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Effect of different organic materials with fly ash in integrated plant nutrient system for groundnut (*Arachis hypogaea*)

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ABSTRACT

An investigation was carried out during the dry season (February – May) of 1996 and 1997 at the Indian Institute of Technology, Kharagpur, to study the effect of paper factory sludge and fly ash on groundnut (*Arachis hypogaea* L.) and to find out their suitable time of incorporation in acid lateritic soils. Paper factory sludge along with fly ash and chemical fertilizers increased the dry matter accumulation, leaf area index and nodule number/ plant compared to farmyard manure and their combination along with fly ash and chemical fertilizers. The beneficial effect was also recorded in yield attributes, yield, oil content in kernel, nutrient uptake and chemical properties of soil. Their incorporation at 15 days before sowing or at sowing was more advantageous than that at 30 days before sowing.

Key words : Paper factory sludge, Fly ash, Farmyard manure, Groundnut, Chemical fertilizers, Nutrient uptake, Oil content

Groundnut seems to be a promising crop with dual advantage of meeting the increasing demand of oilseeds and restoring soil fertility. Like any other crop, the productivity of groundnut in acid lateritic soil is very low which can be raised through integrated nutrient management combining organic source, liming material (an amendment) and chemical fertilizers. Some of the industrial wastes like paper factory sludge and alkaline fly ash have the potentiality to enrich and amend the soil (Sajwan, 1995). These industrial wastes should be incorporated into the soil while performing tillage before sowing to ensure benefits with no deleterious effects which mainly depends on C:N ratio of the materials and time of incorporation. As adequate information on relative efficiency of these materials under aerated condition of soil is lacking, the present investigation was conducted under field condition to study the effect of industrial wastes and their time of incorporation on groundnut.

MATERIALS AND METHODS

A field experiment was conducted at the Agricultural and Food Engineering Department, Indian Institute of Technology, Kharagpur, during dry season (February - May) of 1996 and 1997. A bunch type groundnut variety 'JL 24' was grown on acid lateritic sandy clay-loam soil (pH 5.38), tested low in organic carbon (0.34%), available N (165.9 kg/ha), available P (15.1 kg/ha) and medium in available K (129.4 kg/ha). The climate of the region is warm and humid with an average annual rainfall of 1,400 mm. The industrial wastes, viz. paper factory sludge (PFS) and fly ash (FA), were used in the experiment and farmyard manure (FYM) was taken for comparison. The PFS (pH 5.87, 21.60% organic carbon, 1.17 % N, 0.37% P, 0.76% K, 0.19% Ca and 140.7 ppm Zn), FYM (pH 5.76, 19.67% organic carbon, 0.76% N, 0.14 % P, 0.40 % K, 0.15% Ca and 335.7 ppm Zn) and their combinations, were applied @ 15 kg N/ha along with FA (pH 8.5, 0.34% organic carbon, 0.05% N, 0.03 % P, 0.18% K, 0.42% Ca and 25.1 ppm Zn) @ 10 tonnes/ha. A recommended and uniform dose @ 30 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha was maintained through these materials and chemical fertilizers (CF). Three dates were chosen for incorporation of the materials, viz. 30 days before sowing (DBS), 15 DBS and at sowing. The sources of chemical fertilizers for N, P_2O_5 and K_2O were urea, single superphosphate and muriate of potash, respectively. The experiment was laid out in factorial randomized complete-block design with 3 replications.

The oil content in kernel was estimated by solvent extraction method using Soxtherm apparatus. The concentration of nutrients (N,P,K, Ca and Zn) for plant kernel and shell was determined separately and total uptake of nutri-

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ents was calculated accordingly.

RESULTS AND DISCUSSION

Yield components

The pods/plant, seeds/pod, 100-kernel weight and shelling percentage were influenced significantly either by the fertilization sources or their time of incorporation or by both (Table 1). The pods/plant, kernels/pod and 100-kernel weight were influenced significantly by the time of application but shelling percentage remained unaffected. Kernels/pod were not affected by the fertilization treatments, whereas the other 3 yield components were significantly higher under PFS+ FA + CF treatment compared with the remaining treatments. The beneficial effect of the integrated sources of fertilization was greater when fertilization sources were applied at sowing or at 15 DBS. Adequate supply of nutrients during the growth period of crop increased the dry matter accumulation which resulted an increase in yield attributes as also evident from significant positive correlation between dry matter accumulation and nutrient uptake (r=0.71**, r=0.86** and r=0.86** for N, P and K uptake respectively).

Yield

The pod and haulm yields increased significantly when the organic sources and FA were applied at sowing or at 15 DBS compared with their application at 30 DBS in both the years (Table 2). In order to meet plant nutritional requirements, both organic and chemical sources were applied. From these sources, the nutrients were utilized depending on the availability of nutrients. Incorporation of partly decomposed organic sources at sowing or at 15 DBS supplied higher available nutrients at the active crop-growth period than that at 30 DBS. This led to adequate uptake of nutrients at the active growth stage increased dry matter production, which ultimately reflected in yield. Among the fertilization sources, the yield was higher under treatment PFS along with FA and CF than the rest. This was certainly because of favourable condition created by PFS (Cabral and Vasconcelos, 1993). To maintain 30 kg N/ha from organic materials, PFS of lower N content was required in higher quantity than FYM of higher N content. An application of PFS in higher amount than FYM reduces bulk density of the soil (George *et al.*, 1998) which was congenial for pegging. Besides, the soil

Table 1. Effect of fertilization sources and their time of application on yield components and oil content of groundnut (mean data of 2 years)

Treatment	Pods/ plant	Kernels/ pod	100 kernel weight (g)	Shelling %	Oil content (%)
Fertilization source					
FYM+FA+CF	15.3	1.85	45.28	66.81	49.67
PFS+FA+CF	17.2	1.87	47.50	69.29	47.59
FYM+PFS+FA+CF	15.1	1.86	46.43	66.84	46.44
CD (P=0.05)	0.34	NS	1.73	1.03	0.25
Time of application					
At sowing	16.3	1.89	47.05	68.33	46.80
At 15 days before sowing	15.3	1.84	45.52	67.30	47.81
At 30 days before sowing	15.9	1.85	46.64	67.31	46.08
CD (P=0.05)	0.34	0.02	1.44	NS	0.25

FYM, Farmyard manure; FA, fly ash; CF, chemical fertilizers; PFS, paper factory sludge

Table 2. Effect of different fertilization sources and their time of application on pod and haulm yield (q/ha) of groundnut (mean data of 2 years)

Fertilization source (F)	Pod yield D_1	Pod yield D_2	Pod yield D_3	Pod yield Mean	Haulm yield D_1	Haulm yield D_2	Haulm yield D_3	Haulm yield Mean
FYM+FA+CF	25.73	27.07	23.85	25.55	43.78	45.85	40.45	43.36
PFS+FA+CF	27.70	28.60	25.19	27.16	47.48	49.34	42.48	46.43
FYM +PFS+FA+CF	25.27	24.75	27.34	25.79	43.37	42.93	46.55	44.28
Mean	26.23	26.81	25.46		44.88	46.04	43.16	
	F and D		*F × D*		*F and D*		*F × D*	
CD (P=0.05)	0.93		1.62		1.68		2.92	

FYM, Farmyard manure; FA, fly ash; CF, Chemical fertilizers
D_1, at sowing; D_2, 15 days before sowing; D_3, 30 days before sowing

was enriched with Ca which was 90 kg/ha more than that added by FYM resulting increase in yield of high Ca-requirement bunch type groundnut crop. In the interaction effect, it was noted that the yield increased under PFS or FYM along with FA and chemical fertilizers when they were applied at 15 DBS or at sowing as compared to 30 DBS, whereas, the trend was opposite when they were applied together. This was primarily due to the added advantage of PFS having high acid neutralizing capacity (Panda, 1998). As a result, a congenial condition was created in the acid soil for the useful soil microbes resulting less loss and more utilization of nutrients by groundnut from the decomposed organic sources applied at sowing or at 15 DBS than that at 30 DBS.

Oil content

The oil content of kernel was higher under the integrated nutrient supply through PFS+ FA+CF than FYM+FA+CF or FYM+ PFS+FA+CF (Table 1). The content of Zn in PFS (335.7 ppm) was much higher than FYM (140.7 ppm). Moreover, the former was applied in larger quantity than the latter. As a result, the greater availability of Zn in the soil increased uptake of Zn in the kernel. Since Zn is considered to be essential for the activity of dehydrogenase enzyme and $NADH^+$ related with the fat synthesis, any increase in Zn uptake obviously increased the oil content in the kernel. Beneficial effect of Zn in increasing the lipids in groundnut has also been reported by Nayyar *et al.* (1990). The superiority of PFS over FYM in increasing oil content of the kernel was thus attributed by the enrichment of the soil particularly with Zn.

Nutrient uptake

Fertilization sources and their time of application significantly influenced the uptake of N, P, K, Ca and Zn (Table 3). The highest uptake of all the nutrients was recorded where paper factory sludge was applied along with fly ash and chemical fertilizers. The results are in close conformity with the findings of Panda (1998). The nutrient uptake for N, P, K, Ca and Zn was recorded higher under the application of the nutrient sources at 15 days before sowing over the application at 30 days before sowing but at par with the application at sowing. Significantly highest P uptake was recorded when fertilization sources applied at 15 days before sowing.

Residual fertility

The changes in chemical properties of soil (0–15 cm) after harvest of crop as affected by different nutrient sources and their time of application are given in Table 3. An increase in the pH (5.38–5.79) and organic carbon content (0.34-0.49%) was recorded due to addition of PFS along with fly ash and chemical fertilizer compared with the rest. Maximum gain in the available N (165.9–218.7 kg ha), P(15.1–22.2 kg/ha) and K (129.4–139.2 kg/ha) was also recorded there. The increase in residual fertility was mainly owing to increase in soil pH and carryover effect of paper factory sludge which added a large quantity of nutrients benefiting crop growth. Sajwan (1995) also observed such beneficial effect. Application of organic source along with fly ash at 15 days before sowing recorded the highest increase in pH, organic carbon and available N, P and K content of soil.

It may be concluded that paper factory sludge along with fly ash could be applied to improve the productivity of acid lateritic soil. These industrial wastes proved helpful in increasing yield and quality of groundnut when incorporated into the soil up to 15 days in advance of sowing. Incorporation of these materials 15 days before sow-

Table 3. Effect of different fertilization sources and their time of application on uptake of nutrients (kg/ha) by groundnut and on pH, organic carbon content (%) and available nutrient status (kg/ha) of soil after harvest (mean data of 2 years)

Treatment	Uptake of nutrients					Soil	OC	Available nutrient status		
	N	P	K	Ca	Zn	pH		N	P	K
Fertilization source										
FYM+FA+FC	188.23	15.32	34.25	62.46	168.23	5.71	0.42	214.2	18.3	135.6
PFS+FA+CF	197.71	16.41	36.71	67.41	180.64	5.79	0.49	218.7	22.1	139.2
FYM+PFS+FA+CF	189.66	15.53	34.68	63.08	170.82	5.73	0.44	215.1	19.5	138.3
CD (P=0.05)	5.85	0.48	1.02	2.17	5.11					
Time of application										
At sowing	193.20	15.72	35.36	64.33	174.38	5.81	0.45	216.3	18.5	137.2
At 15 days before sowing	196.45	16.28	36.18	65.94	177.81	5.76	0.48	219.2	21.9	139.9
At 30 days before sowing	186.96	15.25	34.11	62.04	167.53	5.66	0.41	212.5	19.7	136.0
CD (P=0.05)	5.85	0.48	1.02	2.17	5.11	*	*	*	*	*

*Initial soil pH, 5.38; organic carbon (OC), 0.33; N, 165.9; P, 15.1, K, 129.4

FYM, Farmyard manure; FA, fly ash; CF, chemical fertilizers; PFS, paper factory sludge ing of groundnut had an added advantage as compared to sowing for operational convenience.

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