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Assessment of Relationship between Physiological Traits, Groundnut Yield and Yield Components of Groundnut (*Arachis hypogeal L.)* Germplasm

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Abstract

Physiological traits contributing to high yield in groundnut might reveal the underlying mechanism from which improved strategies could be developed to enhance the effectiveness and progress in breeding for yield component of groundnut. The study aim to determine some physiological characters such as chlorophyll content, canopy temperature, leaf area index (LAI) and photosynthetic active radiation (PAR) related to groundnut yield. Twenty-five (25) groundnut accessions were evaluated in randomized block design (RBD) with two replications at ICRISAT research farm, Wasai, Minibir, Kano State, Nigeria. The study was carried out during the 2014 rainy season to evaluate physiological relationship to yield variations in groundnut accessions from different parts of Nigeria and Mali. The observations on Chlorophyll Content, Canopy Temperature, leaf area Index (LAI), Photosynthetic Active Radiation, Pod length, Pod width, pod yield, shelling percentage, hundred seed weight and fodder yield characters were recorded. The physiological and yield data were subjected to analysis of variance General Linear Model (GLM) using SAS verse 9.3 means were separated using Least Significant Difference (LSD) at P>0.05 The accessions were significantly different (1.207) for all the physiological traits and yield traits except for pod length, pod width and hundred seed weight where no significant difference was recorded. The highest dry pod and fodder yield was recorded from the accessions 25, 23 and 22 due to significant favorable yield contributing characters like: chlorophyll content, canopy temperature, Leaf Area Index (LAI), Photosynthetic Active Radiation, pod length, pod width, pod yield, shelling percentage, hundred seed weight (g), and fodder weight (g). With regard to physiological traits and yield and yield related traits, accessions 25, 23, and 22 were considered as promising genotypes for future breeding programme for pod and fodder yield improvement.

Keywords: Physiological trait, yield and yield contributing traits.

INTRODUCTION

Groundnut (*Arachis hypogaea L.*) is one of the most important legumes in subsistence and commercial agriculture in arid and semi-arid regions of the world (Izge*et al.*,2005). It is grown extensively in about 108 countries with over two-thirds of global production coming from seasonally rained areas of tropical, sub-tropical and warm regions of the world. The groundnut cultivation globally covers 23.50 million hectares with 35.52 million tons of production (FAOSTAT 2009). Information on physiological traits contributing to high yield in groundnut might reveal the underlying mechanism from which improved strategies could be developed to enhance the effectiveness and progress in breeding for yield. Some physiological characters such as chlorophyll content, canopy temperature, leaf area index (LAI) and photosynthetic active radiation (PAR) are related to groundnut yield. Chlorophyll content was directly related to the amount of chlorophyll in the leaf of groundnut (Akkasaeng *et al*., 2008). The amount of chlorophyll in a leaf depends on how the plant is exposed to optimum condition that favor or enhance photosynthesis. Photosynthesis is one of the major physiological processes, and crop yield depends on proper functioning of photosynthesis (Rasmusson *et al*., 1983). Canopy temperature is another physiological aspect of groundnut that is mostly related to drought. Groundnut varieties vary in terms of their canopy temperature as stated by Wahid *et al*.,(2007).

In normal physiological circumstances, the rise in canopy temperature leads to the closure of stomata to reduce higher transpiration or loss of water and results in lower carbon exchange which cause poor growth and poor pod yield. Leaf area index (LAI) is another important physiological factor because the interaction between vegetation surface and the atmosphere e.g. radiation uptake, precipitation interception, energy conversion and gas exchange is substantially determined by the vegetation surface (Monteith and Unsworth, 1990). The photosynthetically active radiation measurement is important in evaluating the effect of light on groundnut yield. As stated by Papioannou *et al*., (1993) that canopy photosynthetically

active radiation (PAR) interception of groundnut increase with the increased crop development. As ground covered by leaf canopy increase, plant grow to cover the inter row spaces leading to higher rate of light interception, transpiration and therefore higher rate of pod yield.

MATERIALS AND METHODS

Experimental Site

The research was conducted at ICRISAT (International Crops Research Institute for Semi-Arid Tropics) research farm located at Wasai Minjibir Kano state Nigeria. The geographical location of Wasai Minjibir is 12° 9′ 14′ north 8° 40′ 45′ east. The Wasai Minjibir has altitude of 508m (1669ft) above the sea level with an average temperature of 30°C (80°F) and long term average rainfall of 880mm annually and mean relative humidity of 39.7%.

The germplasms were collected from different sources in Nigeria and outside Nigeria (Mali). The experiment was conducted in the rainy season of the year 2014. The treatment consisted twenty-five (25) groundnut germplasm collected from different sources of Nigeria and Mali. About one hundred (100) kg/ha ssp (fertilizer) was applied. The experimental design was Randomized Complete Block Design (RCBD) with two replications.

The land was ploughed and ridged with work bulls mounted with plough. The ridges are made 0.75m. The seeds were sown on plot size of 2 rows of 4m length with 30cm between rows and 10cm between plants. 1-2 groundnut seeds are sown per hole at 5-6cm depth in the soil according to the availability of germplasm seeds.

Manual weeding (using hoe) and hand puling was done to control weeds. The weeding was done twice. The first weeding was done three weeks after sowing and second weeding was done seven weeks after sowing.

Physiological Traits Evaluation

Four physiological traits were evaluated and recorded (Table 1). These physiological traits are chlorophyll content which was measured using SPAD meter (ranges from 21.35 to 52.75), canopy temperature which was measured using INFRARED THERMOMETER (the canopy temperature measured ranges from 26.30 ^{o}C to 41.90 ^{o}C), Photosynthetic Active Radiation (ranges from 564 to 240.5) and Leaf Area Index (which ranges from 0.82 to 2.39). Both Photosynthetic Active Radiation and Leaf Area Index were measured using LP-80 CEPTOMETER.

Chlorophyll Content

The chlorophyll content was measured using SPAD meter (SPAD 502 meter). A number of five well developed leaf from main stem of each plant was selected. Each leaf was inserted under the detector and pressed and the machine automatically record the chlorophyll content and produce an average value of chlorophyll content of five leaves which were recorded. this method was repeated on ten plants from each plot. Therefore, an average of fifty readings from each plot was calculated and recorded. The procedure was adopted by of Thakur *et al*., (2013) and Painawadee *et al*., (2009)

Canopy temperature

Canopy temperature was measured using the method adopted by Balota *et al*. (2012). This involve the use of gun shaped infrared thermometer. The nose of thermometer is pointed at the canopy of the seedling, the trigger of the thermometer is squeezed and automatically

record the temperature. This was done five times on each row, i.e. ten times on each plot and the average value was recorded in a field plan book.

PAR (Photosynthetic Active Radiation) (μM/S^{-1})
Photosynthetic active radiation was measured using LP-80 ceptometer. It was measured on the very bright day. Initially, the machine was calibrated by setting the date, time and geographical location of the farm. The machine sensor stick was placed 40-50 centimeters above the plant, the atmospheric solar radiation was recorded by pressing upper arrow, then the sensor stick is inserted under the canopy and the down arrow is pressed, the machine automatically records the PAR and LAI and stored. The procedures was adopted by Breda, (2003) and Idinoba *et al.,* (2008).

LAI (Leaf Area Index)
Leaf area index was also measured using LP-80 ceptometer at the same time and the same procedure with PAR. But during the measurement, the LAI is recorded when the sensor stick is inserted under the canopy and the down arrow was pressed. This method was carried out in accordance with the procedure of Breda, (2003) and Idinoba *et al.,* (2008)

Yield and yield related traits evaluation.
The groundnut accessions were evaluated for six (6) yield and yield related traits using digital Vanier caliper for the measurement of pod length and pod width and digital weighing scale for the measurement of pod yield, shelling percentage, hundred seed weight and fodder yield. Six yield and yield related traits were recorded. The yield and yield related traits include, pod yield (which ranges from 80.50g to 353.5g), shelling percentage (which ranges from 52.65% to 73.55%), hundred seed weight (which ranges from 26.00 to 58.00) and fodder yield (which ranges from 100g to 625g).

Pod Length (mm)
Ten matured pods were collected at random from each accession. The digital Vanier caliper was used to measure the length of each pod by inserting the pod into measurement rack. The length of the pod was recorded from the reading screen, and the average length of ten (10) matured pods is calculated and recorded. This process is repeated on all the twenty-five (25) accessions.

Pod Width (mm)
Ten matured pods were collected at random from each accession. The digital Vanier caliper was used to measure the width of each pod by inserting the pod into measurement rack. The width of the pod is recorded from the reading screen, and the average width of ten (10) matured pods is calculated and recorded. This process was repeated on all the twenty-five (25) accessions.

Dry Pod Weight (g)
The harvested dry pods of each accession were cleaned by removing the dust and other unwanted things. The digital weighing scale was calibrated to zero gram and the dry groundnut pods was placed on weighing scale which gives the weight in grams. The result was recorded in field plan book adopted by Nath and Alam, (2002) and Swamy *et al.,* (2006).

Shelling Percentage
The method adopted by Thakur *et .al*., (2013) . After weighing the groundnut dry pods, the shells of the pods are removed using hands. The groundnut kernels or seeds of each accession

are measured in grams using the same procedure of measuring dry pod weight with digital weighing scale. Therefor the seed mass and pod mass were recorded in field plan book which are the data for calculating the shelling percentage using the following formula:

$$shelling\ \% = \frac{seedmass}{podmass} \times 100$$

Hundred Seed Weight:
One hundred matured seeds were collected at random from each accession according to the method adopted by Thakur *et al.,*(2013) and measured as pod and fodder yield was measured using digital weighing scale. The data was recorded in field plan book for all the 25 accessions.

Dry Fodder Weight (g)
After harvesting, the fodder of each accession was allowed to dry. The dry fodder weight was obtained by measuring the fodder of each accession using the same procedure of measuring the dry pod adopted by Nath and Alam, (2002). The kernel weight using digital weighing scale in grams and the data was recorded in field plan book.

Data Analysis
The data obtained were subjected to Analysis of Variance (ANOVA) in General Linear Model (GLM) using SAS verse 9.3.And means were separated using Least Significant Difference (LSD) at P> 0.05%.

RESULTS AND DISCUSSION
The physiological data obtained from the ANOVA is presented in Table 1. The result showed that there are significant differences among all the physiological traits of 25 groundnut accessions. This is indicating the presence of large magnitude of genetic variability among the 25 groundnut accessions. This result is in conformity with the result of Ntare, *et.al.,* (2001) who observed a significant difference among 625 genotypes for pod yield and physiological traits. However, Singh, *et.al.,* (2003) found a significant variation in pod yield, Canopy Temperature, Leaf Area Index and SPAD Chlorophyll meter reading of eight Virginia type peanut.

Accession 12 has exhibited the highest Chlorophyll content (52.75), followed by accession 25 (51.60) and accession 24 exhibited a lowest Chlorophyll content (21.35). Accession 15 has the highest Canopy Temperature (41.90 ^{0}C), followed by accession 7 (41.10 ^{0}C), while accession 8 has the lowest Canopy Temperature (26.30 ^{0}C). The result is also indicating that the accession 21 has exhibited a highest Leaf Area Index (2.39), followed by accession 25 (2.30), while accession 17 has exhibited the lowest Leaf Area Index (0.82). Accession 15 showed the highest Photosynthetic Active Radiation (564), followed by accession 25 (544), and accession 21 showed the lowest Photosynthetic Active Radiation (240.5). The range for all the physiological traits was also presented in Table 1,2,3 and 4.

However, according to Jongrungklang *et al*., (2008), the canopy of peanut genotypes with low canopy temperature had higher transpiration and higher CO_2 exchange rate than peanut genotypes with high canopy temperature. According to present study, the accession number 15 with highest canopy temperature exhibited a significantly high amount of pod yield, while the previous study accession number 95 with lowest canopy temperature exhibit a low pod yield. This result was supported by Koolachart *et al*., (2013) who stated that the relationship between canopy temperature and pod yield is not found because genotypes had high canopy temperature and had high number of pods per plant. And also Koolachart *et al*., (2013)

suggested that the relationship between physiological traits related to drought and yield component of peanut genotypes are not well understood.

The yield and yield related traits data also obtained from the ANOVA was presented in Table 2. The result showed that there is significant difference among all the yield and yield related traits for 25 accessions except for pod length, pod width and hundred seed weight. Pod yield, shelling percentage and fodder weight are indicating the presence of large magnitude of genetic variation. Conversely, pod length, pod width and hundred seed weight showed no significant difference evidencing low variation in these traits.

These results were confirmed by the findings of Nath and Alam (2002) who found highly significant variation among the groundnut genotypes for pod yield, shelling percentage, days to 50% flowering and plant height. However, Saleh and Masiron (1994) found a highly significant differences in pod yield, seed yield number of pods per plant, fodder yield and days to flowering. Similar findings were also reported by Meta and Monpara (2010) and Zaman *et al. (*2011).

Among the accessions evaluated for yield and yield related traits, accession 6has the highest pod length (30.9mm) followed by accession 5 (29.8mm), while accession 15 has the lowest pod length (17.3mm). Accession 1 has the highest pod width (13mm) followed by accession 4 (12.5mm), while accession 15 has the lowest pod width (7.9mm).

Accession 25 and 23 has shown the highest pod yield (353.5g each) followed by accession 22 (341g), while accession 3 has the lowest pod yield (80.5).The accession with the highest shelling percentage is 17 (73.55g) followed by accession 13 (72.85g), while accession 8 has the lowest shelling percentage (52.65g). The highest hundred seed weight was exhibited by accession 25 (58g) followed by accession 16 (46g), while the lowest hundred seed weight was exhibited by accession 20 (26g). The highest fodder yield was exhibited by accession 23 (625g) followed by accession 24 (550g), while accession 7 exhibited the lowest fodder yield (100g). The range for all the yield and yield related traits are presented in Table 5,6,7,8,9 and 10.

The accessions 25,23 and 22 were significantly superior for dry pod yield and dry fodder yield. The pod and fodder yield of these accessions might be due to favorable yield contributing characters like chlorophyll content, canopy temperature, Leaf Area Index (LAI), Photosynthetic Active Radiation (PAR), pod length, pod width, pod yield, shelling percentage, hundred seed weight and fodder yield. These findings are similar to findings of Mishra *et al.,* (1991), Jadhav and Sengupta (1991) and Jayalakshmi *et al*., (2000).

From the result obtained in the present study, it was concluded that, the accession 23 with the highest dry pod yield and highest dry fodder yield, accession 25 also with high dry pod yield and significantly high fodder yield and accession 22 with significantly high pod and fodder yield are high yielding varieties. While, accession 3 with lowest dry pod yield and accession 7 with low dry pod yield and lowest fodder yield indicated poor translocation of assimilate from source to sink, therefore, these accessions could be utilized by the breeders in their breeding programmes for the high dry pod and fodder yield improvement.

The physiological traits like chlorophyll content, canopy temperature (CT), Leaf Area Index(LAI) and Photosynthetic Active Radiation(PAR) were found at highest rate in some accessions like accession 12 which resulted in high shelling percentage, hundred seed weight and fodder yield.

On the basis of relative ranking, the accessions 25,23, 22 and 12 were promising for maintaining high yield. Therefore, these accessions can be considered for future breeding programme for improving the yield heterosis. Physiological characteristics of 25 groundnut accessions evaluated during 2014 rainy season in ICRISAT research farm Minjibir Kano.

Table 1: Total SPAD value of 25 Groundnut Accessions during 2014 rainy season.

Acc.no	SPV	Acc.no	SPV	Acc.no	SPV	Acc.no	SPV	Acc.no	SPV
1	44.45	6	36.15	11	42.15	16	40.60	21	33.75
2	38.35	7	40.05	12	52.75	17	45.35	22	45.45
3	36.55	8	46.15	13	50.75	18	37.40	23	38.20
4	36.25	9	42.25	14	38.70	19	36.35	24	21.35
5	40.15	10	45	15	37.45	20	42.65	25	51.60
MEAN	41.75	MEAN	41.75	MEAN	41.75	MEAN	41.75	MEAN	41.75
LSD	1.2507	LSD	1.2507	LSD	1.2507	LSD	1.2507	LSD	1.2507
RANGE	52.75-21.35	RANGE	52.75-21.35	RANGE	52.75-21.35	RANGE	52.75-21.35	RANGE	52.75-21.35

Key: Acc. no: Accession number; SPV: SPAD value; LSD: Least Significant Difference

Table 2: Total Canopy Temperature of 25 Groundnut Accessions during 2014 rainy season.

Acc.No	CT	Acc.No	CT	Acc.No	CT	Acc.No	CT	Acc.No	CT
1	36.55	6	35.5	11	34.35	16	38.15	21	31.4
2	39.45	7	41.1	12	31.5	17	37.4	22	33.9
3	38.75	8	26.3	13	30.8	18	38.4	23	30.05
4	37.8	9	36.85	14	34.5	19	31.4	24	35.95
5	33.55	10	33.7	15	41.9	20	32.65	25	35.4
MEAN	34.391	MEAN	34.391	MEAN	34.391	MEAN	34.391	MEAN	34.391
LSD	1.0619	LSD	1.0619	LSD	1.0619	LSD	1.0619	LSD	1.0619
RANGE	41.9-26.3	RANGE	41.9-26.3	RANGE	41.9-26.3	RANGE	41.9-26.3	RANGE	41.9-26.3

Key: Acc.no: Accession number CT: Canopy Temperature; LSD Least Significant Difference

Table 3: Total Photosynthetic Active R+adiation of 25 Groundnut Accessions during 2014 rainy season.

Acc.No	PAR	Acc.No	PAR	Acc.No	PAR	Acc.No	PAR	Acc.No	PAR
1	348	6	378.5	11	342.5	16	524.5	21	430.5
2	379	7	366.5	12	415	17	435.5	22	400.5
3	350	8	514.5	13	357.5	18	241.5	23	471
4	324.5	9	334.5	14	432	19	378	24	275
5	362	10	415.5	15	564	20	319.5	25	544
MEAN	34.391	MEAN	34.391	MEAN	34.391	MEAN	34.391	MEAN	34.391
LSD	1.0619	LSD	1.0619	LSD	1.0619	LSD	1.0619	LSD	1.0619
RANGE	240.5-564	RANGE	240.5-564	RANGE	240.5-564	RANGE	240.5-564	RANGE	240.5-564

Key: Acc.no: Accession number; PAR: Photosynthetic Active Radiation; LSD: Least Significant Difference

Yield and yield related characteristics of 25 groundnut accessions evaluated during 2014 rainy season in ICRISAT research farm Minjibir Kano.

Table 4: Pod Yield of 25 Groundnut Accessions during 2014 rainy season.

Acc.No	PYLD	Acc.No	PYLD	Acc.No	PYLD	Acc.No	PYLD	Acc.No	PYLD
1	87	6	91.5	11	142	16	121.5	21	353.5
2	106	7	96	12	168.5	17	149	22	341
3	80.50	8	187	13	135.5	18	95	23	353.5
4	110.50	9	174	14	124.5	19	110	24	283
5	98	10	118.50	15	90.5	20	114.5	25	353.5
MEAN	34.391	MEAN	34.391	MEAN	34.391	MEAN	34.391	MEAN	34.391
LSD	1.0619	LSD	1.0619	LSD	1.0619	LSD	1.0619	LSD	1.0619
RANGE	80.50-353.50	RANGE	80.50-353.50	RANGE	80.50-353.50	RANGE	80.50-353.50	RANGE	80.50-353.50

Key: Acc.no: Accession number PYLD: Pod Yield; LSD: Least Significant Difference

Table 5: Shelling % of 25 Groundnut Accessions during 2014 rainy season.

Acc.No	SHL%	Acc.No	SHL%	Acc.No	SHL%	Acc.No	SHL%	Acc.No	SHL%
1	60.35	6	65	11	69.3	16	66.25	21	59.4
2	59.40	7	70.9	12	68.3	17	73.55	22	68.85
3	57	8	52.65	13	72.85	18	66.1	23	67.5
4	62.45	9	67.5	14	55.8	19	69.1	24	60
5	59.65	10	66.15	15	65.25	20	65.45	25	71.65
MEAN	34.391	MEAN	34.391	MEAN	34.391	MEAN	34.391	MEAN	34.391
LSD	1.0619	LSD	1.0619	LSD	1.0619	LSD	1.0619	LSD	1.0619
RANGE	77.25-43.6	RANGE	77.25-43.6	RANGE	77.25-43.6	RANGE	77.25-43.6	RANGE	77.25-43.6

Key: Acc.no: Accession number SHL%: Shelling Percentage LSD: Least Significant Difference

Table 6: Hundred Seed Weight of 25 Groundnut Accessions during 2014 rainy season

Acc.No	HSW	Acc.No	HSW	Acc.No	HSW	Acc.No	HSW	Acc.No	HSW
1	45	6	35	11	32	16	46	21	30
2	28	7	46	12	40	17	36	22	41
3	34	8	35	13	40	18	35	23	46
4	44	9	40	14	40	19	34	24	36
5	45	10	32	15	35	20	26	25	58
MEAN	38.36	MEAN	38.36	MEAN	38.36	MEAN	38.36	MEAN	38.36
LSD	0	LSD	0	LSD	0	LSD	0	LSD	0
RANGE	70-32	RANGE	70-32	RANGE	70-32	RANGE	70-32	RANGE	70-32

Key: Acc.no: Accession number HSW: Hundred Seed Weight LSD: Least Significant Difference

Table 7: Fodder yield of 25 Groundnut Accessions during 2014 rainy season.

Acc.No	**FYLD**	**Acc.No**	**FYLD**	**Acc.No**	**FYLD**	**Acc.No**	**FYLD**	**Acc.No**	**FYLD**
1	400	6	190	11	450	16	275	21	300
2	165	7	100	12	450	17	350	22	425
3	275	8	225	13	350	18	250	23	625
4	190	9	250	14	400	19	325	24	550
5	550	10	250	15	185	20	275	25	275
MEAN	323.20	MEAN	323.20	MEAN	323.20	MEAN	323.20	MEAN	323.20
LSD	174.16	LSD	174.16	LSD	174.16	LSD	174.16	LSD	174.16
RANGE	625-175	RANGE	625-175	RANGE	625-175	RANGE	625-175	RANGE	625-175

Key: Acc.no: Accession number FYLD: Fodder Yield; LSD: Least Significant Difference

CONCLUSION

From the results obtained in the present study, it was concluded that, the accessions 25, 23 and 22 with highest dry pod and fodder yield are high yielding. The accessions 12 and 13 showed the highest chlorophyll content and showed a significant amount of shelling percentage, hundred seed weight and fodder yield. The accessions 3 with the lowest dry pod yield, low shelling percentage, low hundred seed weight and significantly low fodder yield indicated poor translocation of assimilate from source to sink. Therefore, this accession could be used for breeding programme for high yielding.

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