The influence of inoculation, starter nitrogen and some micronutrients on groundnut grown on a granitic soil in the Sudan-savana zone of Ghana

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SUMMARY

A field experiment was conducted to study the influence of inoculation and micronutrients (Mo and Bo) application in combination with starter nitrogen (SN) at the rate of 15 kg/ha at planting on nodulation, N uptake and dry matter yield of groudnut at the pod-filling stage on a sandy loam soil (*Plinthaqualf*) in the Sudan-savana zone of Ghana. The results revealed possible presence of effective native rhizobial strains capable of forming root nodules on groudnut in the soil. Although the application of SN alone tended to reduce nodulation, total N uptake and total dry matter yield of the crop, a combination of the SN with 3 kg/ha of sodium molybdate appreciably increased nodulation and total dry matter yield, and significantly increased the total N uptake of groudnut (P=0.5). Inoculation had no significant effect on any of the parameters studied.

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RÉSUMÉ

Kwakye, P. K. & Dennis, E. A. : *L'influence d'inoculation, de starter azote, et de certains micronutritives sur l' arachide cultivée sur le sol de granit dans la zone soudano-savane du Ghana.* Une expérience sur le terrain s'est déroulée pour étudier l'influence de l'application d'inoculation et de micronutritive (Mo et Bo) en combinaison avec le starter azote (SN) à une proportion de 15 kg/ha en plantant sur nodulation, la consommation de N (azote) et le rendement de matiére séche d'arachide à la phase du remplissage de cosse sur le sol sablonneux riche en terreau (Plinthaqualf) dans la zone soudano-savane du Ghana. Les résultats ont révélé la présence possible de genres de rhizobial indigène capable de former les nodules de racine sur l'arachide dans le sol. Malgré le fait que l'application de SN seul avait la tendancé de réduire la nodulation, la consommation de N totale et la totalité de rendement de matière sèche de la culture, une combinaison de SN avec 3 kg/ha de soude molybdate a augmenté sensiblement la nodulation et le rendement total de matière sèche et a augmenté considérablement la consommation de N totale d' arachide (P = 0.5). L' inoculation n'a pas eu d'effet considérable sur aucun des paramètres étudiés.

Introduction

Groudnut is an important crop grown in the interior savanna zone of West Africa. The soils in the area are characterized by low inherent fertility(Nye & Greenland, 1960; Jones & Wild, 1976). Ofori (1973) indicated that nitrogen is included in fertilizer formulation on groudnuts in Ghana as starter nitrogen (SN); the main nutrient to which the crop responds being phosphorus.

It has been reported that inoculation increases nodulation of legumes such as soybean in Nigeria (Kang, 1975; Ayanba, 1977), and in Ghana (Mercer-Quashie & Nsowah, 1975; Owiredu & Danso, 1988). Significant increases in nodule number, seed weight and plant dry matter yield of groundnut due to inoculation have also been reported in Sri Lanka (Senaratne & Amarasekara, 1984), and in India (Kulkarni. Joshi & Sojtra, 1984; Nambiar, 1985; Singh & Ahuja, 1985). In spite of successful seed inoculation of legumes, the practice is not widespread in the tropics (Ayanaba, 1977). Farmers in West Africa rarely practise inoculation as it is generally assumed that these plants are capable of fixing atmospheric nitrogen to satisfy their N requirement. This assumption may be true only when the soil abounds in sufficient native rhizobial straints capable of being used by the legume. It has been reported (Hadad, *et al*., 1986) that field inoculation of groundnut with effective strains of *Rhizobium* is complicated because many tropical soils contain indigenous cowpea rhizobia capable of forming nodules on this host.

It is, therefore, necessary to evaluate the influence of inoculation of either the legume or the soil to assess the suitability of the inoculant under different agro-ecological and climatic conditions. Besides inoculation, micronutrients, notably boron and molybdenum, have been found to influence the growth and yield of groundnut (De &Chatterjee, 1976; Muralidaran & Sanadan, 1975; Muthuswamy & Sundarajan, 1973).

The role of micronutrients in the nutrition of groundnut in West Africa has not been established. The objective of this study was to evaluate the influence of SN, inoculatoin, molybdenum and boron application on nodulation, N uptake and total dry matter yield of groundnut at the pod filling stage.

Materials and methods

The experiment was conducted on an intensively-cropped sandy loam soil of granitic origin (*Varempere* series) classified as Plinthaqualf and sited at the Crop Research Institute Experiment Station, Manga/Bawku (11° 3' N, 0°19' W) in the northern Sudan-savanna zone of Ghana. The climate of the experimental station is hot and dry with average annual rainfull and temperature ranging from 965 to 1092 mm and from 29.0 to 38.1°C, respectively. The distribution of rainfall in the area is erratic. Drought occurs frequently resulting in either low crop yields or complete crop failure. The soil is characterized by low inherent fertility: *p*H 6.2; organic carbon 0.63 per cent, total N 0.47 per cent; NH_4-N 15.4 µg/g; NO_3-N 2.1 µg/g; Bray P_1 4.5 µg/g; exchangeable K 0.17 cmol/kg. There were six treatments arranged in a randomized complete block design replicated five times. Details of the treatments are shown below:

1. Control (no fertilizer)
2. 15 kg N/ha
3. 15 kg N/ha + inoculum applied to soil
4. 15 kg N/ha + inoculum aplied to seed
5. 15 kg N/ha + 3 kg/ha of sodium molybdate
6. 15 kg N/ha + 2 kg/ha of borax

The site was harrowed to a depth of 23 cm. Each plot size measured 2 m × 12.8 m. A basal dressing of 25 kg P and 30 kg K/ha as triple superphosphate and muriate of potash, respectively, was broadcast together with 15 kg N/ha as urea and incorporated at about 10 cm depth at planting. In treatments 3 and 4, the soil and the groundnut seeds (*Arachis hypogaea* L.) were treated with a composite peat-based inoculum, NC92 of Nitragin Company, Wisconsin, USA, at the rate of 1.5×10^6 cells/seed approximately. The soil application was accomplished by mixing the inoculum with a small volume of soil and incorporating in the planting rows. The seed inoculation was done by soaking the seed in milk-inoculum slurry with occasional shaking for 1 h followed by air drying. A semi-erect type of a Senegalese groundnut variety 55-437 was planted on flat ground spaced at 40 cm between rows and 20 cm within rows.

Periodic sampling of 20 plants per plot, 30, 45, 60 and 75 days after emergence (DAE) were carried out for the assessment of nodule number and weight. The samples collected at the 75th DAE were also used for the determination of total N in the haulm, husk and grain. The samples were initially air-dried followed by oven-drying at 65 °C for 48 h and finely ground in a Willey Mill. The total N was determined by the micro-Kjeldhal method described by AOAC (1970).

Pod-filling of the groundnut started at the 66 DAE. This was noticed by opening pods of a few plants in the discard rows. Harvesting was done on two rows of 80 cm wide and 12 m long. The plants were separated into haulm, husk and grain, freshly weighed, air-dried and oven-dried at 65°C to a constant weight. The experimental data were statistically analysed as described by Steel & Torrie (1980).

ing nodules on the groundnut in the soil. In Senegal, Badiane & Gueye (1992) studied the effect of inoculation in combination with 20 kg N/ha on groundnut and observe no effect on N fixation and total N content indicating the presence of effecient indigenous strains.

TABLE 1

Effect of Nitrogen with or without Inoculant or Micronutrient on Nodulation of Groundnut

Treatment	*Nodule* Number (per plant)	Dry weight (mg/plant)	Number (per plant)	Dry weight (mg/plant)	Number (per plant)	Dry weight (mg/plant)	Number (per plant)	Dry weight (mg/plant)
	30 DAE+		45 DAE		60 DAE		75 DAE	
Control	49ab*	119.8a	90a	102.9ab*	72a	295.4a	103a	307.6a*
15 kg/ha	33a	107.7a	72a	68.4b	61a	265.2a	63a	341.4ab
15 kg N/ha + Soil inoculation	33a	101a	74a	92.4b	67a	267.6a	96a	377.8b
15 kg N/ha + Seed inoculation	73b	126.0a	94a	106.0ab	92a	367.8a	86a	361.2ab
15 kg N/ha + 3 kg/ha Sodium molybdate	69ab	136.6a	104a	141.5a	78a	341.4a	85a	324.6ab
15 kg N/ha + 2 kg/ha Borax	61ab	119.5a	68a	86.9b	82a	277.4a	86a	328.0ab
SE ±	11.2	26.3	20.3	15.1	14.6	48.9	11.1	16.8

+DAE - Days after emergence

* Means in a column followed by the same letter are not significantly different at 5% level in this and subsequent tables.

Results and discussion

The average number of nodules formed per plant substantially increased between the 30th and 45th days after emergence (DAE), but their corresponding dried weights reduced by 45th DAE (Table 1). This indicates that there was formation of nodules with relatively smaller sizes between the 30th and 45th DAE than before 30th DAE. From the 45th to the 75th DAE, the number of nodules did not appreciably change. However, there were sharp increases in their dry weights indicating significant nodule development within the period. The number of nodule per plant was highest at 75th DAE. The plants grown on the uninoculated plots and without nitrogen fertilizer produced appreciable number of nodules indicating the presence of effective native rhizobial strains capable of form-

The application of SN alone reduced the number of nodule per plant compared with other treatments, but not significantly. Ofori (1975 unpublished) studied the effect of the same inoculant on groundnut in Ghana and observe no significant effect on nodulation. At the early stages of growth (30 DAE) of the groundnut crop, the SN with seed inoculation significantly increased the number of nodules compared with soil inoculation (P=0.05). Generally, the effect of seed inoculation was superior to that of soil inoculation of the crop up to the 60 DAE, but differences were not significant. In Brazil, nodulation of inoculated groundnuts was similar to that of uninoculated plants with or without nitrogen application (Giadini *et al*, 1985) while the results reported by Kullkani, Joshi & Sojtra (1984) in India indicated significant increases in nodule number due to inoculation. The divergent effects of inoculation on nodulation of groundnut in the different geographic and agroclimatic zones might be the result of differences in rhizobial population and activity.

It is observed that the significant effect of seed inoculation at DAE was transient. The lack of rhizobial effect in this study could be due to either possible competition between the native and the nitroduced rhizobia or reduced activity of the introduced *rhizobium* because of the high solar radiation and moisture stress during the cropping period. Moisture stress is very common in non-irrigated soils in the tropics and this has been shown to reduce nodule number and size (Amara &Miller, 1986; Sprent, 1976). The north-east zone of the country, where the experiment was carried out, experienced intermittent drought during the cropping season.

Dry weight of the nodules increased with age of the crop attaining the greatest weight at 75 DAE. The treatments including seed inoculation, and sodium molybdate recorded the greatest dry weights of nodules but these were not significantly greater than with other treatments except at 45 DAE when the application of SN in combination with Mo showed a significant increase in the dry weight of nodules compared with the application of SN alone, SN + B or SN + Soil inoculation.

TABLE 2

Content of Total N in Groundnut at Pod-filling Stage per cent

Treatment	*Haulm*	*Hust*	*Grain*
Control	2.34	2.14	3.54
15 kg N/ha	2.08	2.34	3.44
15 kg N/ha + Soil inoculation	2.18	2.41	3.70
15 kg N/ha + Seed inoculation	2.12	2.12	3.74
15 kg N/ha + 3kg/ha Sodium molybdate	2.23	2.57	3.78
15 kg N/ha + 2 kg/ha Borax	2.03	2.23	3.52
SE ±	0.29	0.36	0.30
LSD (P=0.05)	NS	NS	NS

TABLE 3

Effect of Starter Nitrogen with or without Inoculation or Micronutrients on Total N Uptake by Groundnut at Pod-filling Stage (kg/ha)

Treatment	*Haulm*	*Husk*	*Grain*	*Total*
Control	62.66ab	4.21a	4.21a	71.08a
15 kg N/ha	50.52ab	5.29a	3.78a	59.59ab
15 kg N/ha + Soil inoculation	52.49ab	4.84a	4.11a	61.44ab
15 kg N/ha + Seed inoculation	53.87ab	4.71a	4.37a	62.95ab
15 kg/ha Sodium molybdate	64.96a	3.83a	3.70a	72.49a
15 kg N/ha + 2kg/ha Borax	45.67b	3.97a	4.50a	54.14b
SE ±	6.76	0.56	0.32	6.29

The total N contents in the different plant parts of the groundnut ranged from 2.03 to 3.78 per cent (Table 2). The N concentration was highest in the grain (3.44 - 3.78 per cent) followed by the husk (2.14 -2.57 per cent) and least in the haulm (2.03 - 2.34 per cent).

The total N uptake by the crop ranged from 54.14 to 72.49 kg/ha (Table 3). During the pod-filling stage 84.35 to 89.61 per cent of the total N absorbed by the groundnut plant was found in the haulm with the remaining N almost equally share between the husk and the grain. There was a decrease, even though not significant, of 17.17 per cent in the total N uptake as a result of applying SN alone compared to the control. Inoculation and the application of boron also caused a decrease in the total N uptake by the plant. The highest N uptake by the plant was obtained with the application of Mo in combination with the SN which produced significantly higher (P=0.05) effect than the treatment with boron. The decrease in N uptake by the crop may be associated with moisture stress resulting from the intermitent drought which persisted during the cropping season. This is in conformity with the observation of Frota & Tucker (1978) and Polara, Patel & Pathak (1984) who reported significant reduction in the

TABLE 4

Effects of Inoculation and Micronutrients on Dry Matter Yield of Groundnut at Pod-filling Stage (kg/ha)

Treatment	*Haulm*	*Husk*	*Kernel*	*Total*
Control	2678	197	119	2994
15 kg N/ha	2429	226	110	2765
15 kg N/ha + Soil inoculation	2408	201	111	2720
15 kg N/ha + Seed inoculation	2541	213	117	2871
15 kg N/ha + 3 kg/ha Sodium molybdate	2913	149	98	3160
15 kg N/ha + 2 kg/ha Borax	2250	178	128	2556
SE ±	221	30	24	237
LSD (*P*=0.05)	NS	NS	NS	NS

absorption of N under water stress. Treatment results indicate that the groundnut haulm is the dominant sink for the total N up to the pod-filling stage of the crop.

Yield

There was no significant treatment effects on all the yield components (Table 4). However, slight decreases ranging from 5.1 to 16.0 per cent due to treatments were observed except the treatment receiving SN and Mo which increased haulm yield by 8.8 per cent over the control. The lowest haulm yield was obtained with the application of SN in combination with B which resulted in yield reduction of 16.0 per cent compared with the control. The application of SN alone resulted in 14.7 per cent increase in the yield of the husk. Seed inoculation caused an increase of 8.1 per cent yield of husk while the effect of soil inoculation was only 2.0 per cent increase over the control. The husk yield was reduced by 24.4 and 9.6 per cent due to the application of Mo and B, respectively.

With the exception of SN +Mo application, all treatments resulted in yield decreases of the total dry matter (TDM), but differences were not significant. The low TDM yield might be due to moisture stress caused by the temporary drought during the the pod-filling stage of the crop. This is in agreement with the observation of Polara, Pate & Pathak (1984) who reported a reduction in pod yield of groundnut by moisture stress imposed during the pegging or pod development period.

The haulm:husk:grain ratio was highest (29.7:1.5:1) with the application of Mo in combination with SN while the lowest ratio was recorded with the treatment including B. The ratio supports the high N uptake in the haulm and the high TMD yield in the Mo plots.

The results of this study have revealed that there is the presence of effective rhizobial strains capable of forming root nodules on groundnut in the sandy loam soil. Although the application of SN alone tended to reduce nodulation, total N uptake and yield of the crop at the pod-filling stage, a combination of SN and Mo significantly increased the total N uptake (*P*=0.05). Generally, the effect of seed inoculation on the growth and yield of groundnut on the sandy loam soil was superior to that of the soil inoculation, but differences were not significant.

Under conditions of low inherent fertility, the presence of effective rhizobial strains of a host legume in the soil may promote nodulation, total N uptake and dry matter yield of a crop such as groundnut without the application of a starter N. Similarly, inoculation may also not be beneficial on the soil. The application of molybdate has been found to be necessary for the growth of groundnut on this soil.

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