Influence of Single and Twin Row Pattern on Yieldand Yield Components of Two Groundnut (*Arachishypogaea* L.*)* Varieties in Ghana

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Abstract: ***Two field experiments were conducted in the research field of Mampong - Ashanti campus, Ghana from May to August, 2017 and 2018 to compare interactions of single or twin row pattern onyield and yield components ofgroundnut.The experimental design was a 2 x 4 factorial laid in a randomized complete block design (RCBD) with three replicates. The factors studied included: (A) Varieties [(i) Yenyawosoand (ii) Otuhia] and (B) Row pattern [(i) 50 × 10 cm single row, (ii) 60 × 10 cm single row, (iii) [50 × 20 cm] × 20 cm twin row and (iv) [60 × 20 cm] × 20 cm twin row.The result showed that Otuhia produced the widest canopy spread at 86 days after planting (DAP), highest number of pods per plot, significantly higher pod weight per plot,heavier haulm weight at harvest than Yenyawoso, highest pod and seed yield (kg/ha) per plot.The 60 x20 x 20 cm twin row pattern produced the widest canopy spread at 86 DAP and highest seed yield (kg/ha) per plot in both 2017 and 2018 growing seasons.The 60 x 10 single row pattern produced the heaviest haulm weight at harvest and highest number of filled pods per plot during the 2018 growing season. Farmers should grow Otuhia variety of groundnut using 60 x 20 x 20 cm twin row pattern or 60 x 10 cm single row pattern for highest seed yield, heaviestpod and seed weight, highest number of filled pods and heaviest haulm weight as fodder to feed livestock.***

Keywords: Groundnut, Otuhia, Yenyawoso, single row pattern, twin row pattern, seed yield

1. Introduction

Groundnut is one of the most important oilseedscrop produced in the world.The annual food and groundnut production was around 45 million tonnes and it is the fifth major oilseeds crop in the world (FAO, 2015).Groundnut the most important grain legume grown in Ghana (MoFA, 2014) is mostly cultivated under rainfed conditions largely within the Guinea savannah zone (Oteng- Frimpong*et al.*, 2017) and also in forest-savannah transitional zone in the country.Groundnut provides highly nutritious meals and a protein substitute for household with fewer resources to acquire meat products(Martey*et al*., 2015). Sale of the grains fetches additional income for the households and the haulms serve as high quality protein fodder for livestock (Martey*et al.*, 2015). Despite the importance of groundnut the grain yield on farmers' fields is still low. In Ghana the average yield of groundnut was estimated at 1.5 Mt/ha as against the estimated potential yields of 2.5 Mt/ha (MoFA, 2016). The average yield of groundnut in Ghana was 1.10 Mt/ha compared to 3.57 Mt/ha obtained in China and 4.19 Mt/ha in United States (USDA, 2018). The decline in yield may be attributed to improper use of agronomic practice such as row planting spacing and pattern.The manipulation of row spacing dimensions, plant populations and the overall spatial arrangement of crop plants in a field has been the subject of considerable discussion among farmers and agronomists for many years.Many field trials have been conducted to determine the effect of row pattern on yield of groundnut. Twin row planting effect on groundnut has been reported by Arioglu, (2017) in Cukurova region using 70 x 25 x 70 x10 cm, 75 x 25 x 75 x 10 cm and 80 x 25 x 80 x 10 cm twin row planting pattern and 70 x 10 cm, 70 x 15 cm and 70 x 20 cm single row planting pattern. The 70 x 25 x 70 x 10 cm had the highest pod yield of 7833.6 kg/ha while 70 x 15 cm single row pattern had pod yield of 6688.8 kg/ha (Arioglu, 2017).

Crop response to row planting pattern can be influenced by variety selection.Groundnut varieties vary in the duration of plant growth and maturity, growth habits and branching patterns that range from the erect and the semi - erect and runner type with alternated branching (Onat, 2017). For new crop varieties, different aspects of spatial arrangement need to be understood (Konlan*et al*., (2013). The number of plants per unit area is one of the important yield determinants of field crops (Gulluoglu*et al*., (2016b). Row pattern is thus one of the main factors that have an important role on yield and quality of groundnut. Altering row pattern and variety can affect crop growth, yield and yield components in groundnut. Researches to compare the interaction of single and twin row pattern on improved varieties of groundnut yield however,are still new and there is limited information in Ghana.There is the need for further assessments on effect of single and twin row patternand their interaction on groundnut yield and yield components in the study area. The objective of this study was to compare interactions of single and twin row pattern onyield and yield componentsof two varieties ofgroundnut in the forest-savannah transition zone of Ghana.

2. Materials and Methods

2.1 Description of study area

A two field experiments were conducted in 2017 and 2018 growing seasons at College of Agriculture Education of the University of Education, Winneba, Asante Mampong campus research fields. The experimental site is gently incline and is well drained. The climatic conditions at the experimental sites for 2017 and 2018 cropping seasons is presented in Table 1.The climatic conditions during the field research periods show that differences in environmental factors (rainfall, temperature and relative humidity) were shown in both 2017 and 2018 growing seasons. The overall monthly rainfall during the 2017 growing season was 512.4 mm and it occurred from May to August, 2017 with the peak in May and June (Meteorological Department- Mampong-Ashanti, 2017). The average monthly temperature of the experimental site for the 2017 growing season was between 21.7 °C to 32.4 °C, with the highest daily of 32.4 °C occurring in May. The mean monthly relative humidity ranged from 63% to 97% with the highest occurring between June and July. In the 2018 growing season, the overall monthly rainfall was 568.0 mm and it occurred from May to August, 2018 with the peak in May and June (Meteorological Department- Mampong- Ashanti, 2018). The average monthly temperature of the experimental site for the 2018 growing season was between 21.2 °C to 31.1 °C, with the highest daily of 31.1 °C occurring in May. The mean monthly relative humidity ranged from 65% to 92% with the highest occurring between May and June. The soil at the experimental site has been categorized as Chronic Luvisol and locally as the Bediesiseries with a pH range of 4.0-6.5 suitable for root, cereal, vegetable and legume crops production (Asiamah, 1988; FAO/UNESCO,1988) legend.

2.2 Experimental design and planting

The experimental design was a 2 x 4 factorial laid in a Randomized Complete Block Design (RCBD) with three (3) replications. The factors studied included: (A) Variety (Yenyawoso and Otuhia) and (B) Row pattern (i) 50 cm × 10 cm single, (ii) 60 cm × 10 cm single, (iii) [50 cm × 20 cm] × 20 cm twin row and (iv) [60 cm × 20cm] × 20 cm twin row.

The total field size of 28.8 m × 13 m (374.4 m^2) was demarcated, cleared, lined and pegged and ridges prepared. Each experimental plot measured 2 m x 2 m, 2.4 m x 2 m, 2.8 m x 2 m and 3.2 m x 2 m respectively based on the respective treatment. A space of 2 m was left between blocks with 1 m interval between plots. Two groundnut varieties Yenyawoso and Otuhia seeds obtained fromCSIR of Crops Research Institute in Fumesua near Kumasi, Ghana were used as a plant material in the study. Yenyawoso groundnut variety has a semi-erect plant type, with 50% oil content while Otuhia has a spreading plant type with 49% oil content. Both varieties areresistant to rust with high yield potential. Yenyawoso and Otuhia have averagely two seeds per pod and a maturity period of between 90 to 115 days respectively. Three seeds of Yenyawoso and Otuhia were planted per hill at a depth of 3-4 cm according to row planting pattern.Seedlingswere thinnedto2 plants per hill in single row pattern and 1 plantper hill in twin row pattern 8 days after emergence. Each treatment plot had 4 rows on single row pattern with thirty (30) plants on each row and eight (8) rows on twin row pattern with fifteen (15) plants on each row.

Table 1: Climatic data for 2017 and 2018 experimental periods

Month	Total monthly rainfall (mm)		Mean monthly Relative humidity (%) (Hours GMT)				Mean monthly temperature (^{o}C)			
			06.00	06.00	15.00	15.00	Minimum		Maximum	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
May	161.2	184.6	95	91	63	65	23.6	22.9	32.4	31.1
June	175.0	185.5	97	92	70	73	23.0	22.5	30.6	29.7
July	139.3	157.2	97	89	75	73	21.8	22.0	29.2	29.8
August	51.8	40.7	96	86	73	71	21.7	21.2	27.2	28.3
Total	512.4	568.0								

(Meteorological Department- Mampong-Ashanti, Ghana, 2017, 2018)

2.3 Data collection and analysis

Data were collected on sixty plants from the two central rows and the means were taken. The parameters measured werecanopy spread,days to 50% pegging, haulm weight at harvest (kg), number of filled and unfilled pods per plot, seed yield per plot (kg/ha), number of pods per plot, pod and seed weight per plot and yield (kg/ha). Number of pods per plot,as well as number of filled and unfilled pods per plot was counted from the two harvestable areas. Days to 50% pegging was determined when half of the plants from the two middle rows were observed to have developed peg of small and thin crack at the base of the plant. The days were counted from the day of planting to when pegs were formed. Pods, seeds and haulm from the two middle rows per plot at harvest were weighed for the determination of pod weight, seed weight and haulm weight (kg)per plot using electronic weighing scale.Seed yield per plot was estimated by multiplying the number of seeds per pod by the number of pod per plot and weight of seeds per plot. Data collected were subjected to ANOVA using GenStat Statistical Package, version 11.1. Least significant difference (LSD) was used to separate means at 5% level of probability.

3. Results

3.1 Vegetative growth

3.1.1 Canopy spread

There was general increase in canopy spread from 30 days after planting (DAP) to 86 DAP.Otuhia differed significantly from Yenyawoso in canopy spread at 30 days after planting (DAP) during the 2017 growing season (Table 2). There was no significant difference between Otuhia andYenyawoso in canopy spreadfrom 44 DAP to 86 DAP in both 2017 and 2018 growing seasonsalthough differences exist between variety means (Table 2). The50 × 10 cm single row pattern differed from the other row patterns in canopy spreadat 30 DAP and also differed from 50 x 20 x 20 cm and 60 x 20 x 20 cm twin row planting at 44 DAP (Table 2). Canopy spread during the 2017 growing season was not significantly influenced by row patternfrom 58 to 86 DAP and also interaction by variety and row pattern from 30DAP to 86 DAP although difference exist among treatment (Table 2).

There was no significant difference between Otuhia and Yenyawoso in canopy spread at 30 DAP during the 2018 growing season (Table 3). However, Yenyawoso differed significantly (($P < 0.05$) from Otuhia in canopy spread from 44 DAP to 86 DAP in the same growing season. The 60×10 cm single row pattern differed significantly from 60 × 20 cm × 20 cm twin row pattern in canopy spread at 30 DAP and also from 50 x 20 x20 cm and 60 × 20 cm × 20 cm twin row pattern at 44 DAP during the 2018 growing season (Table 3).Canopy spread during the 2018 growing season was not significantly influenced by interaction between varietyand row pattern from 30 DAP to 86 DAP(Table 3).

Table 2: Canopy spread (cm) as affected by variety and row pattern during the 2017 growing season

	Days After Planting				
Treatment	30	44	58	72	86
Variety					
Otuhia	38.5	65.8	83	101.6	171
Yenyawoso	34.9	67.2	87.5	108.2	126
Mean	36.7	66.5	85.2	104.9	148.5
LSD ($P \leq 0.05$)	2.73	NS	NS	NS	NS
Row pattern					
50 x10 Single	41.1	73.9	92.2	110.4	132
60 x10 Single	36	69.6	85.9	107.8	125
50 x 20 x 20 Twin	36.3	62.2	83.1	101.5	120
60 x 20 x 20 Twin	33.5	60.1	79.8	99.7	217
Mean	36.7	66.5	85.2	104.9	148.5
LSD ($P \leq 0.05$)	3.86	4.77	NS	NS	NS
Variety x Row pattern Interaction	NS	NS	NS	NS	NS

Table 3: Canopy spread (cm) as affected by variety and row pattern during the 2018 growing season

	Days after planting				
Treatment	30	44	58	72	86
Variety					
Otuhia	34.4	54.2	68.7	70.4	87.4
Yenyawoso	34.8	64.5	75.8	82.3	100.5
Mean	34.6	59.3	72.3	76.3	93.9
LSD ($P \leq 0.05$)	NS	4.07	4.77	4.69	7.82
Row pattern					
50 x10 Single	36.8	61.2	73.4	75.4	94.8
60 x10 Single	37.1	64.2	76.2	81.7	101.2
50 x 20 x 20 Twin	33.3	57.6	71.4	74.2	92.1
60 x 20 x 20 Twin	31.2	54.3	68.2	74.1	87.7
Mean	34.6	59.3	72.3	76.3	93.9
LSD ($P \leq 0.05$)	4.1	5.76	NS	NS	NS
Variety x Row Planting Pattern Interaction	NS	NS	NS	NS	NS

3.2 Phenology

3.2.1 Days to 50% pegging

There was a significant difference between Yenyawoso from Otuhia in days to 50% pegging (Table 4). Yenyawoso pegged between 6 to 7 days earlier than Otuhiain both 2017 and 2018 growing seasons (Table 4). Days to pegging in both 2017 and 2018 growing seasons was not significantly influenced by row pattern and interaction between variety and row pattern (Table 4). Both Yenyawoso and Otuhiaand row pattern pegged earlier during the 2018 growing season than during the 2017 growing season (Table 4).

3.3 Yield and Yield Components

3.3.1 Number of pods per plot

There was no significant difference between variety and row pattern and their interaction in number of pods per plot in both 2017 and 2018growing seasons although differences exist among treatment (Table 4).Otuhia and Yenyawoso planted on both single and twin row pattern during the 2018 growing season had higher number of pods per plot than those planted on same during the 2017 growing season (Table 4).

3.2.2 Number of filled pods per plot

Thenumber of filled pods per plotwas not significantly influenced by variety, row pattern and their interaction in both 2017 and 2018 growing seasons although differences exist between treatments (Table 4). The number of filled pods per plot for 2018 was however, higher than those produced during the 2017 cropping season (Table 4).

Table 4: Days to pegging, number of filled pods per plot and number of pods per plot as affected by variety and row pattern during the 2017 and 2018 growing seasons

Treatment	Days to pegging 2017	Days to pegging 2018	Number of filled pods per plot 2017	Number of filled pods per plot 2018	Number of pods per plot 2017	Number of pods per plot 2018
Variety						
Otuhia	45	43.4	549.33	1358	892.58	2076
Yenyawoso	38	37.1	517.17	1394	793.17	1844
Mean	41.5	40.2	533.25	1376	842.88	1960
LSD ($P \leq 0.05$)	1.22	1.32	NS	NS	NS	NS
Row pattern						
50 x10 Single	44	41	440.17	1331	708.5	1900
60 x10 Single	43.5	40	510.5	1447	775.67	2032
50x 20 x 20 Twin	43.5	42	575.83	1296	873.5	1841
60 x 20 x20 Twin	42.6	42	606.5	1429	1013.83	2068
Mean	43.4	41.2	533.25	1375.7	842.88	1960.2
LSD ($P \leq 0.05$)	NS	NS	NS	NS	NS	NS
Variety x Row Pattern Interaction	NS	NS	NS	NS	NS	NS

3.2.3 Number of unfilled pods per plot

Thenumber of unfilled pods per plot was not significantly influenced by variety during the 2017 growing season (Table 5). However, Otuhia produced significantly higher number of unfilled pods per plot than Yenyawoso during the 2018 growing season (Table 5).Thenumber of unfilled pods per plot was not significantly influenced by row pattern and interaction by variety and row pattern during the 2018 growing season (Table 5). The number of unfilled pods per plot for 2018 growing season was however, higher than those produced during the 2017 growing season in both variety and row pattern (Table 5).

3.2.4 Haulm weight at harvest

The haulm weight at harvest was not significantly influenced by variety during the 2017 growing season (Table 5). Haulm weight at harvest varies between 8.1 – 12.6 kg during the 2018 growing season with Otuhia producing significantly heavier haulm weight at harvest than Yenyawoso (Table 5). There was no significant difference between row patternin haulm weight at harvest during the 2017 growing season.Haulm weight at harvest during the 2017 growing season was influenced by interaction between variety and row pattern (Table 5). However, haulm weight at harvest during the 2018 growing season was not significantly influenced by row pattern although differences exist between treatment as well as interaction between variety and row pattern (Table 5).There was higher haulm weight produced at harvest during the 2018 growing season than those produced during the 2017 growing season (Table 5).

3.2.5 Pod weight per plot (kg)

Otuhia and Yenyawoso produced the same pod weight per plot during the 2017 growing season (Table 6). Variations in pod weight per plot which ranged from 2.87 to 3.47 (kg) during the 2018 growing season was significantly influenced by variety (Table 6). Pod weight per plot in both 2017 and 2018 growing seasons was not significantly influenced by row pattern as well as interaction between variety and row pattern (Table 6). However, pod weight per plot produced during the 2018 growing season was higher than those produced during the 2017 growing season (Table 6).

Table 5: Number of unfilled pods per plot and haulm weight at harvest (kg) as affected by variety and row pattern during the 2017 and 2018 growing seasons

Treatment	Number of unfilled pods per plot	Number of unfilled pods per plot 2018	Haulm weight at harvest (kg) 2017	Haulm weight at harvest (kg) 2018
Variety				
Otuhia	343.2	718	8	12.6
Yenyawoso	276	450	7.4	8.1
Mean	306.6	584	7.7	10.3
LSD (P ≤ 0.05)	NS	124	NS	1.89
Row pattern				
50 x10 Single	268.3	569	7.7	10.5
60 x10 Single	265.1	585	8.1	11.8
50 x 20 x 20 Twin	297.6	545	6.9	10
60 x 20 x 20 Twin	407.3	639	8.1	9.1
Mean	309.6	584 0	7.7	10.3
LSD (P ≤ 0.05)	NS	NS	NS	NS
Variety x Row Pattern Interaction	NS	NS	1.6	NS

3.2.6 Seed weight per plot (kg)

In both growing seasons variations in seed weight per plot which ranged from 1.27.0- 1.36(kg) and 1.39- 1.60 (kg) in both 2017 and 2018 growing seasons was not significantly influenced by variety (Table 6). Variations in seed weight per plot which ranged from 1.20.0- 1.35.0 (kg) and 1.36- 1.61 (kg) in both 2017 and 2018 growing seasons was not significantly influenced by row pattern as well as interaction between variety and row pattern (Table 6). However, seed weight per plot produced during the 2018 growing season was higher than those produced during the 2017 growing season (Table 6).

3.2.7 Seed Yield (kg/ha)

In both growing seasons variations in total seed yield (kg/ha) which ranged from 3728.0- 3940.0 and 5118.0 – 5864.0 (kg) in both 2017 and 2018 growing seasons was not significantly influenced by variety (Table 6). Variationin seed yield was not significantly influenced by variety and row pattern interaction (Table 6). However, total seed yield (kg/ha) produced during the 2018 growing season was higher than those produced during the 2017 growing season (Table 6).

Table 6: Pod weight per plot (kg), seed weight per plot (kg) and yield (kg/ha) as affected by variety and row pattern during the 2017 and 2018 growing seasons

Treatment	Pod weight per plot (kg) 2017	Pod weight per plot (kg) 2018	Seed weight per plot (kg) 2017	Seed weight per plot (kg) 2018	Seed yield (kg/ha) 2017	Seed yield (kg/ha) 2018
Variety						
Otuhia	2.8	3.47	1.36	1.6	3940	5864
Yenyawoso	2.8	2.87	1.27	1.39	3728	5118
Mean	2.8	3.17	1.31	1.49	3834	5491
LSD (P ≤ 0.05)	NS	0.47	NS	NS	NS	NS
Row pattern						
50 x10 Single	2.7	3.08	1.2	1.36	4300.5	4881

60 x10 Single	2.8	3.4	1.35	1.61	4038	4812
50x 20 x 20 Twin	2.8	3.08	1.34	1.56	3706	6695
60 x 20 x20 Twin	2.9	3.1	1.37	1.45	3292.5	5577
Mean	2.8	3.16	1.31	1.49	3834.2	5491.2
LSD ($P \leq 0.05$)	NS	NS	NS	NS	NS	NS
Variety x Row Pattern Interaction	NS	NS	NS	NS	NS	NS

4. Discussion

4.1 Canopy spread

The significantly wider canopy spread byOtuhia than Yenyawoso at 30 days after planting (DAP) during the 2017 growing season could be due to the indeterminate growth habit of Otuhia as compared to Yenyawoso. This might have causedOtuhia to display morphological adaptations to its growth environment, by modifying its canopy structure in response to planting patterns (Huang *et al.*, (2017). The non- significant difference between Otuhia and Yenyawoso in canopy spread from 44 DAP to 86 DAP in both 2017 and 2018 growing seasons could be that row pattern had no influence on groundnut varieties. The significantly wider canopy spread produced by 50 × 10 cm single row pattern than all the other row pattern at 30 DAP could be due to close inter and intra row planting spacing and single row pattern. The high number of plants per row in single row pattern might have led to high productivity per unit area of land, efficient use of water and nutrients for early canopy formation with subsequent high light interception. Canopy spread determines solar radiation interception and utilization and may impact positively on yield (Dapaah *et al.*, 2014). The wider canopies spread at 44 DAP with 50 x 20 x 20 cm and 60 x 20 x 20 cm twin row pattern could probably be due to wider intra row planting spacing and twin row pattern. Wider intra row spacing and twin pattern might have provided enough space for horizontal growth coupled with efficient use of light interception. Light interception is highly influenced by different planting patterns (Liu and Song, 2012), since the canopy structure changes in response to planting patterns. The wider canopy spread by Yenyawoso compared to Otuhiafrom 44 DAP to 86 DAP during the 2018 cropping season could be due to the fact that it is an early maturity variety and thus had early canopy closure than Otuhia which is a late maturity variety with comparatively growth delay. The significantly wider canopy spread by 60 × 10 cm single row pattern from 60 × 20 × 20 cm twin row pattern at 30 DAP and also from 50 x 20 x20 cm and 60 × 20 cm × 20 cm twin row pattern at 44 DAP during the 2018 growing season could be due to close intra row planting spacing and single row pattern.The single row pattern might have enhanced early canopy closure and light interception. This confirms (Liu and Song, 2012).

4.2 Days to 50% pegging

The earliest days to50% pegging by Yenyawoso than Otuhiain both 2017 and 2018 growing seasons could be due to differences in genetic characteristics of varieties and their response to climatic conditions and row pattern. The non-significant difference between variety and row pattern interaction in days to 50% pegging in both 2017 and 2018 growing seasons could be that row pattern had no effect on variety.The early peg formation by Yenyawoso and Otuhia during the 2018 growing season than during the 2017 growing season could probably be due to maximum rainfall experienced during the pegging stage of the crop in 2018 growing season. This agrees with Wright *et al.*, (2010) that in peanut the period of greatest water use occurs during pegging stage.

4.3 Number of pods per plot

Thenon-significant difference between variety and row pattern and their interaction in number of pods per plot in both 2017 and 2018growing seasons could be that row pattern had no influence on variety.The higher number of pods per plot produced by Otuhia and Yenyawoso during the 2018 growing seasonthan during the 2017 growing season could be due to high rainfall experienced during the 2018 growing period. Adequate water in the plant serves as a medium that gives turgor to plant cells. Turgor promotes cell enlargement, plant structure and foliar display. This might have enhanced solar radiation interception and utilization and subsequent pod formation. There was a close and positive relationship between Otuhia and 60 x 20 x 20 cm twin row pattern in canopy spread at 86 DAP during the 2017growing seasonin number of pods per plot. The wider canopy spreadmight have enhanced light interception and utilization. This agrees with (Liu and Song, 2012; Wang *et al.*, 2017) that light interception is highly influenced by different planting patterns, since the canopy structure changes in response to planting patterns, and the more efficient capture and use of light contribute to yield advantages.

4.4 Number of unfilled pods per plot

The non-significant difference between varieties in number of unfilled pods per plot during the 2017 growing season could be that row pattern had no effect on variety during the growing period. Thesignificantly higher number of unfilled pods per plot produced by Otuhia than Yenyawoso during the 2018 growing season could be due to narrow canopy spread produced at 86 DAP than Yenyawoso in the same growing period. The narrow canopy spread might have resulted in lower rate of biomass accumulation, decreased leaf photosynthesis and lower rate of pod filling. The higher number of unfilled pods per plot produced during the 2018 growing season than those produced during the 2017 growing season in both varieties and row pattern might be linked to narrower canopy spread producedduring the 2018cropping seasoncompared to 2017 cropping season. The narrow canopy structure might have reduced light interception and utilization with subsequent increased number of unfilledpods.

4.5 Number of filled pods per plot

The non-significant difference between variety, row pattern and their interaction in number of filled pods per plot in both 2017 and 2018 growing seasons could be that row pattern had no effect on variety. The higher number of filled pods per plot during the 2018 than those produced during the 2017 growing season could be attributed to high haulm yield produced. Increased haulm yield might have increased leaf photosynthesis, sink assimilate and high rate of pod filling.There was a close and positive relation between pod filling with 60 x 10 cm single row pattern and haulm weight at harvest during the 2018 growing season. The morphological development of Otuhia might have probably influenced haulm weight with efficient solar radiation interception for photosynthesis. Morphological development, light interception, source-sink relationships and assimilate partitioning are the major determinant of yield (Chen *et al.*, 2018).

4.6 Haulm weight at harvest

The variations in haulm weight at harvest ranged from 7.4 - 8.0 kg and 8.1-12.8 kg in 2017 and 2018 growing seasons respectively. The significantly higher haulm weight at harvest produced by Otuhiathan Yenyawoso could be due to differences in genetic characteristics (Vara Prasad *et al.*, 2009).The significant difference between variety and row patterninteraction in haulm weight at harvest during the 2017 growing season could be attributed to differences in genotype and their response to temperature. This attest to Vara Prasad *et al.*, (2009)that leaf production differs as well as leaf and stem morphology alters based on genotype and their response to temperature. There was a close and positive relation between canopy spread and haulm weight at harvest with Otuhia and 60 x 20 x 20 cm twin row pattern during the 2017growing season.The wider canopy spread might have resulted in early canopy closure due to ample space, efficient light interception and utilization of solar radiation with subsequent high haulm yield (Dapaah *et al.*, 2014).The high haulm weight produced at harvest during the 2018 growing season than those produced during the 2017 growing season could be attributed to initial high rainfall with low temperature experienced during the vegetative growth stage of the crop in 2018 growing season compared to 2017 growing season. Exposure of groundnut to high temperature stress decreases the overall vegetative growth of plants (Vara Prasad *et al.*, (2009).

4.7 Pod weight per plot

The significant difference between Otuhia and Yenyawoso in pod weight per plot during the 2018 growing season could be due to differences in genetic characteristics and its response to initial high rainfall and low temperature experienced during the growing period. High rainfall might have increased the amount of moisture in pod zone thereby improving the development of pegs to pods. Pod development is sensitive to drought stress, where it decreases the pod growth (Vara Prasad et al., 2009).The non-significant difference between row pattern in pod weight per plot in both 2017 and 2018 growing seasons could be that row pattern had no effect on varieties.

4.8 Seed weight per plot (kg)

The non-significant difference between variety, row pattern and their interaction in pod weight per plot in both 2017 and 2018 growing seasons could be that row pattern had no effect on varieties. The higher seed weight per plot produced in both varieties and row pattern during the 2018 growing season than those produced during the 2017 growing season could probably be due tohigh rainfall and low temperature experienced during the peg and pod formation stage of groundnuts in 2018 cropping season.Adequate pod zone moisture is critical for development of pegs to pods and that pods that are initiated and developed under high temperature stress conditions have lower seed quality (Vara Prasad *et al.*, 2009).

4.9 Seed Yield (kg/ha)

The non-significant difference between variety, row pattern and their interaction in seed yield (kg/ha) in both 2017 and 2018 growing seasons could be that row pattern had no effect on varieties. The higher seedyield produced in both varieties and row pattern during the 2018 growing season than those produced during the 2017 growing season could be attributed to high rainfall coupled with low temperature experienced during the 2018 growing season.This attest to Wright *et al.*, (2010) that peanut requires maximum water during its growth and development, and that the period of greatest water use occurs during pegging and fruiting stage. Both high day and night temperatures result in reduced partitioning of biomass to yield in groundnut (Vara Prasad *et al.*, 2009).

5. Conclusion

Growth, yield and yield components ofgroundnut were affected by row pattern. Otuhia produced the widest canopy spread at 86 DAP, significantly heavier haulm weight at harvest and pod weight per plot (kg) than Yenyawoso during the 2018 growing season, highest seed yield per plot during the 2017 and 2018 growing seasons respectively and highest total yield (kg/ha) during the 2018 growing season. Yenyawoso pegged 6 to 7 days earlier than Otuhia in both growing seasons and also produced highest number of filled pods per plot during the 2018 growing season. The 60 x 10 cm single row pattern produced the least number of unfilled pods per plotduring the 2017 growing season, highest pod weight per plot (kg) and seed weight per plot (kg) during the 2018 growing season and heaviest haulm weight at harvest during the 2018 growing season. The 60 x 20 x 20 cm twin row pattern produced the widest canopy spread during the 2017 growing season and highest seed yield per plot (kg/ha) in both 2017 and 2018 growing seasons.

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