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INFLUENCE OF PHOSPHORUS FERTILIZER AND MULCHING MATERIALS ON THE GROWTH AND YIELD ATTRIBUTES OF GROUNDNUT VARIETIES IN THE NORTHERN GUINEA AND SUDAN SAVANNAH ZONES OF NIGERIA

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Abstract

Field trials were conducted during the 2017 dry season at the Irrigation Research farms of the Institute for Agricultural Research, Samaru and Kadawa to study the influence of phosphorus fertilizer and mulching materials on the performance of groundnut (*Arachis hypogaea* L.).The treatments consisted of two mulching materials and a control i.e. polythene mulch, rice straw mulch and no mulch respectively, two varieties of groundnut (SAMNUT 24, and 25) and three rate of phosphorus (0, 30 and 60 $kgha^{-1}$ per P_20_5 respectively) factorially combined and laid in a randomized complete block design (RCBD) and replicated three times. Data were collected on plant height, leaf area index and harvest index. All data collected were analyzed statistically and treatments means were compared using Duncan multiple range test (DMRT). Although it was noted that no statistical difference was observed with the application of phosphorous fertilizer in plant height across sampling periods except in leaf area index where a significant difference was observed at 6 weeks after sowing in both locations. Where the application of 60 kg ha^{-1} P_20_5 at 6 weeks after sowing produced higher leaf area index and harvest index. However, application of rice straw mulch produced taller plants, high leaf area index at 3 and 6 weeks after sowing and higher harvest index in both locations. The interactions between mulching materials and phosphorus fertilizer was significant on plant height at 3 WAS in Samaru with the application of 30 kg P_20_5 with rice straw mulch resulted in taller plants. Samnut 25 produced higher harvest index in both locations. Based on the results obtained from this trail, the application of 60 kg P_20_5, rice straw mulch on Samnut 25 variety resulted in better growth and higher harvest index of groundnut in both locations and this could be recommended for use by farmers in the Northern guinea and Sudan savannah agroecological zones.
should be encouraged to use field trip instructional strategy in the teaching of Ecological concepts.

Keywords: Harvest index, Phosphorus fertilizer, Mulching materials, Groundnut and Varieties

Introduction

Groundnut *(Arachis hypogaea L.)* is a leguminous oil seed crop cultivated in the semi-arid and subtropical regions of the world. It is grown in nearly 100 countries on six continents between 40^0 North and South of the equator on nearly 24.6 m ha, with a production of 41.3 m.t. and productivity of 1676 kg ha-1 during 2012. China, India, Nigeria, USA and Myanmar are the leading groundnut producing countries in the world. Asia, with 11.6 m ha (47.15%), and Africa, with 11.7 m ha (47.56%), hold maximum global area under groundnut. Developing countries in Asia, Africa and South America account for over 97% of world groundnut area and 95% of total production. However, the productivity of Asia (2217 kg ha^{-1}) and Africa (929 kg ha^{-1}) is very poor as compared to Americas (3632 kg ha^{-1}), (FAOSTAT, 2014). Groundnut is usually grown as a smallholder crop in the semi-arid tropics under rain-fed conditions. It is an important crop in many countries, especially in Sub Saharan Africa, where it is a good source of protein (25%-34%), cooking oil (48%-50%) and vitamins. The haulms are a good source of feed for livestock, especially during the dry season when fresh green grasses are not available. This serves as an additional source of income for farmers in the dry season when the fodder is in high demand. Groundnut improves soil fertility through nitrogen fixation, thereby increasing the productivity of other crops when used in rotation or in a cereal cropping system.

Groundnut production is constrained by a number of biotic and abiotic stresses such as insects, diseases, drought and low soil fertility. Small holder farmers are particularly affected because they lack resources and access to currently available technologies to overcome these stresses. Lower production prices and limited marketing opportunities reduce incentives for producers to invest in productivity-enhancing technologies such as improved seeds, fertilizer and pesticides. In small holder farms, all field operations from land preparation to harvesting are done by hand. Lack of labor and drought causes delay in sowing and weeding, which reduces yield. Moisture stress at critical periods of crop growth substantially reduces yield and quality, while end of season drought increases labour requirements for harvesting. Also, lack of adoption improved varieties to the various agro-ecological zones of the producing areas is a major effect in groundnut production (Anon, 2004).

Water availability is a major obstacle to sustainable agricultural production in the tropics. It may not always be possible to procure more water, so farmers must adopt management practices which maximize water use efficiency. Applying mulches is one cultural practice which can help in achieving this goal. Mulch has been widely used to increase the water intake and storage (Schneider & Mathers, 1970), to improve moisture distribution in soil profile, or to decrease evaporation (Bennett *et al.,* 1964). Mulch improved root growth in the upper 15cm of the soil and increased the lateral spread of roots. Any reduction in evaporation can be as beneficial to crop growth as additional water intake by the soil (Chaudhary & Prihar, 1974 & Khan, 1998). Mulches increase the soil temperature, retard the loss of soil moisture, and check the weed growth, which are the key factors contributing to the production of groundnut (Ramakrishna *et al*., 2006).

Phosphorous plays a role in cell division, flowering, crop maturation, root development and nodulation. It plays an important role in the maturity of the crop, root development, photosynthesis, nitrogen fixation and other vital physiological processes. In the order of importance to crop performance, phosphorus is rated second to nitrogen (Gervey, 1987). The uses of seeds of improved varieties of groundnut have been reported to lead to significant yield increases. This coupled with agronomic practices could lead to further increase in the yield of groundnut. Higher yields and returns on investment are capable of encouraging smallholder farmers to invest in productivity enhancing technologies. This research was carried out to evaluate the performance of groundnut varieties as influenced by phosphorus rates and mulching materials.The study was therefore conceived with the objective of determining the influence of phosphorous fertilizer and mulching materials on the performance of groundnut (*Arachis hypogaea* L.) in the Northern Guinea and Sudan Savanna Zones of Nigeria.

Materials and Methods

Experimental Site

The experiment was conducted at the Institute for Agricultural Research (I.A.R) Irrigation Research Farms, Samaru, (Latitude 11^0 11N Longitude 07' 38 E, 686m) above sea level in Kaduna State and at Kadawa, (Latitude 11^0 39 N Longitude 08' 27 E, 500m) above sea level in Kano State, in the northern Guinea and Sudan savannah ecological zones of Nigeria, respectively during the 2017 dry season (Kowal & Knabe, 1972).

Treatments, Experimental Design and Plot Size

The treatments consisted of two mulching materials and a control i.e. polythene mulch, rice straw mulch and no mulch respectively, two varieties of groundnut (SAMNUT 24, and 25) and three rates of phosphorus (0, 30 and 60kgha^{-1} per P_20_5 respectively). The treatments were laid out in a randomized complete block design and were replicated three times. The gross and net plot sizes were 3.0m x 4.0m (12m^2) and net plot size of 2.0m x 3.0m (6m^2) respectively.

Description of varieties

Samnut 24: This is an early maturing variety, maturing between 80-90 days with good haulm yield (2.5-3.0 t ha^{-1}). It has vigorous plant growth, good pod yield potential (2-2.5 t ha^{-1}) and high oil content (53%).

Samnut 25: This is an early maturing variety, maturing between 80-90 days, has pod yield potential (2.5-3 t ha^{-1}), highly resistant to rossete and moderately resistant to early leaf spot and late leaf spot disease and with high oil content of (51.5%).

Land preparation

Two weeks prior to land preparation, glyphosate was applied at the rate of 0.5 Kg a.i ha^{-1} was applied in Kadawa due to high weed infestation, so also paraquat was applied in Samaru at the rate 0.276 Kg a.i ha^{-1}. The fields were harrowed once and ridged 75cm apart. The field was then marked out into plots which were leveled into basins. This was done for all the three replications.

Mulch application

The rice straw was shredded, weighed for each plot and used as straw mulch. It was evenly spread on the plots as per treatments. The Polythene mulch was obtained from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). It is transparent and was pre-punched at 25×20cm inter and intra-row spacing respectively and used in plots as per treatment.

Sowing

Three (3) seeds per hole were sown which were later thinned to one seedling per stand. Seeds were dressed with Dress force (ai Imidacloprid 20% +Metlaxyl 20% + Tebuconazole 2% WS) @10g/8Kg prior to sowing. Sowing was done on 27th February at Samaru and 4th March in Kadawa.

Weed Management

Weeding was carried out by hand pulling in the mulched treated plots at 4 and 7 WAS, whereas hoe weeding was carried out in the controlled plots at 3 and 6 WAS respectively.

Pest and Disease Control

There were no pests or diseases observed during this trial.

Harvesting

Harvesting was done when the crop reached physiological maturity i.e. when most leaves turned brown and the groundnut pod had a pronounced brown colour. The plants in the net plots were harvested by digging out the whole plant including the pods with a hand hoe and picking up the remaining pods from the soil. Thereafter, pods were detached from the haulms and allowed to dry for seven days under the sun. The dried pods for each net plot were then weighed using E2000 mettler balance and the value was recorded on per plot basis.

Data collection

Plant height (cm)

Plant height was measured using a meter rule from the ground level to the terminal leaflet at 3, 6, 9 and 12 WAS and recorded.

Leaf area index (LAI)

The leaf area index was derived from the result of the leaf area and calculated as shown below

$$LAI = \frac{\text{Total leaf area per plant}}{\text{Area of ground covered}}$$

Harvest index

The ratio of the grain yield to the total dry matter was calculated at harvest using the formular below :- HI= Grain yield from sample × 100
Total dry matter of sample

$$HI = \frac{\text{Grain yield from sample}}{\text{Total dry matter of sample}} \times 100$$

Statistical Analysis

The data collected were subjected to statistical analysis of variance (F-test) as described by (Snedecor and Cochran, 1967) to test significance of treatment effects. The treatment means were compared using Duncan's Multiple Range Test (DMRT) (Duncan, 1955).

Results

Table 1 shows the plant height of groundnut varieties as influenced by phosphorus rates and mulching materials during 2017 dry season. Increase in phosphorus fertilizer had no significant effect on the plant height at both locations during the sampling periods. Samnut 24 had taller plants at 3 WAS than Samnut 25 with the exception of 3 WAS and 9 WAS at Kadawa. Samnut 24 consistently produced taller plants than Samnut 25 at all other sampling periods in both locations.

Mulching materials had significant effect on the plant height of groundnut varieties at 3 WAS and 6 WAS in both Samaru and Kadawa. In Samaru, using rice straw mulch led to significantly taller plants than using the polythene mulch. At 6 WAS, using the rice straw led to significantly taller plants than the control but was statistically similar to using the polythene mulch. At Kadawa, using both the rice straw and polythene mulch led to significantly taller plants than the control at 3 WAS, while the polythene mulch led to significantly taller plants than the rice straw mulch and control at 6 and 9 WAS.

Highly significant interaction between phosphorus rates and mulching materials was observed at 3WAS in Samaru. Application of 30 KgP_20_5 with rice straw resulted in the tallest plant which was statistically similar to application of 0 Kg P_20_5 with rice straw. (See Table 2).

Table 1: Plant height of groundnut varieties as influenced by phosphorus rates and mulching materials in Samaru and Kadawa at 3, 6, 9 and 12 WAS during 2017 dry season

Treatment	**Plant height (cm)**							
	Samaru				Kadawa			
	3WAS	6WAS	9WAS	12WAS	3WAS	6WAS	9WAS	12WAS
Phosphorus(kgP_20_5)								
0	6.89	12.59	29.46	41.57	6.27	14.31	28.03	39.18
30	6.69	13.69	29.88	43.47	5.82	14.39	27.77	40.26
60	6.20	14.17	30.63	43.38	6.53	15.77	29.88	43.21
SE±	**0.279**	**0.673**	**0.928**	**1.255**	**0.350**	**0.531**	**0.994**	**1.790**
Variety								
SAMNUT 24	6.98a	13.56	30.26	43.54	5.99	14.99	28.51	41.15
SAMNUT 25	6.19b	13.41	29.73	42.10	6.42	14.65	28.62	40.62
SE±	**0.229**	**0.549**	**0.758**	**1.024**	**0.286**	**0.432**	**0.812**	**1.462**
Mulch								
Control	5.47b	12.21b	29.77	41.80	4.66b	14.21b	27.12b	38.13
Polythene	6.17b	13.88ab	29.46	42.32	7.32a	16.47a	31.83a	42.31
Rice straw	8.12a	14.36a	30.74	44.29	6.63a	13.79b	26.74b	42.21
SE±	**0.279**	**0.673**	**0.928**	**1.255**	**0.350**	**0.531**	**0.994**	**1.790**
Interaction								
VxP	NS	NS	NS	NS	NS	NS	NS	NS
VxM	NS	NS	NS	NS	NS	NS	NS	NS
PxM	**	NS	NS	NS	NS	NS	NS	NS
VxPxM	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letter(s) are significantly different at 5% level using DMRT.
WAS= Weeks after sowing.
**= Significant at 1%
NS = Not significant

Table 2: Interaction of phosphorus rates and mulching materials on plant height of groundnut in Samaru at 3 WAS during 2017 dry season

Treatment	**Phosphorus (Kg P_20_5)**		
Mulch	**0**	**30**	**60**
Control	5.26b	5.45b	5.68b
Polythene	6.83b	5.43b	6.23b
Rice straw	8.56a	9.18a	6.60b
SE±		**0.485**	

Means followed by different letter(s) are significantly different at 5% level using DMRT.
WAS= Weeks after sowing.

The effects of Phosphorus rates, varieties and mulching materials on the leaf area index of groundnut during the 2017 dry season at Samaru and Kadawa is shown in Table 6. A significant difference was observed with the application of Phosphorus fertilizer on the leaf area index of groundnut at 6 WAS in Samaru and Kadawa respectively. Where the application of 60 kgP_2O_5 produced significantly high leaf area index than the application of 30 kgP_20_5 but statistically at par with 0 kg P_20_5. Application of mulching materials significantly influenced leaf area index of groundnut at 3 and 6 WAS in Samaru and Kadawa respectively. At 3 and 6 WAS in Samaru, the application of rice straw mulch produced significantly high leaf area index than polythene mulch but statistically at par with control (no mulch). At 3 WAS in Kadawa, application of polythene sheet and rice straw mulch produced similar and higher leaf area index than the untreated control. While at 6 WAS, application of rice straw mulch significantly produced higher leaf area index than polythene sheet and control which were statistically at par with each other. The interaction between Phosphorus fertilizers, varieties and mulching materials on the leaf area index of groundnut was not significant throughout the period of study.

Table 3: Leaf Area Index of groundnut varieties as influenced by phosphorus rates and mulching materials in Samaru and Kadawa at 3, 6, 9 and 12 WAS during 2017 dry season

	LAI							
Treatment	Samaru				Kadawa			
Variety	3WAS	6WAS	9WAS	12WAS	3WAS	6WAS	9WAS	12WAS
Samnut 24	0.23	1.21	4.52	9.13	0.16	0.83	7.86	17.31
Samnut 25	0.21	1.03	4.11	8.57	0.18	0.87	8.11	17.56
SE±	**0.013**	**0.117**	**0.251**	**0.406**	**0.01**	**0.040**	**0.337**	**0.831**
Phosphorus (KgP_20_5)								
0	0.22	1.01ab	4.09	8.62	0.17	0.85ab	8.62	17.11
30	0.21	0.93b	4.73	9.30	0.15	0.76b	7.91	18.70
60	0.21	1.43a	4.11	8.63	0.18	0.93a	7.39	16.51
SE±	**0.016**	**0.144**	**0.307**	**0.498**	**0.012**	**0.049**	**0.413**	**0.017**
Mulch Materials								
Control	0.18b	0.95b	4.70	9.32	0.15b	0.77b	8.46	18.54
Polythene sheet	0.22ab	1.00ab	4.11	8.98	0.20a	0.79b	7.89	17.42
Rice straw	0.25a	1.42a	4.13	8.25	0.20a	0.99a	7.56	16.35
SE±	**0.016**	**0.144**	**0.307**	**0.498**	**0.012**	**0.049**	**0.413**	**0.017**
Interaction								
VxP	NS	NS	NS	NS	NS	NS	NS	NS
VxM	NS	NS	NS	NS	NS	NS	NS	NS
PxM	NS	NS	NS	NS	NS	NS	NS	NS
VxPxM	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letter(s) are significantly different at 5% level using DMRT, WAS= Weeks after sowing.
**= Significant at 1%.
NS = Not significant.

The harvest index of groundnut as influenced by phosphorus rates and mulching materials in Samaru and Kadawa during the 2017 dry season is shown in Table 4 . A significant difference was observed between varieties at Samaru only where Samnut 25 produced higher harvest index than Samnut 24 variety. The Application of 60 Kg P_20_5 significantly resulted in high harvest index in Samaru than 0 kg P_20_5 but statistically at par with the application of 30 kg P_20_5, while the application of 60 kg P_20_5 significantly produced higher harvest index over the application of 30 kg P_20_5 and 0 kg P_20_5 in Kadawa. Similarly, the application of 30 kg P_20_5 recorded significantly higher harvest index than 0 kg P_20_5. The application of rice straw mulch produced higher harvest index in both locations than polythene mulch and control which were statistically at par with each other. The interaction between Phosphorus fertilizers, varieties and mulching materials on the harvest index of groundnut was not significant throughout the period of study.

Table 4: Performance of groundnut varieties as influenced by phosphorus rates and mulching materials on harvest index in Samaru and Kadawa during 2017 dry season

	Harvest index	
Treatment	**Samaru**	**Kadawa**
Variety		
Samnut 24	36.06b	34.10
Samnut 25	37.42a	35.02
SE±	**0.421**	**0.342**
Phosphorus (KgP_20_5)		
0	26.58b	25.01c
30	41.16a	38.61b
60	42.48a	40.06a
SE±	**0.516**	**0.419**
Mulch		
Control	36.12b	33.81b
Polythene	35.96b	34.09b
Rice straw	38.13a	35.78a
SE±	**0.516**	**0.419**
Interaction		
VxP	NS	NS
VxM	NS	NS
PxM	NS	NS
VxPxM	NS	NS

Means in a column of any set of treatment followed by different letter(s) are significantly different at 5% level using DMRT.
WAS= Weeks after sowing.
NS= Not significant

Discussion

From the result obtained, the two groundnut varieties exhibited minimal differences in growth parameters (plant height and leaf area index) and harvest index in both locations. However, higher growth attributes and harvest index of groundnut was observed in Samaru than Kadawa. This difference among groundnut varieties could be attributed to differences in growth factors imposed by differences in genetic make-up of the variety and interaction with the environment (moisture, soil fertility and solar radiation) as well as crop management which was in line with the report of Usman (2015) and Patel *et al*. (2013).

This study indicated the positive role phosphorus plays in enhancing groundnut yield. The growth components such as (plant height and leaf area index) were significantly affected by phosphorus rates. The increase in pod yield with increasing phosphorus rates observed in this study could be due to the higher requirement of phosphorus for symbiotic nitrogen fixation. This result is in line with the findings of Kamara *et al*. (2011) and Mouri *et al*. (2018) who observed higher harvest index with application of 60 Kg P_20_5. Kwari (2005) reported that, low phosphorus content of the soil may restrict *rhizobia* population and legume root development, which in turn can affect groundnut nitrogen fixing potential. Chiezey and Odunze (2009) also reported an increase in yield parameters with application of phosphorus in soybean.

Application of mulch materials greatly improved the yield of groundnut varieties which resulted in higher harvest index of groundnut. This could be associated with bio availability of macro and micro nutrients during the decomposition of organic mulch and favourable soil temperature and soil water under rice straw mulch during the pod development stage was the reason for higher pod yield groundnut which also conforms with the findings of Ghosh *et al*. (2006). The interaction between phosphorus rate and mulching materials was significant at 3 WAS in Samaru.This could be as a result of favorable soil temperature and soil water during pod development stage (Osuji, 1990), Khistaria *et al.* (1994) and Pawar *et al*. (2004).

Conclusion

Groundnut variety Samnut 25 showed superiority over Samnut 24 on growth attributes and harvest index in this study. The study further confirmed the valuable contribution of Phosphorous fertilizer and mulch, where the application of 60 kg P_20_5 and rice straw mulch resulted in higher growth attributes and harvest index in both locations.

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