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Role of Soil Amendments in Improving Groundnut Productivity of Acid Lateritic Soils

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Abstract: The present field experiment was conducted in sandy loam acid lateritic soil to study the effect of Fly Ash (FA), organic wastes like farmyard manure (FYM), vermicompost (VC) and green manure (*Sesbania rostrata*) (GM) and chemical fertilizers on growth and yield of groundnut during rainy season. A uniform fertilizer dose of 20:40:40 kg N:P:K ha^{-1} was maintained through CF alone or through CF+organic wastes by supplementing 50% of N dose. Nine treatment combinations were tested under completely randomized block design. Application of organic wastes in combination with CF recorded better growth and yield as compared to sole application of CF. Among three organic sources of nutrients GM showed superior performance of the crop over FYM and VC. Integrated application of FA, organic wastes and chemical fertilizers increased the pod yield to the extent of 24.7% over sole application of CF.

Key words: Groundnut, fly ash, organic wastes, chemical fertilizers, acid soil

Introduction

Although India is steadily progressing in oilseeds production, but the average yields of most oilseeds are still extremely low when compared to those prevailing in other countries of the world. This is because oilseeds are cultivated mostly in marginal and sub-marginal land of semi-arid areas with no or very less management, hence remain vulnerable to vagaries of nature. Among all the oilseed crops, groundnut (*Arachis hypogaea* L.) has the first place in India accounting for more than 28% acreage and 32% production in the country (Anonymous, 2004). The physical condition of acid lateritic soils is congenial for groundnut cultivation but, the lack of response by the crop to normal fertilization and cultural practices has been ascribed to the toxic presence of exchangeable Al, low level of Ca and Mg (Coleman and Thomas, 1967) and poor nodulation due to low pH of the soil. Therefore raising the soil pH will create favorable condition for growth of the crop. Recent research has shown that use of fly ash as liming agent in acid soils may improve soil properties and increase crop yield (Matsi and Keramidas, 1999). Moreover, fly ash contains all the essential elements (except N) including P, K, Ca, Mg. S, Fe, Mn, Zn, Cu, Co, B and Mo (Kumar *et al*., 2000; Jala and Goyal, 2006). The lateritic soils being low organic carbon and available nutrient content require supply of essential nutrients through the organic sources.

Therefore the present investigation was undertaken to study the effect of fly ash, organic manures and chemical fertilizers on growth and yield of groundnut in acid lateritic soil.

Materials and Methods

Treatments

A field experiment was conducted for two years (2003-04 and 2004-05) with groundnut (variety AK 12-24) at the experimental farm of Indian Institute of Technology, Kharagpur, India. The

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Table 1: Physical and chemical properties of experimental soil and fly ash

Particulars	Soil	Fly ash
Particle size distribution		
Sand (%)	60.25	40.51
Silt (%)	22.65	49.29
Clay (%)	17.10	11.20
Bulk density (Mg/cu. m)	1.64	0.92
Soil reaction (pH)	5.39	8.28
Organic carbon (%)	0.29	0.31
Total N (%)	0.42	0.05
Total P (%)	0.25	0.29
Total K (%)	0.57	0.48
Available N (g kg^{-1} of soil)	74.82	16.20
Available P (g kg^{-1} of soil)	6.09	45.30
Available K (g kg^{-1} of soil)	47.81	69.30

climate of this region is warm humid and the soil is acid lateritic with a sandy loam texture. Coal fly ash was obtained from Kolaghat Thermal Power Plant, West Bengal, India produced through combustion of pulverized bituminous coal. The physical and chemical properties of the test soil and fly ash are presented in Table 1. Fly ash was applied at the rate of 10 t ha^{-1}. Farmyard manure (FYM), vermicompost (VC) and Green Manure (GM), *Sesbania rostrata* were used as organic nutrient sources. A uniform fertilizer dose of 20:40:40 kg N:P:K ha^{-1} was maintained in all the treatments (except control) through chemical fertilizers and organic wastes. Half of the dose of N was supplemented by the organic wastes. Rest 50% N and balanced amount of P and K was applied through CF. All together nine treatments viz., 1. CF; 2. FA+CF; 3. VC+CF; 4. VC+FA+CF; 5. FYM+CF; 6. FYM+FA+CF; 7. GM+CF; 8. GM+FA+CF and 9. Control were arranged in a Complete Randomized Block Design (CRBD) with three replications. The plant of *Sesabnia rostrata* (GM) was chopped manually to 3-4 cm sizes before application while dust form of VC and FYM were applied to the field 15 days before sowing of groundnut. The crop was sown in first week of July with the onset of monsoon at a spacing of 30 cm by 10 cm between rows and plants, respectively. The necessary management practices were followed during crop growth. Earthing up was done two times at 30 and 60 Days After Sowing (DAS). The field was kept weed free. Remarkable incidence of pests and diseases were not found. Harvesting was done in first week of November. Data were recorded on different growth parameters like Leaf Area Index (LAI), dry matter production (g m^{-2}) and number of nodules per plant of groundnut at 50 DAS. At the time of harvest data on various yield components like number of pods per plant, number of kernels per pod and 100 kernel weight (g) and pod yield (kg ha^{-1}) were collected for analysis. Pooled mean data of two years has been presented here.

Chemical Analysis of Soil

For soil chemical analysis, samples were collected from 20 cm soil depth at random from different locations within each plot before starting of experiments. The samples were air-dried in shade, ground in a pestle and mortar and passed through a 2 mm sieve. Estimation of the pH, organic carbon and available N, P and K contents of the soil were done using a glass electrode, Walkley and Black method, Kjeldahl distillation, NH_4F extraction and NH_4OAc extraction methods, respectively (Jackson, 1973).

Statistical Analysis

The recorded data were analyzed with the help of analysis of variance (ANOVA) for Completely Randomized Block Design (CRBD). Least Significant Differences (LSD) were conducted at a 5% level of probability, where significance was indicated by F-test (Gomez and Gomez, 1984).

Results and Discussion

Effect of Nutrient Sources on Growth of Groundnut

It is apparent from Table 2 that all the fertilizer treatments influenced the growth parameters like Leaf Area Index (LAI), dry matter production (g m^{-2}) and number of nodules per plant of groundnut

Table 2: Effect of different nutrient sources on growth parameters of groundnut at 50 DAS (Pooled mean of two years)

Treatments	Leaf Area Index (LAI)	Number of nodules $plant^{-1}$	Dry matter ($g\ m^{-2}$)
CF	3.19	64.33	320.87
FA+CF	3.39	66.57	339.32
VC+CF	3.35	68.33	345.12
FA+VC+CF	3.54	74.19	366.15
FYM+CF	3.41	70.78	349.33
FA+FYM+CF	3.65	79.36	376.48
GM+CF	3.49	72.89	356.25
FA+GM+CF	3.87	82.69	415.13
Control	2.55	45.56	241.15
LSD (p = 0.05)	0.15	4.68	17.45

CF = Chemical Fertilizer; FA = Fly Ash; VC = Vermicompost; FYM = Farmyard manure; GM = Green Manure (*Sesbania rostrata*); LSD = Least Significant Difference

at 50 DAS. Application of VC+CF, FYM+CF and GM+CF resulted in significantly higher dry matter as compared to CF alone and the increment was 7.6, 8.9 and 11.0%, respectively. For LAI the values were 5.0, 6.9 and 9.4%, respectively. GM was more effective in promoting the growth of groundnut as compared to VC or FYM. This might be due to variation in decomposition rates of different organic wastes. Decomposition of added materials depends on its chemical constitutes and physical and biochemical conditions in the surrounding environment (Subba Rao, 1988). The C:N ratio of organic materials greatly influences the rate at which they are decomposed (Mahmoud and El-Sawy, 1982). Lower C:N ratio of GM (17:1) as compared to FYM (27:1) or VC (45:1) might had been responsible for its faster decomposition and effective supply of nutrients to the crop after incorporation in the soil. The mineralization of humified FYM and composts is known to be slow and steady process that makes them to act as slow release fertilizer. Kumada (1977) examined several kinds of organic material and observed that materials with C:N ratio below 20 did not immobilize N. Application of FA along with CF+organic sources further improved the growth over CF and CF+organic wastes and the differences were 20.3 and 9.2%, respectively. This might be due to the fact that FA contains essential macro nutrients including P, K, Ca, Mg and S and micronutrients like Fe, Mn, Zn, Cu, Co, B and Mo (Adriano *et al*., 1980). Therefore application of FA supplied all essential nutrients to groundnut and thereby improved the dry matter production. Moreover, FA increased the mineralization of organic manures (Menon *et al*., 1990) and thus combined application of both, enhanced the availability of nutrients. Beneficial effect of FA on growth of groundnut was also reported by Khan and Khan, (1996) and Basu *et al*. (2006). The LAI and nodule number per plant followed the same trend as dry matter production. Higher nodule number was observed in FA+organic wastes+CF treated plots as compared to sole CF applied plots. Increased population of *Rhizobium* sp. under the soil amended with either farmyard manure or fly ash individually or in combination was also reported by Sen (1997).

Effect of Nutrient Sources on Yield Components and Yield of Groundnut

Different fertilizer sources applied to groundnut significantly influenced the yield components like number of pods per plant, number of kernels per pod and 100 kernel weight (g) and pod yield (kg ha^{-1}) over control (Table 3). Combined application of CF and organic wastes resulted higher pod yield as compared to CF alone or control. Among three different organic wastes GM based treatments showed better performance than that of FYM or VC based treatments. CF+GM recorded 3.1 and 7.3% higher yield as compared to CF+FYM and CF+VC. FA+CF recorded significantly higher yield as compared to CF alone but it was statistically at par with VC+CF. The integrated fertilization treatments involving FA, organic wastes and CF were superior to CF or CF+organic wastes or CF+FA. The average increase in pod yield under FA+organic wastes+CF over CF varied from 16.8% under FA+VC+CF to 24.7% under FA+GM+CF. However, there was no significant difference between FA+FYM+CF and FA+GM+CF. Being alkaline in nature FA improves the pH of the soil and thereby facilitates the availability of P, K, Ca and Mg (Khan and Khan, 1996; Ko, 2000) in the

Table 3: Effect of different nutrient sources on yield components and yield (kg ha^{-1}) of groundnut (Pooled mean of two years)

Treatments	No. of pods $plant^{-1}$	No. of kernels pod^{-1}	100 kernel weight (g)	Pod yield (kg ha^{-1})
CF	10.37	1.69	37.49	1175.43
FA+CF	11.07	1.77	37.54	1273.67
VC+CF	10.63	1.76	36.52	1285.81
FA+VC+CF	12.20	1.85	38.43	1373.16
FYM+CF	11.47	1.81	37.53	1338.36
FA+FYM+CF	13.73	1.92	38.97	1432.45
GM+CF	12.45	1.83	38.27	1379.70
FA+GM+CF	15.57	2.01	39.90	1465.74
Control	7.87	1.52	36.01	705.23
LSD (p = 0.05)	0.85	0.09	2.89	55.63

CF = Chemical Fertilizer; FA = Fly Ash; VC = Vermicompost; FYM = Farmyard manure; GM = Green Manure (*Sesbania rostrata*); LSD = Least Significant Difference

soil. Supply of Ca through FA improved the growth and quality of pods as reported by Kanwar *et al*. (1983). Organic wastes also contributed other macro and micro nutrients in addition to N, P and K. Improved pH might have promoted the population of nitrogen fixing bacteria *Rhizobium* and thereby increased the nodule formation. As a result the plant was benefited with higher supply of N under FA treated plots. According to Perez-Galdona and Kahn (1994) some species like *Rhizobium meliloti* is highly sensitive to acid condition at a pH range from 5.5 to 6.0. Hence, higher availability of nutrients in soil promoted higher uptake of nutrients over CF only and finally led to higher pod yield of groundnut (Basu *et al*., 2006). According to Kuchanwar *et al*. (1997) application of 10 t fly ash ha^{-1} and 25:50:0 kg ha^{-1} N:P:K, respectively resulted in better growth and yield attributes which led to highest pod yield of groundnut.

Conclusions

From the above investigation it can be stated that combined application of fly ash, organic wastes and chemical fertilizers was found to be more effective in improving growth and yield of groundnut as compared to continuous use of only chemical fertilizers. Fly ash having both the properties of soil enrichment and amendment proved helpful in increasing crop growth and yield in acid lateritic soil, which are low in fertility.

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