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PERFORMANCE OF GROUNDNUT (*Arachis hypogaea* L.) VARIETIES AS INFLUENCED BY PHOSPHORUS AND MULCHING IN THE NIGERIA SAVANNA

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ABSTRACT

The study on groundnut (*Arachis hypogaea* L.) performance under different rates of phosphorus and mulching in the Nigeria savannas addresses challenges of low soil fertility and harsh climatic conditions. Groundnut, an important crop in Nigeria, is limited by phosphorus deficiency and soil moisture stress in the savannas. Phosphorus is vital for root development, flowering, and seed production but is often deficient in the region's alkaline soils. Mulching helps conserve moisture, reduce erosion, and improve fertility by adding organic matter. Identifying optimal combinations of phosphorus and mulching can enhance groundnut yield and sustainability. Field trials were conducted at the Irrigation Research Farms of the Institute for Agricultural Research, Samaru and Kadawa in dry season of 2024 to evaluate two varieties of groundnut (SAMNUT-24 and SAMNUT-25), three phosphorus rates 0, 30 and 60 kgP_20_5ha^{-1}), and three mulch materials (no mulch, polythene sheet and rice straw). Treatments were laid out in a randomized complete block design with three replications. Results showed SAMNUT-24 excelled in branches, canopy spread and shoots dry weight, while SAMNUT-25 produced higher pod yield and harvest index. Applying 60 kgP_20_5 ha^{-1} improved leaves, pod yield and harvest index, while polythene sheets enhanced leaf number and canopy spread. Both varieties performed well under irrigation. SAMNUT-24 and SAMNUT-25 with 60 kgP_2O_5ha^{-1} and rice straw mulch is recommended for farmers. Further research is needed to explore phosphorus rates with new/improved varieties.

Keywords: Number of branches, Canopy spread, Shoots dry weight, Harvest index, Mulch, Phosphorus, Groundnut variety

INTRODUCTION

Groundnut (Arachis hypogaea L.) is a leguminous oilseed crop cultivated in the semi-arid and subtropical regions of the world. It is grown in nearly 100 countries across six continents, typically between 40°N and 40°S of the equator, covering an area of approximately 24.6 million hectares with a production of 41.3 million tones and a productivity of 1,676 kg/ha in 2012. The leading groundnut-producing countries include China, India, Nigeria, the USA, and Sudan (USDA, 2022). In 2020, global groundnut production reached 54 million tones, representing an 8% increase over 2019. China contributed 34% of global production, followed by India with 19%, and other significant producers including Nigeria (8%), the USA (5%), and Sudan (5%) (FAOSTAT, 2020).

Groundnut is predominantly cultivated as a smallholder crop in the semi-arid tropics under rain-fed conditions. It is an essential crop in many countries, particularly in Sub-Saharan Africa, where it serves as a valuable source of protein (25%-34%), cooking oil (48%-50%), and essential vitamins. The haulms (stems and leaves) also provide a vital feed resource for livestock, especially during the dry season when fresh fodder is scarce. This contributes to additional income for farmers in the off-season when the demand for fodder is high. Moreover, groundnut enhances soil fertility through nitrogen fixation, improving the productivity of other crops when incorporated into crop rotations, particularly with cereals (Witcombe and Tiemann, 2022).

Despite its significance, groundnut productivity in many African countries remains low due to a combination of factors such as erratic rainfall, reliance on rain-fed cultivation, traditional small-scale farming practices with limited mechanization, pest and disease outbreaks, the use of low-yielding varieties, continued cultivation on marginal land, inadequate adoption of improved agronomic practices, and limited extension services (Anonymous, 2015). A major barrier to improving groundnut production is the lack of adoption of improved varieties suited to the different agro-ecological zones. The use of improved varieties has been shown to significantly increase yields. Coupled with the adoption of sound agronomic practices, these efforts could lead to further yield improvements. Increased yields and better returns on investment would incentivize smallholder farmers to invest in productivity-enhancing technologies.

Moisture stress during critical growth periods significantly reduces both yield and quality, while end-of-season droughts increase labor demands during harvesting. Water availability remains a major constraint to sustainable agricultural production in the tropics. Given the challenges in procuring additional water resources, farmers must adopt water-use efficiency practices. One such practice is the use of mulches, which have been shown to enhance water absorption and retention in the soil (Schneider and Mathers, 1970). Mulches help regulate soil temperature, reduce moisture loss, and suppress weed growth—factors that contribute to improved groundnut production (Ramakrishna *et al*., 2006).

Given these challenges, the objectives of this study are to assess the effects of phosphorus and mulch application on the performance of improved groundnut varieties in the Nigerian savannas.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Institute for Agricultural Research (I.A.R) Farm, Ahmadu Bello University, Samaru, Zaria (Latitude 11^{0}N 39' Longitude 08^0 02' E 686m above sea level) and at the Irrigation Research Station Kadawa (Latitude 11^0 11' N Longitude 7^0 38' E 500m above sea level) in Northern Guinea and Sudan Savannah ecological zones of Nigeria, respectively during the 2024 dry season (Kowal and Knabe, 1972).

Treatments, Experimental Design and Plot size

The treatments consisted of three mulch materials (polythene mulch, rice straw mulch and no mulch), two groundnut varieties (SAMNUT-24, SAMNUT-25) and three phosphorus rates (0, 30 and 60 kg P_20_5/ha). The treatments were factorialy combined and laid out in a randomized complete block design and replicated three times. Sunken bed was prepared in which the gross and net plot sizes were 3.0m x 4.0m (12m^2) and 2.0m x 3.0m (6m^2), respectively.

Soil Sampling and Analysis

Soil samples will be taken randomly from ten points each in the experimental sites at a depth of 0-30 cm using soil auger prior to land preparation for physical and chemical properties determination in the soil analytical laboratory.

Description of Varieties

SAMNUT-24: An early maturing variety with good haulm yield, plant growth, good pod yield potential and high oil content (53%). Anonymous, (2021)

SAMNUT-25: An early maturing variety, with pod yield potential, highly resistant to rosette and moderately resistant to early leaf spot and late leaf spot disease and with high oil content of (51.5%). Anonymous, (2021)

Cultural Practices

Land preparation

Two weeks prior to land preparation, glyphosate will be applied at the rate of 0.5 kg a.i. ha^{-1} in both locations. The fields will be harrowed, marked out into plots and levelled into basins. This was done for all the three replications.

Mulch application

The rice straw was shredded, weighed 6 kg for each plot and used as straw mulch. It was evenly spread on the plots as per treatments. The Polythene mulch was purchased from a renowned supplier in Kano State. It is transparent and was pre-punched at 25 by 20 cm inter- and intra-row spacing respectively and used in plots as per treatment.

Sowing

Three (3) seeds per hole were sown, which was later thinned to one seedling per stand. Seeds will be dressed in Dress force (a.iImidacloprid 20%+Metlaxyl 20%+Tebuconazole 2% WS) @10g/4kg prior to sowing.

Irrigation

Water was applied prior to sowing once every five days for four weeks and will be later increased to twice a week for six weeks, which will be subsequently reduced to once a week until maturity/harvest.

Weed Management

Hoe weeding was carried out in the controlled plots at 3 and 6 weeks after sowing (WAS), and by hand pulling in the mulched treated plots at 4 and 7 WAS.

Harvesting

Harvesting of the crop was done when most leaves turn brown and the groundnut pod have a pronounced brown colour inside.

Data collection

Data collection commenced from 3WAS. Five plants were randomly tagged within the net plot and growth parameter was measured from the tagged plants at 3, 6, 9, and 12 WAS.

Assessment of growth characters

Assessment of growth characters was done at 3, 6, 9 and 12 WAS, and in each plot, plants will be randomly selected, and the following parameters will be measured.

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.

Number of leaves plant^{-1}

The number of leaves was counted per plant from the five tagged plants from each plot and the average per plot will be determined and recorded.

Canopy spread (cm)

Canopy spread will be measured by taking the diameter of the open canopy using a meter rule and the mean obtained will be recorded on per plot basis.

Assessment of Yield Components

Assessment of yield components was done at harvest

Pod yield hectare^{-1} (kg)

The weighed pod per plot will be extrapolated to per hectare basis and recorded as pod yield hectare^{-1}.

Haulm yield hectare^{-1}(kg)

The weighed haulm plot^{-1} will be converted to per hectare and the value will be recorded as haulm yield ha^{-1}.

Harvest index

The ratio of the pod yield to the total dry matter will be calculated at harvest using the formula:-

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

Statistical Analysis

Data collected was subjected to statistical analysis of variance (ANOVA) as described by Snedecor and Cohran (1967). The differences between treatment means was compared using Duncan Multiple Range test (DMRT) (Duncan, 1955). The relationship between parameters was determined by simple correlation coefficient using the procedure described by Little and Hills (1978). Regression analysis as described by Steal and Torrie (1980) and Gang and Banse (1972) were done to determine the optimum rate of phosphorous fertilizer for maximum Haulm and kernel yield of groundnut.

RESULTS AND DISCUSSION

Soil Physical and Chemical Properties of the Experimental Sites

Soil samples from the two experimental sites (Samaru and Kadawa) were loam and sandy loam, respectively (Table 1). The soil of Samaru has moderate level of nitrogen, high level available phosphorus while organic carbon, calcium, magnesium, potassium, sodium and cation exchange capacity were moderate while pH was slightly acidic in H_2O. In Kadawa the soil has high level of nitrogen and moderate level of available phosphorus and organic carbon, low level of calcium, magnesium, potassium and sodium contents, while pH is slightly acidic in H_2O and strongly acidic in $CaCl_2$.

Plant Height (cm)

Table 2 shows the plant height of groundnut varieties as influenced by phosphorus rates and mulching materials during 2024 dry season. At 3 WAS in Samaru, significantly taller plants were observed for SAMNUT-24. A similar trend was observed for all the other sampling periods at both locations, with the exception of 3 WAS and 9 WAS at Kadawa, although the differences were not significant. Increase in phosphorus fertilizer had no significant effect on the plant height at both locations during the sampling periods. Mulching materials had significant effect on the plant height of groundnut varieties at 3 and 6 WAS in Samaru and at 3, 6 and 9 WAS at Kadawa. In Samaru, at 3 WAS 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. In 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 the control at 6 and 9 WAS.

Highly significant interaction between phosphorus and mulching materials was observed at 3WAS in Samaru. Application of 30 kgP_20_5ha^{-1}with rice straw resulted in the tallest plant which was statistically similar to control with rice straw (Table 3).

Number of leaves plant^{-1}

Number of leaves of groundnut varieties as influenced by phosphorus rate and mulching at Samaru and Kadawa in 3, 6, 9 and 12 WAS is presented in (Table 4). At both locations, variety did not differ significantly on the number of leave throughout the sampling periods. Phosphorus application rate did not significantly increase number of leaves throughout the sampling periods at Samaru while significant(P=<0.05) increase of number of leaves at sampling periods of 6 and 9 WAS where control treatments and higher rate of 60 kg ha^{-1}were statistically at par with 30 kg P_20_5ha^{-1} significantly(P=<0.05) produced lower number of leaves. Mulching had significant (P=<0.05) effect on both locations. In Samaru, polythene mulch recorded the highest number of leaves, which was statistically similar with no-mulch at 3 WAS. However, no-mulch recorded significantly (P=<0.05) higher number of leaves at 6 WAS which was followed by rice straw mulch. At 12WAS, zero mulch gave the highest number of leaves, trailed by polythene sheet. In Kadawa, Polythene mulch had the highest number of leaves at 3WAS which was statistically similar with straw mulch. At 6WAS, no mulch had the highest number of leaves in which polythene and rice straw mulch were statistically similar. However, no mulch and polythene sheet are statistically similar having higher number of leaves than rice straw mulch at 9 WAS.

The interaction between variety and phosphorus was significant (P=<0.05) at 6WAS in Kadawa (Table 5). Increase in phosphorus fertilizer led to increase in number of leaves for SAMNUT-24. However, more number of leaves was observed with application of 60kgP_20_5 ha^{-1} and SAMNUT-24, which was statistically similar with application of 60kgP_20_5 with SAMNUT-25 and also control with SAMNUT-25, while 30kgP_20_5ha^{-1} with SAMNUT-25 had the least number of leaves.

Canopy Spread

Table 6 presents the canopy spread of groundnut as influenced by varieties, phosphorus rates and mulching materials in Samaru and Kadawa during 2024 dry season. The effect of phosphorus was highly variable and significant (P=<0.05) in Samaru at 6WAS while there was no significant effect of phosphorus on the canopy spread at Kadawa. 0 kgP_20_5 ha^{-1} at 3WAS produced the widest canopy. While, at 6WAS widest canopy was observed with application of 30 kgP_20_5 ha^{-1}. Significant (P=<0.05) effect of mulch was observed at 3WAS in Samaru, while there was statistical similarity in the subsequent weeks. At 3WAS polythene mulch had the widest canopy spread which was followed by no mulch, followed by rice straw mulch.

In Kadawa, significant (P=<0.05) differences in canopy spread due to mulch was observed at 12 WAS, where no mulch was observed with wider canopy than that of rice straw which was at par with that of polythene mulch. Significant interactions were observed between variety and phosphorus in Samaru and Kadawa at 6WAS. Application of 30 kgP_20_5 ha^{-1}with both SAMNUT-24 andSAMNUT-25 was found to have the highest canopy spread (which corresponded with application of 60kgP_20_5 ha^{-1}with SAMNUT-25 and also 0kgP_20_5 ha^{-1}with SAMNUT-24 at Samaru). The least canopy spread was observed with application of 60kgP_20_5 ha^{-1}with SAMNUT-24 (Table 4.10). Significant (P=<0.01) interaction between variety and phosphorus was observed at 6WAS in Kadawa. SAMNUT-24 had the widest canopy with application of 30kgP_20_5 ha^{-1}while for SAMNUT-25; widest canopy was observed with application of 60kgP_20_5 ha^{-1}, while the least canopy spread was observed with application of 30kgP_20_5 ha^{-1}with SAMNUT-25 (Table 7).

Pod Yield ha^{-1}

The effect of phosphorus rates and mulch on pod yield per hectare of groundnut variety as well as phosphorus had no significant effect in both locations. However, mulch had significant (P=<0.05) effect in Samaru in which rice straw mulch had the highest pod yield, followed by polythene mulch. The least pod yield was produced by no mulch during the growing period. In Kadawa, there was no significant response to the mulch materials throughout the trial. There was no significant interaction of treatments on pod yield at both locations and in all the sampling periods (Table 8).

Harvest index

The harvest index of groundnut as influenced by phosphorus rates and mulching materials in Samaru and Kadawa during the 2024 dry season is shown in (Table 9). The effect of varieties phosphorus and mulch was variable in both locations. SAMNUT-25 had significantly (P=<0.05) higher harvest index than SAMNUT-24 in Samaru, where there was no statistical difference in the harvest index of the varieties in Kadawa. Application of 60 kgP_20_5 ha^{-1}significantly (P=<0.05) resulted in highest harvest index at both locations, which was followed by 0 kg P_20_5 ha^{-1}at Samaru and application of 30 kgP_20_5 ha^{-1}at Kadawa. The lowest harvest index was observed at Kadawa with 0 kgP_20_5 ha^{-1}. Rice straw mulch significantly (P=<0.05) resulted in highest harvest index at both locations which was followed by polythene and zero mulch which were statistically similar at both locations.

Significant (P=<0.01) interaction was observed between variety and phosphorus rates at Samaru. Highest harvest index was recorded with application of 60kgP_20_5 ha^{-1}and SAMNUT-24 which corresponds with application of 30kg P_20_5 ha^{-1}and SAMNUT-25. 0 kgP_20_5 ha^{-1}with SAMNUT-25 was observed to have the least harvest index (Table 10). Significant (P=<0.01) interaction was observed between variety and phosphorus rates in Kadawa. Increase in phosphorus fertilizer increased harvest index in SAMNUT-24 in which application of 60 kgP_20_5 ha^{-1}with SAMNUT-24 had the highest harvest index, while SAMNUT-24 with 0 kgP_20_5 ha^{-1}had the least harvest index (Table 10).

Significant (P=<0.01) interaction between phosphorus rates and mulch materials was observed in Samaru. Highest harvest index was observed with application of 60kgP_20_5 ha^{-1}and no mulch, whereby increase in phosphorus fertilizer increased the harvest index with no mulch. The least harvest index was observed with $0kgP_20_5$ $ha^{-1}$and both no mulch and polythene sheet (Table 4.37). There was significant (P=<0.01) interaction observed between phosphorus rates and mulch materials in Kadawa. Harvest index increased with increase in phosphorus fertilizer with both zero mulch and polythene sheet. Highest harvest index was recorded with application of $60kgP_20_5$ $ha^{-1}$with no mulch, whereas $0kgP_20_5$ $ha^{-1}$with no mulch had the least harvest index (Table 11)

Table 1: Soil Physical and Chemical Properties of the Experimental Sites for 0 – 30cm during 2024 dry season at Samaru and Kadawa

	Samaru	Kadawa
Physical properties		
Particle Size Distribution (gkg^{-1})		
Clay	140	80
Silt	400	310
Sand	460	610
Textural class	Loam	Sandy loam
Chemical properties		
pH (H_2O) 1:2:5	6.21	6.01
pH 0.01m $CaCl_2$	5.61	5.68
Total N gkg^{-1}	1.10	1.18
Available P $mgkg^{-1}$	9.78	6.84
Organic carbon gkg^{-1}	10.10	11.56
Exchangeable bases (cmol/kg)		
Calcium	2.85	2.58
Magnesium	0.61	0.58
Potassium	0.11	0.15
Sodium	0.16	0.20
Exchangeable Acidity	0.19	0.20
CEC cmol/kg	3.92	3.73

Source: Soil Analysis was, done at Department of Agronomy, Soil Analysis Laboratory, Ahmadu Bello University, Samaru Zaria Kaduna State.

Table 2: 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 2024 dry season

	Plant height (cm)							
	Samaru (WAS)				Kadawa (WAS)			
Treatment	**3**	**6**	**9**	**12**	**3**	**6**	**9**	**12**
Variety (V)								
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
Phosphorus (P) ($kgP_20_5ha^{-1}$)								
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
Mulch Type (M)								
No mulch	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 are significantly different at 5% level using DMRT. WAS= Weeks after sowing. **= Significant at 1% NS = Not significant

Table 3: Interaction of phosphorus and mulching materials on plant height of groundnut in Samaru at 3WAS during 2024 dry season

Mulch	Phosphorus (kg ha^{-1})		
	0	**30**	**60**
No mulch	5.26^{b}	5.45^{b}	5.68^{b}
Polythene	6.83^{b}	5.43^{b}	6.23^{b}
Rice straw	8.56^{a}	9.18^{a}	6.60^{b}
SE±	0.485		

Means followed by different letter in a column are significantly different at 5% level using DMRT.
WAS= Weeks after sowing

Table 4: Number of leaves of groundnut varieties as influenced by phosphorus and mulching materials in Samaru and Kadawa at 3, 6, 9 and 12 WAS during 2024 dry season

	Number of leaves							
	Samaru				Kadawa			
Treatment	**3WAS**	**6WAS**	**9 WAS**	**12WAS**	**3 WAS**	**6WAS**	**9 WAS**	**12 WAS**
Variety (V)								
SAMNUT-24	6.36	18.16	39.89	61.26	8.55	20.73	35.03	59.98
SAMNUT-25	6.23	17.77	37.02	59.44	9.28	20.50	37.33	59.28
SE±	0.261	0.894	1.852	2.157	0.469	0.671	1.271	2.151
Phosphorus(P) (kg$P_2 0_5$ha^{-1})								
0	6.62	17.79	38.56	59.38	9.47	20.60^{ab}	39.18^{a}	59.36
30	6.21	19.10	40.14	61.87	8.46	19.25^{b}	33.56^{b}	59.81
60	6.10	17.02	36.66	59.79	8.82	22.00^{a}	35.83^{ab}	59.73
SE±	0.319	1.095	2.269	2.642	0.575	0.822	1.557	2.634
Mulch Type (M)								
No mulch	6.67^{a}	21.87^{a}	41.12	64.89^{a}	8.32^{b}	23.21^{a}	39.45^{a}	63.74
Polythene	7.06^{a}	15.16^{b}	35.99	59.42^{ab}	10.26^{a}	18.79^{b}	35.00^{ab}	59.26
Rice straw	5.16^{b}	16.87^{b}	38.24	56.72^{b}	8.17^{b}	19.86^{b}	34.11^{b}	55.90
SE±	0.319	1.095	2.269	2.642	0.575	0.822	1.557	2.634
Interaction								
VxP	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 5% NS = Not significant

Table 5: Interaction of phosphorus and varieties on number of leaves of groundnut in Kadawa at 6 WAS during 2024 dry season

Treatment	**Phosphorus (kg $P_2 0_5$)**		
Variety	**0**	**30**	**60**
SAMNUT-24	19.16^{ab}	20.70^{ab}	22.33^{a}
SAMNUT-25	22.04^{a}	17.80^{b}	21.67^{a}
SE±	1.162		

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

Table 6: Canopy spread of groundnut varieties as influenced by phosphorus rates and mulching materials in Samaru and Kadawa at 3, 6, 9 and 12 WAS during 2024 dry season

	Canopy spread (cm)							
Treatment	Samaru				Kadawa			
Variety (V)	**3 WAS**	**6 WAS**	**9 WAS**	**12 WAS**	**3 WAS**	**6 WAS**	**9 WAS**	**12WAS**
SAMNUT-24	9.92	17.05	33.42	42.49	9.27	17.65	26.21	40.21
SAMNUT-25	9.71	17.74	32.73	40.30	9.57	17.47	25.06	40.27
SE±	0.249	0.519	1.194	1.379	0.392	0.507	0.612	1.536
Phosphorus (P) (kg$P_2 0_5$ha^{-1})								
0	10.33^{a}	17.23^{ab}	32.90	40.42	9.38	17.86	25.19	38.55
30	9.87^{ab}	18.52^{a}	34.22	42.95	8.84	17.15	25.71	40.43
60	9.24^{b}	16.43^{b}	32.09	40.83	10.05	17.67	26.02	41.73
SE±	0.305	0.636	1.463	1.690	0.480	0.621	0.749	1.882

Mulch Type (M)								
No mulch	9.83^{ab}	18.39	33.68	43.91	9.02	17.97	26.44	44.18^{a}
Polythene sheet	10.42^{a}	16.91	31.67	40.72	9.99	17.95	25.32	39.36^{ab}
Rice straw	9.19^{b}	16.88	33.87	39.57	9.26	16.77	25.16	37.17^{b}
SE±	0.305	0.636	1.463	1.690	0.480	0.621	0.749	1.882
Interaction								
VxP	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% *= significant at 5%.NS = Not significant

Table 7: Interaction of phosphorus rates and variety on canopy spread of groundnut in Samaru at 6WAS during 2024 dry season

Treatment	Phosphorus (kg P_20_5 ha^{-1})		
Variety (V)	**0**	**30**	**60**
SAMNUT-24	17.92^{a}	18.43	14.80^{b}
SAMNUT-25	16.54^{ab}	18.61	18.10^{a}
SE±	0.898		

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

Table 8: Interaction of phosphorus rates and variety on canopy spread of groundnut in Kadawa at 6WAS during 2024 dry season

Treatment	Phosphorus (kg P_20_5 ha^{-1})		
Variety (V)	**0**	**30**	**60**
SAMNUT-24	17.79^{ab}	18.63^{a}	16.52^{ab}
SAMNUT-25	17.93^{ab}	15.67^{b}	18.82^{a}
SE±	0.878		

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

Table 9: Pod yield of groundnut varieties as influenced by phosphorus rates and mulching materials in Samaru and Kadawa during 2024 dry season

	Pod yield (kg ha^{-1})	
Treatment	**Samaru**	**Kadawa**
Variety	(V)	
SAMNUT-24	1449.1	1649.3
SAMNUT-25	1636.4	1801.0
SE±	121.99	119.24
Phosphorus (P) (kgP_20_5ha^{-1})		
0	1520.9	1663.6
30	1542.2	1672.8
60	1565.2	1839.2
SE±	149.41	146.04
Mulch type (M)		
No mulch	1345.9^{b}	1725.7
Polythene	1427.0^{ab}	1628.3
Rice straw	1855.4^{a}	1821.6
SE±	149.41	146.04
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 are significantly different at 5% level using DMRT.NS = Not significant

Table 10: Performance of groundnut varieties as influenced by phosphorus rates and mulching materials on harvest index in Samaru and Kadawa during 2024 dry season

	Harvest index	
Treatment	**Samaru**	**Kadawa**
Variety (V)		
SAMNUT-24	36.06^{b}	34.10
SAMNUT-25	37.42^{a}	35.02
SE±	0.421	0.342
Phosphorus (P) ($kgP_20_5ha^{-1}$)		
0	26.58^{b}	25.01^{c}
30	41.16^{a}	38.61^{b}
60	42.48^{a}	40.06^{a}
SE±	0.516	0.419
Mulch type (M)		
No mulch	36.12^{b}	33.81^{b}
Polythene	35.96^{b}	34.09^{b}
Rice straw	38.13^{a}	35.78^{a}
SE±	.516	0.419
Interaction		
VxP	**	**
VxM	NS	NS
PxM	**	**
VxPxM	NS	NS

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

Table 11: Interaction of phosphorus and varieties on harvest index of groundnut in Samaru and Kadawa during 2024 dry season

Treatment (A)	**Phosphorus (kg P_20_5)**		
Variety	**0**	**30**	**60**
SAMNUT-24	24.39^{d}	39.24^{b}	44.56^{a}
SAMNUT-25	28.78^{c}	43.10^{a}	40.40^{b}
SE±	0.729		
Treatment (B)			
SAMNUT-24	23.13^{e}	37.02^{c}	42.14^{a}
SAMNUT-25	26.89^{d}	40.19^{b}	37.99^{c}
SE±	0.592		

Means followed by different letter (s) in a column are significantly different at 5% level using DMRT.
Treatment A= Samaru, Treatment B= Kadawa

Table 12: Interaction of phosphorus and mulching on harvest index of groundnut in Samaru and Kadawa during 2024 dry season

Treatment (A)	**Phosphorus (kg P_20_5)**		
Mulch	**0**	**30**	**60**
No mulch	25.12^{e}	39.00^{c}	44.25^{a}
Polythene	25.53^{e}	40.80^{bc}	41.55^{a-c}
Rice straw	29.10^{d}	43.67^{ab}	41.63^{a-c}
SE±	0.893		
Treatment (B)			
No mulch	23.68^{f}	36.10^{d}	41.68^{a}
Polythene	24.13^{f}	38.68^{c}	39.45^{a-c}
Rice straw	27.22^{e}	41.10^{ab}	39.10^{bc}
SE±	0.725		

Means followed by different letter (s) in a column are significantly different at 5% level using DMRT.
Treatment A= Samaru, Treatment B= Kadawa

Discussion

The soil textural class features were loam and sandy loam at Samaru and Kadawa, respectively. Also, the pH of soils at Samaru and Kadawa respectively were slightly below the optimum but fall within the range required by groundnut which is 6.0-6.5 (Chhidda *et al*., 2006). These physical and chemical characteristics were ideal for the production and optimum yield of groundnut.

The general higher growth and yield components of groundnut were observed in Samaru than Kadawa. This could be as a result of relatively higher phosphorus content at Samaru compared to Kadawa.

The two groundnut varieties exhibited minimal differences in growth parameters in both locations. The minimal differences between groundnut varieties could be attributed to variances in their genetic make-up and interaction with the environment.

Usman, (2015) reported that there exhibit a consistent significant difference in growth characters of groundnut which he attributed to variations in their genetic makeup and gene interaction with environment as well as crop management.

The increase in pod yield with increasing phosphorus rates observed in this study could be due to enhancement of symbiotic nitrogen fixation in the varieties. This result is in line with the findings of Kamara *et al*. (2011) who observed high number of pods, pod weight per plant, pod weight per plot and particularly one hundred kernel weights, with increasing phosphorus rates. Similarly, the study is in agreement with Mouri *et al*. (2018) who observed high leaf area, number of branches plant^{-1}, pod yield ha^{-1}, and harvest index with application of 60 kgP_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.

The increased growth parameters of groundnut observed with the use of mulch could be associated with bio availability of macro and micro nutrients during the decomposition of the rice straw mulch. In addition, the favourable soil temperature and soil water under mulch during pod development stage was responsible for higher pod yield and harvest index of observed in this study.

This is in conformity with the report of Ghosh *et al*. (2006) in which favourable soil temperature and soil water under mulch during the pod development stage was the reason for higher pod yield and harvest index of groundnut.

The significant interaction observed among the parameters could be due to the fact that phosphorus helps in the development of more extensive root system and thus enable plants absorb more water and nutrients compared with mulching that increased the water use efficiency of the plants. This in turn could enhance the plant's ability to produce more assimilates which confirm the findings of Mouri *et al.*,(2018) who reported higher values of growth parameters in groundnut.

The interaction between variety and mulch resulted in favourable soil temperature during pod development stage. This is in accord to the report of Ajeigbe *et al.,* (2014) that mulching had positive and significant effects on the phonological, growth and yield parameters of groundnut.

CONCLUSION

It is concluded that both SAMNUT-24 and SAMNUT-25 are suitable for production under irrigation at both ecologies of the savannah. Application of 60 kg P_2O_5 ha^{-1} gave highest number of leaves, pod yield and harvest index in both locations. There were a significantly positive association between groundnut growth and yield parameters in both locations.

Due to the difficulty to keep polythene mulch throughout the growing season in the field, it can be recommended that SAMNUT-25 with application of 60 kgP_2O_5ha^{-1} using rice straw mulch should be used by farmers in the savannah. However, there is need for further research on phosphorous rates with new/improved varieties.

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