Original Research Article

Effect of cowpea (*vigna unguiculata*) variety and plant spacing on grain and fodder yield

Abstract
A field experiment was conducted to examine the effect of plant spacing on grain and fodder yield of four cowpeas varieties. Four cowpea varieties i.e. Asetenapa, Asomdwe, Hewale and Videza were sown with three plant spacing i.e. 30 x 15 cm, 45 x 15 cm and 60 x 15 cm at Samboligo in the Bongo District of the Upper East of Ghana. The experiment was laid in randomized complete block with four replicates in factorial fashion. Cowpea variety and plant spacing significantly influenced grain yield, 1000 seed weight, nodules per plant and plantheight. Plant spacing had no significant effect on stem girth, pods per plant, pod length and seed per pods. Variety 'Hewale' produced the highest grain yield of 991.3 kg ha^{-1} while Asetenapa produced the highest fodder yield of 1025.5 kg ha^{-1}. Interactive effect between Asomdwe and 45 x 15 cm had the highest 1000 seed weight (170.6 g) while Asetenapa and 30 x 15 cm produced the highest grain yield (1072.9 kg ha^{-1}). Variety 'Hewale' is recommended for commercial grain production while Asetenapa for fodder production. Asetenapa and 30 x 15 cm combination is recommended for commercial grain production.
Keywords: cowpea, grain yield, fodder yield, plant spacing and varieties.

1.0 INTRODUCTION

Cowpea (*Vigna unguiculata* Walp (L.) is an essential component of the cropping systems in the drier regions of the tropics [1] and of vital importance to the livelihood of millions of people in Sub-Sahara Africa.It provides nutritious grain and a low-cost source of protein for both rural and urban consumers [2]. Cowpea is consumed in many forms like young fresh leaves, immature green pods and green seeds used as vegetables; dry seeds used in various food preparations includingover 50 different dishes known [3] and[4]. Cowpea seed contains 20 - 24%protein, 63.3% carbohydrates and 1.9% fat [5]. Globally, it is grown on about 14.5 million hectares producing over 6.5 million metric tons of grain[1]. Africa alone accounts for about 83% of the world production, with Nigeria being the world largest producer (45.76%), followed by Niger (15%) [1]. Fodder from cowpea is also highly valued for livestock. It can also be grown as a relay inter-crop with cereals or other crops in mid, ifmaturing varieties were used [6].

Row spacing has been reported to be very important agronomic practice and affect the crop yield potential of every crop[7]. Walker and Buchanan [8] reported that reducing narrow row spacing improves weed control by increasing crop competition, less availability of space for weeds to grow and reducing light penetration to the soil. Narrow row spacing has been reported to result in higher grain yields of soybean[9] and in other crops [10]. Higher yields as a result of narrowrow spacing between sorghum plants attributed to improved light interception were reported by [11] and decreased plant to plant competition between plants [9]. Higher yields have also been reported in close spacing as compared to wide spacing in soybean [12]. Groundnut monocropping in wide rows has been reported to lead to lower yields as aresult of the sub-optimum plant population densities thusencouraging under-utilization of resources[13]. Studies of [14] indicated thepositive effects of 50 cm row spacing against 60 cm row spacing on seed and pod yields of groundnut. [15] also showed reduction in weed density in30cm apart rows of peanut (*Arachis hypogea*) as compared to the weed density at wider spacing. However, [16] observed that average yields did not differ among three row spacings.

The manipulation of row spacing dimensions, plant populations and the overall special arrangement of crop plants in field has been the subject of considerable discussion among farmers and agronomists for many years. The objective of this study was to investigate the effect of plant spacing on grain and fodder yield of cowpea varietiesin northern Ghana.

2.0 MATERIALS AND METHODS

2.1 Experimental sites

The study was carried out on 8th July, 2017 at Samboligo in the Bongo District of the Upper East of Ghana, located on latitude 10.58° N and longitude 0.51°W at238 m above sea level. The climate is warm, semi-arid with mono-modal and unpredictable rainfall distribution with the averageannual amount of 1000 mm, which falls mostly between May and September.This is followed by seven months of dry season, which is characterized by the dry harmattan winds with high risk of uncontrolled bushfires resulting in the loss of vegetative cover of the soil.

2.2 Experimental design and Treatment

The experimental sites were ploughed, ridged and sprayed with herbicides (roundup and stomp)having active ingredients glyphosate and pendimethalin, respectively. The experiment was laid out in factorial design arranged in randomized complete block with four replications. The replicates were made up of 12 plots each measuring 4m x 2.4m with 6 rows per plot, each row had a length of 4 m, 60 cm between rows, 15cm within rows and one meter between plots. The treatments were four cowpea varieties; Asetenapa (V1),Asomdwe (V2), Hewale (V3)and Videza (V4) and three cowpea spacing;30 x 15 cm (S1), 45 x 15 cm (S2) and60 x 15 cm (S3).Three seeds were sown per hill and thinned to two plants per hill after two weeks of planting. Refilling was also done after two weeks of planting.Weeding was done by hoeing and hand pulling. Two middle rows were harvested in order to collect the following data.

2.3 Growth parameters and yield measurements

2.3.1 Plant height

Five plants from each plot were randomly selectedin order to collect data on plant height. Height measurement was done from the ground level to the lastterminal leaf using a measuringtape. The average of these five plants were then calculated for each sampling occasion.

2.3.2 Number of nodules per plant

The number of nodules per plant were taken from the five selected plants. The roots of the plant were thoroughly washed to expose the nodules and a sharp blade was used to separate the nodules from roots. Viable nodules were counted (nodules with pinkish coloration) and the average taken as the number of nodules per plant.

2.3.3 Stem girth

This was measured from five cowpea plants using electronic venire calipers. The stem girth of each of the five cowpea plant were placed in the external jaws of the calipers and the reading that was displaced on the LCD recorded, the average was taken as the stem girth per plot.

2.3.4 Pod length

The pod length of five pods from the selected plants were measured using a ruler and then averaged taken as the pod length per plot.

2.4 Yield and yield components

2.4.1 Number of pods and Number of seeds per pod

Pod harvested from five cowpea plants were countedand the average was taken as the number of pods per plant. Seeds harvested from the pods of the selected five plants were counted and the average number was recorded as seed number pod^{-1}.

2.4.2 1000 seed weight and Grain yield

1000 seeds ofcowpea plants from each plot were weighed. The weight of cowpea grainsin the middle row harvested from each net plot was then extrapolated to total grain yield per hectare.

2.4.3 Fodder yield

The fodder from each treatment were sun dried, bulked and weighed as fodder yieldfor each treatment and converted to kg ha^{-1}.

2.5 Statistical analysis

The data collected were subjected to statistical analysis using Genstat discovery edition 12 (2012). The analysis of varianceprocedure was followed to determine whether difference existed among treatments. Treatment means were separated using the least significant difference (LSD) at 5 % probability level.

3. RESULTS

3.1 Plant Height, Stem girth and Pod length

Interaction between varieties and spacing for plant height was found non-significant (Table 1). Same was the case with individual performance of spacing. As regard to varieties, Hewale produced taller plants (42.99 cm) which were statistically at par to those of Asetenapa (42.30 cm) and Videza (40.09 cm) but significantly taller than those of Asomdwe (38.94 cm).

Varieties, spacing and their interaction did not show any significant effect on stem girth (Table 1). Variety 'Hewale' when sown at spacing 60x15 cm and Videza at 45x15 cm produced significantly lowest pod length than all other treatments, which in turn were at par with each other (Table 1). Individual performance of varieties and spacing remained non-significant for pod length.

Table 1. Effects of cowpea variety and plant spacing on plant height, stem girth and pod length

Treatments	Plant Height (cm)	Stem Girth (cm)	Pod Length (cm)
Variety X Spacing			
V1 X S1	43.68	5.3	13.27
V2 X S1	37.25	5.43	11.22
V3 X S1	45.05	4.9	11.6
V4 X S1	40.33	5.2	11.5
V1 X S2	41.8	5.2	11.35
V2 X S2	39.45	5.18	11.82

V3 X S2	42.15	5.03	12.15
V4 X S2	40.88	4.88	09.80
V1 X S3	41.43	5.1	11.07
V2 X S3	40.13	5.28	12.95
V3 X S3	41.78	5.42	09.37
V4 X S3	39.08	4.7	10.85
LSD (0.05)	NS	NS	03.11
Variety			
V1= Asetenapa	42.30	5.20	11.90
V2= Asomdwe	38.94	5.29	12.00
V3= Hewale	42.99	5.12	11.04
V4= Videza	40.09	4.93	01.72
LSD (0.05)	03.82	NS	NS
Spacing			
S1= 30x15	41.58	5.21	11.90
S2= 45x15	41.07	5.07	11.28
S3= 60x15	40.60	5.12	11.06
LSD (0.05)	NS	NS	NS
C.V. (%)	0.20	2.80	8.8

3.2 Nodules per plant, Pods per plant and Seed per pod.

The effect of cowpea variety and plant spacing on the number of nodules per plant, number of pods per plant and the number of seeds per pods are presented in Table 2. Cowpea variety had no significant influence on number of pods per plant and number of seeds per pods however, a significant effect was observed between cowpea varieties with respect to number of nodules per plant. Hewale produced the highest nodules per plant (43) while Asomdwe produced the least nodules with a mean of 38.94. Plant spacing also had no significant effect on nodules per plant, pods per plant and seed per pods from the results observed in Table 2.

Interaction between cowpea varieties and spacing for number of nodules per plant was significant, while number of pods per plant and number of seed per pods from the results witnessed no significant difference. Videza sown 45 x 15 cm produced the highest number of nodules per plant (48.5) while Asetenapa at 60 x 15 cm produced significantly lowest number of nodules per plant.

Table 2. Effects of cowpea variety and plant spacing on nodules per plant, pods per plant and seeds per plant.

Treatments	Nodules per plant	Pods per plant	Seeds per Pod
Variety X Spacing			
V1 X S1	40.15	54.3	10.1
V2 X S1	44.55	54.2	10.63
V3 X S1	45.65	43.2	10.45
V4 X S1	44.95	48.9	12.5
V1 X S2	40.55	53.1	11.85
V2 X S2	40	51.3	10.18
V3 X S2	42.8	46.2	10.45
V4 X S2	48.5	49.5	10.4

V1 X S3	39.05	46.9	12.1
V2 X S3	40.6	52.6	10.65
V3 X S3	47.4	44.1	11.45
V4 X S3	45.8	52.0	10.45
LSD (0.05)	6.09	NS	NS
Variety			
V1= Asetenapa	39.92	51.4	11.35
V2= Asomdwe	41.72	52.7	10.48
V3= Hewale	45.28	44.5	10.78
V4= Videza	46.42	50.1	11.12
LSD (0.05)	3.52	NS	NS
Spacing			
S1= 30x15	43.83	50.1	10.92
S2= 45x15	42.96	50.0	10.72
S3= 60x15	43.21	48.9	11.16
LSD (0.05)	NS	NS	NS
C.V. (%)	5.6	5.0	5.0

3.3 1000 seed weight, Grain yield and Fodder yield

Table 3 shows the effect of cowpea varieties and plant spacing on 1000 seed weight, grain yield and fodder yield. The effect of cowpea varieties on 1000 seed weight, grain yield and fodder yield were significant. Variety ‘Asetenapa’ recorded the highest 1000 seed weight with a mean of 164.3g while Videza recorded the lowest 1000 seed weight with a mean of 154.3g.

Hewale was the variety that produced the highest grain yield with a mean of 991.3 $kgha^{-1}$ while Asomdwe produced the lowest grain yield with a mean of 906 $kgha^{-1}$. Asetenapa was the variety that produced the highest fodder yield with a mean of 1025.5 $kgha^{-1}$ while Hewale produced the least fodder yield with a mean of 747.1$kgha^{-1}$.

The spacing effect on 1000 seed weight, fodder yield and grain yield was not significant.

The interaction between variety and spacing for 1000 seed weight was significant. Variety 'Asomdwe' when sown with 45 x 15 cm spacing produced the highest 1000 seed weight with a mean of 170.6g, Videza sown with 60 x 15 cm spacing produced the lowest seed weight with a mean of 150.2g.

Interaction between varieties and plant spacing for fodder yield observed from the results was not significant however interaction between variety and spacing for 1000 seed weight and grain yield were significant (Table 3). Asomdwe at 45 x 15 cm recorded the highest 1000 seed weight (170.6g) while Videza at 60 x 15 cm produced the lowest 1000 seed weight (150.2g). Variety 'Asetenapa' when sown at spacing of 45 x 15 cm produced significantly the highest grain yield while Videza at 45 x 15 cm produced significantly lowest grain yield than the other treatments.

Table 3. Effects of cowpea variety and plant spacing on 1000 seed weight, grain yield and fodder yield.

Treatments	1000 seed weight (g)	Grain yield ($kgha^{-1}$)	Fodder yield($kgha^{-1}$)
Variety X Spacing			
V1 X S1	162.4	1072.9	1071.2
V2 X S1	160.8	935.8	762.3
V3 X S1	151.9	1026.1	663.2

V4 X S1	162.1	963.6	911.5
V1 X S2	167.7	932.3	1038.2
V2 X S2	170.6	868.1	993.1
V3 X S2	151.3	1010.4	859.4
V4 X S2	150.7	916.7	691.1
V1 X S3	150.6	929	967
V2 X S3	162.5	914.9	1020.9
V3 X S3	164.9	937.5	918.8
V4 X S3	150.2	941	954.9
LSD (0.05)	15.98	115.9	NS
Variety			
V1= Asetenapa	160.3	978	1025.5
V2= Asomdwe	164.3	906.2	925.4
V3= Hewale	156.0	991.3	747.1
V4= Videza	154.3	940.4	852.5
LSD (0.05)	9.22	66.9	116.3
Spacing			
S1= 30x15	159.3	999.6	852
S2= 45x15	160.1	931.9	895.4
S3= 60x15	157.1	930.5	915
LSD (0.05)	NS	NS	NS
C.V. (%)	1.9	1.3	11.0

4.0 DISCUSSION

4.1 Plant Height, Stem girth and Pod length: The results from the study show the absence of significant influence of cowpea varieties and plant spacing on stem girth and pod length which signifies the lack of genotypic difference between the cowpea varieties for stem girth and pod length. The lack of environmental influence could be the reason for the absent of spacing effect on the stem girth and pod length. Varietal difference in plant height that were shown in the study could be attributed to the genotypic difference between the cowpea varieties other than environmental factors. This variation among cowpea varieties in plant height in the study is in agreement with Masenya [17], Alege and Mustapha [18] and Omoigui, *et al*. [19]. This also explains the absence of significant influence of plant spacing on plant height as observed in the study, this finding contradicts the observation of [20]of who found that plants produced at highest densities were taller and more sparsely branched. The little or no interactive effect of cowpea varieties and plant spacing on plant height, stem girth and pod length could be attributed to the cowpea varieties partitioning most of their photosynthates into the economic yield that is the grain other than partitioning assimilates into plant height, stem girth and pod length development as observed in the studies.

4.2 Nodules per plant, Pods per plant and Seed per pod

The varietal variation in the number of nodules per plant as observed in the studies may be attributed to the effects of genotypic differences between the cowpea varieties. This finding is in agreement with Anyango, *et al.* [2] and [21] who reported genetic difference in nodulation in anevaluation of the functional quality of cowpea and meta-analysis of the effectiveness of diverse rhizobia inoculants on soybean. This finding also conforms to Alemu, *et al.* [22] in a study of growth and yield of common bean (*Phaseolus vulgaris L.*) cultivars as influenced by rates of phosphorus. The difference in number of nodules per plant of cowpea varieties could also be the difference in compatibility of the cowpea varieties with the native rhizobia at the experimental site. This demonstrates that specificity exist between legumes and rhizobia for effective nodulation. This means that with the right legume species and right rhizobia (compatibility) there will be effective nodulation. The varietal and plant spacing effects as observed from the results had little or no significant influence on the number of pods per plant and number of seeds per plant. This outcome is in agreement with the findings of[23]who reported that plant population had a little or no effect on the number of seeds per pod in faba beans. It is also in conformity with El Naim and Jabereldar [24] who observed that cowpea was influenced by sowing date intra – row spacing inoculation and nitrogen fertilization in the effect of plant density and cultivar on growth and yield of cowpea. Also the lack of varietal effect on the number of pods per plant contradicts earlier studies by Shambharkar, *et al.* [25]; Onat, *et al*. [14]; Dapaah, *et al*. [26] and Sharma, *et al*. [27]who reported varietal effect for number of pods per groundnut in a study to determine the responses of groundnut to plant spacing. Similar reports by Masenya [17] recorded significant varietal effect on number of pods per plant in evaluation of introduced cowpea lines. The findings also contradict reports of Ahmad, *et al.* [28]and [13]. The absence of interactive effect between varietal and spacing on the number of pods per plant was in agreement with the report of Çalişkan, *et al.* [29]who observed no significant interactions of cultivar type with spacing within row with regard to pod yield.

4.3 1000 seed weight, Grain yield and Fodder yield

The significant varietal difference on 1000 seed weight as observed in the studies shows the inherent characteristics of the cowpea varieties to produce different 1000 seed weights. This also shows that the different varieties have different means of mobilizing nutrients and other growth resources and partitioning of their photosynthates into seed production. This finding is also in agreement with Wang, *et al*. [30]and [24]who reported genetic difference were responsible for 100 seed weight among cultivars of cowpea. The lack of environmental influence on 1000 seed weight could be attributed to the absence of significant influence of plant spacing on 1000 seed weight. This finding observed in the study is in agreement with [31] in the study of the effect of spacing on yield of chickpea. The interactive effect between Asomdwe at 45 x 15 cm and Videza at 60 x 15 cm for 1000 seed weight shows the genotype and environment influence on 1000 seed weight. This implies that with the right genotype and environmental conditions, the crop will partition most of its assimilates into seed development and economic sink.

The lack of influence of plant spacing on fodder yield as observed in the results is contrary to report by Sokoto, *et al*. [32] who stated that closer spacing is more effective in haulm production while wider spacing is more effective in pod production. Varietal effects on the fodder yield of the different cowpea varieties as observed in the studies may be indicative of the differences in genotypes [33]. Asetenapa was the cowpea variety that produced the highest fodder yield which may infer that, inherently Asetenapa partition most of its photosynthate into its haulms hence producing more fodder yield which could be used for large scale fodder production to feed livestock. The influence of spacing and variety interaction on fodder yield as observed in this experiment shows that there is little or no interactive on fodder production.

Hewale variety had the highest grain yield and the lowest fodder yield from the study; this could be that genetically Hewale partition most of its photosynthate into grain development other than vegetative growth. The varietal variations that were observed between the varieties for grain yield could be attributed to differences in genotypes other than the environment. The variations of variety on grain yield are in agreement with reports by Rachaputi, *et al*. [34]and Blum [35].

Inter row spacing had no influence on the yield of the cowpea varieties, this is also contrary to Grichar [36] who reported row spacing to be very important agronomic practice that affect the crop yield potential. Higher yields were also reported in close spacing compared to wide spacing in groundnut byMickelson and Renner [37] andAhmad, *et al.* [28]which were also contrary to the findings in the studies. Interaction of plant spacing and variety were significant for grain yield, this finding is contrary to reports by Giayetto, *et al.* [38] and Rasekh, *et al*. [39] who found no significant interaction of row distance and plant spaces for grain yield. The interactive effect of Asetenapa at 30 x 15 cm was the most productive treatment for grain yield and this could be attributed to the efficient use of water and other resources in the soil more rapidly than other treatments therefore have a greater partitioning factor forgrain.

5.0 CONCLUSION

The findings of this study showed that cowpea varieties positively influenced plant height, nodules per plant, 1000 seed weight, grain and fodder yield but no influence on stem girth, pod length, number of pods per plant and seeds per plant. Hewale was the cowpea variety that produced the highest grain yield with Asetenapa and Asomdwee producing the highest fodder yield and 1000 seed weight, respectively. Plant spacing had no significant effect on the parameters measured. The interaction between Asetenapa and 30 x 15 cm produced the highest grain yield and Asomdwe and 45 x 15 cm produced the highest 1000 seed weight. It could therefore be recommended that for commercial production of fodder for livestock Asetenapa can be considered while Hewale could be considered for grain production. Asetenapa and 30 x 15 cm combination could also be recommended for commercial grain production.

References

[1] C. A. Fatokun, O. Boukar, and S. Muranaka, "Evaluation of cowpea (Vigna unguiculata (L.) Walp.) germplasm lines for tolerance to drought," *Plant Genetic Resources,* vol. 10, pp. 171-176, 2012.

[2] J. O. Anyango, H. L. de Kock, and J. R. Taylor, "Evaluation of the functional quality of cowpea-fortified traditional African sorghum foods using instrumental and descriptive sensory analysis," *LWT-Food Science and Technology,* vol. 44, pp. 2126-2133, 2011.

[3] W. Quaye, K. Adofo, Y. Madode, and A.-R. Abizari, "Exploratory and multidisciplinary survey of the cowpea network in the Tolon-Kumbungu district of Ghana: A food sovereignty perspective," *African Journal of Agricultural Research,* vol. 4, pp. 311-320, 2009.

[4] O. Boukar, F. Massawe, S. Muranaka, J. Franco, B. Maziya-Dixon, B. Singh*, et al.*, "Evaluation of cowpea germplasm lines for protein and mineral concentrations in grains," *Plant Genetic Resources,* vol. 9, pp. 515-522, 2011.

[5] D. Davis, E. Oelke, E. Oplinger, J. Doll, C. Hanson, and D. Putnam, "Field crops manure, University of Mipesota, St Paul, MN5510," *University of Wisconsin-Madison W,* vol. 1, p. 53706, 1991.

[6] H. Elawad, "The performance of selected cowpea (Vigna unguiculata L. Walp). Varieties in the sandy rainfed areas of Kordofan," *Agricultural Research Corporation, Elobied, Sudan,* 2000.

[7] S. Staggenborg, D. Fjell, D. Devlin, W. Gordon, and B. Marsh, "Grain sorghum response to row spacings and seeding rates in Kansas," *Journal of production agriculture,* vol. 12, pp. 390-395, 1999.

[8] R. H. Walker and G. A. Buchanan, "Crop manipulation in integrated weed management systems," *Weed science,* vol. 30, pp. 17-24, 1982.

[9] J. L. De Bruin and P. Pedersen, "Effect of row spacing and seeding rate on soybean yield," *Agronomy journal,* vol. 100, pp. 704-710, 2008.

[10] F. Stickler and H. Laude, "Effect of Row Spacing and Plant Population on Performance of Corn, Grain Sorghum and Forage Sorghum 1," *Agronomy Journal,* vol. 52, pp. 275-277, 1960.

[11] M. Gondal, A. Hussain, S. Yasin, M. Musa, and H. Rehman, "Effect of seed rate and row spacing on grain yield of sorghum," *SAARC Journal of Agriculture,* vol. 15, pp. 81-91, 2017.

[12] J. A. Liebert and M. R. Ryan, "High planting rates improve weed suppression, yield, and profitability in organically-managed, no-till–planted soybean," *Weed Technology,* vol. 31, pp. 536-549, 2017.

[13] M. Kombiok, "Groundnut (Arachis hypogaea L.) varietal response to spacing in the Guinea savanna agro-ecological zone of Ghana: Growth and yield," *African Journal of Agricultural Research,* vol. 8, pp. 2769-2777, 2013.

[14] B. Onat, H. Bakal, L. Güllüoğlu, and H. Arıoğlu, "The effects of row spacing and plant density on yield and yield components of peanut grown as a double crop in mediterranean environment in Turkey," *Turkish Journal of Field Crops,* vol. 22, pp. 71-80, 2016.

[15] W. C. Johnson III and B. G. Mullinix Jr, "Potential weed management systems for organic peanut production," *Peanut science,* vol. 35, pp. 67-72, 2008.

[16] P. Pedersen and J. G. Lauer, "Corn and soybean response to rotation sequence, row spacing, and tillage system," *Agronomy Journal,* vol. 95, pp. 965-971, 2003.

[17] T. A. Masenya, "Evaluation of introduced cowpea breeding lines in South Africa," 2016. MSc. Thesis, University of Limpopo.

[18] G. Alege and O. T. Mustapha, "Characterization studies and yield attributes of some varieties of cowpea (Vigna unguiculata L.)," *Ethnobotanical Leaflets,* vol. 2007, p. 13, 2007.

[19] L. Omoigui, M. Ishiyaku, A. Kamara, S. Alabi, and S. Mohammed, "Genetic variability and heritability studies of some reproductive traits in cowpea (Vigna unguiculate (L.) Walp.)," *African Journal of Biotechnology,* vol. 5, 2006.

[20] W. Cox and J. H. Cherney, "Growth and yield responses of soybean to row spacing and seeding rate," *Agronomy Journal,* vol. 103, pp. 123-128, 2011.

[21] M. S. Thilakarathna and M. N. Raizada, "A meta-analysis of the effectiveness of diverse rhizobia inoculants on soybean traits under field conditions," *Soil Biology and Biochemistry,* vol. 105, pp. 177-196, 2017.

[22] A. Alemu, A. Nebiyu, and M. Getachew, "Growth and yield of common bean (Phaseolus vulgaris L.) cultivars as influenced by rates of phosphorus at Jimma, Southwest

Ethiopia," *Journal of Agricultural Biotechnology and Sustainable Development,* vol. 10, pp. 104-115, 2018.

[23] F. Salih, "Effect of watering intervals and hill planting on faba bean seed yield and its components [Vicia faba]," *Faba Bean Information Service,* 1992.

[24] A. M. El Naim and A. A. Jabereldar, "Effect of plant density and cultivar on growth and yield of cowpea (Vigna unguiculata L. Walp)," *Australian Journal of Basic and Applied Sciences,* vol. 4, pp. 3148-3153, 2010.

[25] D. Shambharkar, P. Dharne, T. Bahale, D. Anjali, R. Surywanshi, and R. Jadhav, "Assessment of integrated pest management modules in groundnut on farmers' fields," *International Arachis Newsletter,* pp. 31-33, 2006.

[26] H. K. Dapaah, I. Mohammed, and R. T. Awuah, "Growth yield performance of groundnuts (Arachis hypogaea L.) in response to plant density," *International Journal of Plant and Soil Science,* vol. 3, pp. 1069-1082, 2014.

[27] P. Sharma, V. Sardana, and S. S. Kandhola, "Effects of sowing dates and harvesting dates on germination and seedling vigor of groundnut (Arachis hypogaea) cultivars," *Res. J. Seed Sci,* vol. 6, pp. 1-15, 2013.

[28] N. Ahmad, M. Rahim, and U. Khan, "Evaluation of different varieties, seed rates and row spacing of groundnut, planted under agro-ecological conditions of Malakand Division," *Journal of Agronomy,* vol. 6, p. 385, 2007.

[29] S. Çalişkan, M. Arslan, İ. ÜREMİŞ, and M. E. Çalişkan, "The effects of row spacing on yield and yield components of full season and double-cropped soybean," *Turkish Journal of Agriculture and Forestry,* vol. 31, pp. 147-154, 2007.

[30] N. Wang, J. K. Daun, and L. J. Malcolmson, "Relationship between physicochemical and cooking properties, and effects of cooking on antinutrients, of yellow field peas (Pisum sativum)," *Journal of the Science of Food and Agriculture,* vol. 83, pp. 1228-1237, 2003.

[31] M. Agajie, "Effect of Spacing on Yield Components and Yield of Chickpea (Cicer arietinumL.) at Assosa, Western Ethiopia," *Management,* vol. 11, p. 10cm, 2014.

[32] M. Sokoto, I. Bello, and E. Osemuahu, "Effects of Intra-Row Spacing on Herbage Yields of Two Groundnut (Arachis hypogaea L.) Varieties in Sokoto, Semi-Arid Zone, Nigeria," *International Journal of Applied Agriculture and Apiculture Research,* vol. 9, pp. 11-17, 2013.

[33] I. Mohammed, O. Olufajo, B. Singh, S. Miko, and S. Mohammed, "Evaluation of yield of components of sorghum/cowpea intercrops in the sudan savanna ecological zone," *ARPN J. Agric. Biol. Sci,* vol. 3, pp. 30-37, 2008.

[34] R. C. Rachaputi, G. M. Bedane, I. J. Broad, and K. S. Deifel, "Genotype, Row Spacing and Environment Interaction for Productivity and Grain Quality of Pigeonpea (Cajanus Cajan) in Sub-Tropical Australia," *Biosciences Biotechnology Research Asia,* vol. 15, pp. 27-38, 2018.

[35] A. Blum, *Plant Breeding For Stress Environments: 0*: CRC press, 2018.

[36] J. Grichar, "Corn (Zea mays L.) Response to Hybrid, Row Spacing, and Plant Populations in the Blacklands of Central Texas," *JOURNAL OF ADVANCES IN AGRICULTURE,* vol. 8, pp. 1214-1223, 2018.

[37] J. A. Mickelson and K. A. Renner, "Weed control using reduced rates of postemergence herbicides in narrow and wide row soybean," *Journal of production agriculture,* vol. 10, pp. 431-437, 1997.

[38] O. Giayetto, G. Cerioni, and W. Asnal, "Effect of sowing spacing on vegetative growth, dry matter production, and peanut pod yield," *Peanut Science,* vol. 25, pp. 86-87, 1998.

[39] H. Rasekh, J. Asghari, S. Massoumi, and R. Zakerinejad, "Effect of planting pattern and plant density on physiological characteristics and yield of peanut (Arachis hypogaea L.) in Iran," *Research Journal of Biological Sciences,* vol. 5, pp. 542-547, 2010.