while OCP supplied the least. The extent of variation among the manures with regard to quantity of K_2O supplied ranged from 36.1 to 117.6 Kg ha^{-1} (average of two years). The differences among the nutrient sources with regard to supply of P_2O_5 and K_2O have possibly contributed to variation in the uptake of phosphorous and potassium by the crops under different treatments (Table 6). Interestingly, the uptake of P and K was not been proportional to the quantity of P_2O_5 and K_2O supplied by different organic manures. Similarly, uptake of N also varied among the treatments of organic manures and CF, although it was applied at same dosage. This indicates that besides differences among the manures with regard to quantity of nutrients supplied by them, there are other factors that can influence uptake of the nutrients. In this investigation, FYM and commercial manures have been incorporated in soil 15 days before sowing of okra. As these manures varied in their C:N ratio may be evident from Table 1, the mineralisation process conclusively proceeded at a different rate which might have contributed to the variation observed among these manures in their N, P and K availability. The free living N fixing bacteria contained in microbial culture added to FYM must have played beneficial role in increasing N availability (Gaur and Ostwal, 1972; Tilak *et al*. 1982). Higher availability of P in FYM treatment is likely to be due to combined effect of release from manure and the effect of release of organic acids on soil minerals (Patiram, 1994;). Apart from faster decomposition, the solublizing action of phospho-bacteria (Alagawadi and Guar, 1992) present in the microbial culture in FYM+MC treatment could have further increased the availability of P which has actually been noticed when compared with application of only FYM. FYM has been reported to be capable of releasing sufficient K in soil (Rao *et al*. 1996) and that may be the reason for continuous supply of K in high amounts.

Okra is grown under upland conditions and thereby soil physical properties have a bearing on the crop performance (Katyal, 1990). Hence, efficacy of manure with respect to okra not only depends upon its ability to meet nutritional demand but also on the influence it exercises on the soil physical environment. In this respect, quantity of manure applied also offers another bearing on its efficacy. Since different manures have been applied in the present experiment on an N equivalent basis, the quantity of FYM and commercial manures applied to okra have shown variation based on their N content (Table1). The manure low in N content therefore is required in large quantities to meet the desired level of N. In this experiment, the different quantities of manures required to supply N has been in the range from 3.1 to 15.2 t ha^{-1} (average of two years) to meet N requirement at a rate of 120 Kg ha^{-1}. Lowest quantity of manure was applied in treatment with OCP, while highest quantity was with FYM in okra. Water holding capacity, (Figure 1) measured in the FYM treated plots indicate a much higher value as compared to measurements from plots treated with commercial manures and CF. Increased water holding capacity becomes responsible for providing higher availability of water to plants (Epstein, 1997). Treatment with FYM has brought about a decrease in bulk density and the reduction has been much higher compared to different treatments with commercial manures (Figure 1). A decrease in bulk density makes easier for plant roots to proliferate and as a consequence, the potential for plants to extract water and nutrients greatly increases (Allison, 1973).

The percentage of affected plants in okra caused by pathogens and pests attack was lower in treatment with FYM compared to treatments with CF and commercial manures except VC, under conditions where pest control measures were not adopted. However, the FYM treatment showed the maximum tolerance to attack by pests and pathogens since edible fruit yield has been highest when pest control measures have not been adopted (Table 2). It was observed that edible fruit yield recorded in different treatments has not been always proportional to the amount of plants that have been affected, inferring that nutrient source having favorable influence on crop resistance may not have similar influence on its tolerance to attack by pathogens and pests as has been similarly reported by (Huber, 1980.)

As regards tolerance, a general pattern has been described (Huber, 1980, 1989 and Graham, 1983) in which plants suffering from mineral nutrient deficiency have lower tolerance to pathogens and pests, which can be increased by supplying the deficient nutrient. The substance known to influence pest activity are wide ranging and include amino acids, sugars, enzymes, phenols, alkaloids etc (Palaniappan and Annadurai, 1999). When nutrients are made available to the crop-plants in required quantity and proportion, these may aid formation of such substances that impart resistance to disease-pathogens and insect-pests. It can be summarized by stating that higher uptake of N, P and K due to their continuous and balanced availability and, ample supply of minor elements resulted not only in better resistance but also higher tolerance to pathogens and pests in okra following application of FYM. Further, slow release of nutrient from FYM has not been able to swing the nutrient balance in favor of N in okra and thereby borer attack remained considerably suppressed.

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Table 1 Quantity of manures applied to okra and nutrients added by them

Manure	Year	Nutrient content of manures (%)			Quantity Applied (t/ha)	Nutrient added (kg/ha)			C:N ratio (avreage of two years)
		N	P	K		N	P_2O_5	K_2O	
PMW	2003	1.15	0.30	0.71	10.4	120	71.2	89.3	9:1
	2004	1.17	0.30	0.70	10.3	120	69.9	86.5	
VC	2003	1.34	0.21	0.96	08.9	120	42.7	103.6	7:1
	2004	1.26	0.19	0.93	09.5	120	41.1	106.7	
OCP	2003	3.84	1.20	0.97	03.1	120	85.2	36.5	5:1
	2004	3.90	1.21	0.97	03.1	120	84.6	35.9	
FYM	2003	0.78	0.19	0.64	15.4	120	66.4	118.6	14:1
	2004	0.80	0.19	0.65	15.0	120	64.8	117.5	

Table 2 Borer affected plants (%) in okra as influenced by pest control (PC), nutrient sources (NS) and their interaction (I)

Treatments	Pest Control (PC)					
	2003			2004		
	NPC	CPC	Mean	NPC	CPC	Mean
Nutrient Sources (NS)						
PMW	44.2	3.62	23.9	38.2	3.08	20.6
VC	19.8	2.66	11.3	21.6	2.42	12.0
OCP	75.3	4.39	39.8	66.0	3.93	34.9
FYM+MC	47.4	3.66	25.5	41.2	3.27	22.2
FYM	28.1	3.04	15.6	24.8	2.78	13.8
CF	61.7	4.13	32.9	55.6	3.76	29.7
UC	17.8	2.21	10.0	16.0	1.86	8.94
Mean	42.1	3.39		37.6	3.01	
	PC	NS	I	PC	NS	I
SEm ±	0.39	1.26	1.78	0.35	1.07	1.52
LSD (0.05)	2.37	3.68	5.20	2.13	3.12	4.44

Table 3 Fruit and shoot yield of okra as influenced by pest control (PC), nutrient sources (NS) and their interaction (I)

Treatments	**Pest Control (PC)**					
	Fruit Yield* ($Mg\ ha^{-1}$)		Mean	Shoot Yield ($Mg\ ha^{-1}$)		Mean
	NPC	CPC		NPC	CPC	
			--------------------2003--------------------			
Nutrient Sources (NS)						
PMW	6.43	8.75	7.59	5.06	5.68	5.37
VC	6.14	7.06	6.60	4.90	5.29	5.10
OCP	4.56	7.69	6.13	4.62	5.59	5.10
FYM+MC	7.14	9.86	8.50	5.91	6.69	6.30
FYM	8.16	9.28	8.72	6.04	6.61	6.33
CF	4.95	7.71	6.33	4.55	5.39	4.97
UC	3.55	4.09	3.82	1.99	2.14	2.06
Mean	5.85	7.78		4.72	5.34	
	PC	NS	I	PC	NS	I
SEm ±	0.15	0.27	0.39	0.06	0.27	0.38
LSD (0.05)	0.92	0.80	1.14	0.38	0.79	NS
			--------------------2004--------------------			
Nutrient Sources (NS)						
PMW	7.16	9.33	8.25	5.43	5.93	5.68
VC	6.44	7.51	6.98	5.20	5.50	5.35
OCP	5.06	8.08	6.57	4.90	5.81	5.36
FYM+MC	8.08	10.8	9.42	6.49	7.16	6.82
FYM	8.95	10.1	9.51	6.58	7.08	6.83
CF	5.08	7.68	6.38	4.66	5.46	5.06
UC	3.42	3.88	3.65	1.94	2.08	2.01
Mean	6.31	8.19		5.03	5.58	
	PC	NS	I	PC	NS	I
SEm ±	0.04	0.28	0.39	0.06	0.24	0.34
LSD (0.05)	0.24	0.82	1.15	0.37	0.70	NS

∗ Borer affected fruits not considered

Table 4 Major nutrients uptake (Kg ha^{-1}) of okra as influenced by pest control (PC), nutrient sources (NS) and their interaction (I)

Treatments	Pest Control (PC)								
	N			P			K		
	NPC	CPC	Mean	NPC	CPC	Mean	NPC	CPC	Mean
				--------------------2003--------------------					
Nutrient Sources (NS)									
PMW	66.4	75.1	70.7	12.1	13.7	12.9	47.2	55.2	51.2
VC	63.2	68.4	65.8	7.8	8.4	8.1	49.3	53.8	51.5
OCP	59.7	72.9	66.3	8.4	10.3	9.4	31.3	40.8	36.1
FYM+MC	78.7	89.7	84.2	16.0	18.2	17.2	64.5	75.6	70.0
FYM	79.4	87.1	83.3	15.8	17.3	16.5	66.5	73.3	70.0
CF	58.4	69.8	64.1	8.0	9.6	8.8	34.0	42.9	38.5
UC	23.5	25.3	24.4	3.0	3.2	3.1	14.7	16.1	15.4
Mean	61.3	69.7		10.2	11.6		43.9	51.1	
	PC	NS	I	PC	NS	I	PC	NS	I
SEm ±	1.1	2.2	3.2	0.2	0.4	0.5	0.6	1.8	2.6
LSD (0.05)	6.8	6.5	NS	1.3	1.2	NS	3.6	5.3	NS
				--------------------2004--------------------					
Nutrient Sources (NS)									
PMW	72.6	79.9	76.2	14.2	15.6	14.9	52.2	59.2	55.7
VC	68.8	73.1	70.9	8.8	9.3	9.0	53.8	58.0	55.9
OCP	64.0	76.5	70.2	9.2	11.0	10.1	33.3	42.2	37.7
FYM+MC	88.6	98.3	93.5	19.5	21.7	20.6	72.6	82.9	77.7
FYM	89.5	96.5	92.9	19.2	20.7	19.9	74.7	81.1	77.9
CF	59.8	70.6	65.2	7.8	9.2	8.5	34.3	42.6	38.5
UC	22.5	24.2	23.4	2.9	3.1	3.0	14.3	15.6	15.00
Mean	66.5	74.2		11.6	13.0		47.9	54.5	
	PC	NS	I	PC	NS	I	PC	NS	I
SEm ±	1.2	2.5	3.4	0.2	0.3	0.5	0.6	1.7	2.4
LSD (0.05)	7.6	7.2	NS	1.3	1.0	NS	3.5	4.9	NS

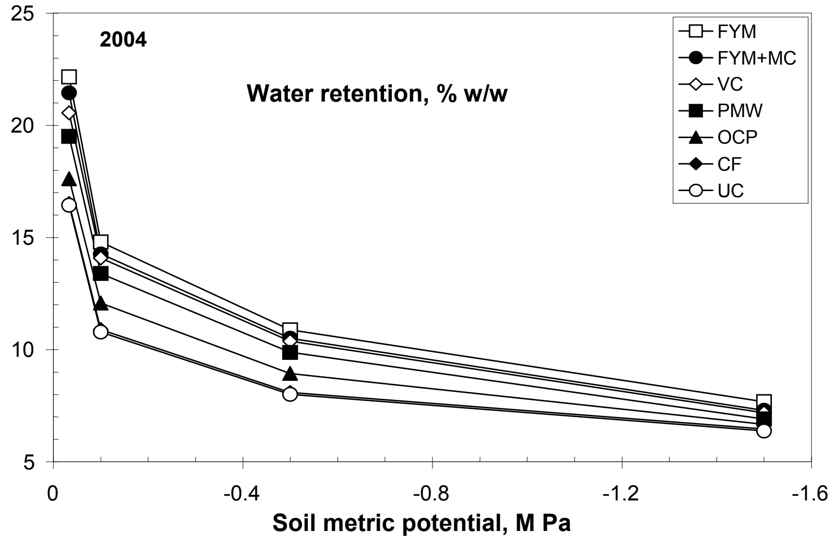
Table 5 Micronutrients uptake (g ha^{-1}) of okra as influenced by pest control and nutrient sources of okra

Treatments	Fe	Mn	Cu	Zn
	--------------------2003--------------------			
Nutrient Sources				
PMW	501	442	60.1	266
VC	412	496	45.1	222
OCP	376	367	42.1	195
FYM+MC	655	646	63.3	276
FYM	665	681	63.8	275
CF	372	307	41.4	187
UC	151	119	17.8	75
SEm ±	13.4	14.9	2.0	7.6
LSD (0.05)	39.1	43.7	5.8	22.2
Pest Control				
NPC	416	410	44.2	199
CPC	479	463	51.1	229
SEm ±	10.2	1.4	0.1	0.3
LSD (0.05)	61.8	8.5	0.4	2.0

	--------------------2004--------------------			
Nutrient Sources				
PMW	531	467	65.6	273
VC	424	532	50.2	243
OCP	380	377	46.3	209
FYM+MC	706	694	72.5	281
FYM	745	694	76.8	285
CF	375	319	42.2	187
UC	155	119	16.6	75
SEm ±	15	17	2.7	9.1
LSD (0.05)	44	49	8.0	26.4
Pest Control				
NPC	441	429	49.0	206
CPC	507	486	56.7	237
SEm ±	10.5	1.7	0.1	0.4
LSD (0.05)	63.6	10.0	0.5	2.7

Table 6 Availability of major (kg ha^{-1}) and minor (g ha^{-1}) nutrients at harvest of okra.

Treatments	N	P	K	Fe	Mn	Cu	Zn
				--------------------2003--------------------			
Nutrient Sources							
PMW	75.5	8.2	48.2	79.8	29.1	2.2	1.8
VC	76.8	4.4	56.6	68.7	30.4	1.8	1.6
OCP	75.0	5.2	40.2	61.1	24.6	1.8	1.4
FYM+MC	78.1	12.8	64.2	84.5	34.9	1.9	1.7
FYM	79.5	11.3	67.5	89.3	35.1	1.9	1.7
CF	70.5	4.6	29.0	56.1	24.3	1.6	1.2
UC	55.8	3.4	26.8	58.0	24.4	1.6	1.2
SEm ±	2.3	0.3	2.0	2.4	1.0	0.1	0.1
LSD (0.05)	6.8	0.8	5.8	6.9	2.9	0.2	0.2
Pest Control							
NPC	74.6	7.4	49.0	71.6	30.2	1.9	1.5
CPC	71.4	6.9	46.00	70.6	27.8	1.7	1.5
SEm ±	1.5	0.1	0.8	1.5	0.5	0.03	0.03
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS
				--------------------2004--------------------			
Nutrient Sources							
PMW	78.2	9.8	51.2	88.5	32.5	2.5	2.2
VC	81.2	4.9	60.7	71.6	34.2	1.9	1.8
OCP	77.7	5.6	41.5	63.0	26.1	1.8	1.6
FYM+MC	81.8	15.7	69.3	101.4	39.2	2.0	2.0
FYM	83.2	14.9	74.1	105.2	39.1	2.0	2.0
CF	70.8	4.3	27.5	55.0	24.1	1.5	1.2
UC	52.3	3.2	24.1	57.1	24.1	1.6	1.22
SEm ±	2.8	0.3	1.7	2.9	1.2	0.1	0.1
LSD (0.05)	7.3	0.9	4.9	8.6	3.4	0.2	0.2
Pest Control							
NPC	77.2	8.7	51.2	79.0	32.7	2.0	1.8
CPC	72.9	8.0	48.3	75.8	30.0	1.8	1.6
SEm ±	1.7	0.14	0.7	1.8	0.65	0.03	0.04
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS



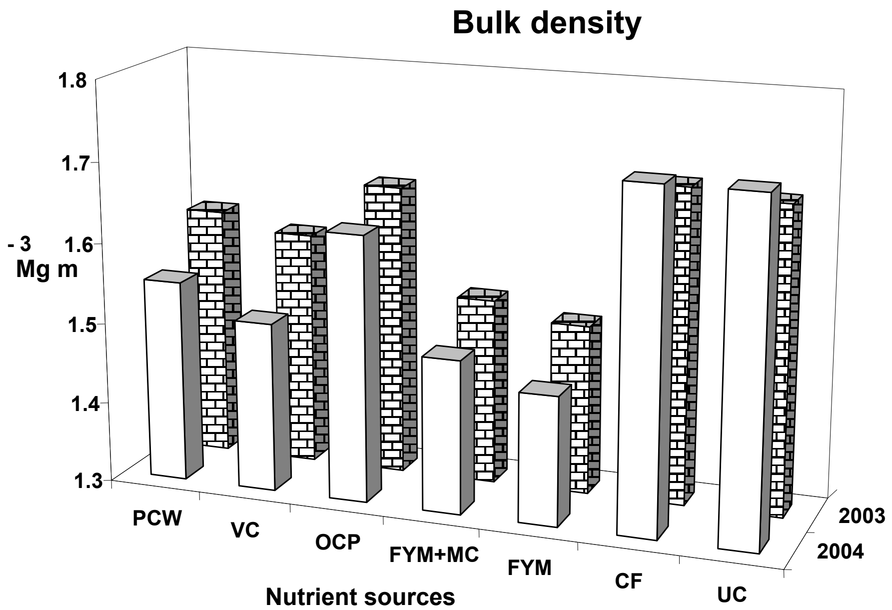


Figure 1. Water retention characteristics and bulk density of soil at harvest of okra as influenced by nutrient sources.