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Influence of Late Planting on Growth and Yield of F3 Cowpea (*Vigna unguiculata L. Walp*) Inbred Lines in the Guinea Savanna Agro-Ecology of Ghana

S. Luriwie [a] and M. S. Alidu [a*]

[a] Department of Crop Science, Faculty of Agriculture, Food and Consumer Sciences, University for Development Studies, P. O. Box TL 1882, Nyankpala, Tamale, Ghana.

Authors' contributions

This work was carried out in collaboration between both authors. Author SL did the writing and original draft preparation of the study and author MSA did the reviewed and edited of the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Planting time is an essential agronomic practice for the growth and yield of crops. This phenomenon enhances the crop ability to perform better in varied environments. The experiment was conducted during the late season in September, 2020 at the University for Development Studies (UDS) experimental field. The objective was to evaluate the influence of late planting on the growth and yield of third filial generation of cowpea inbred lines. The experiment was a single factor experiment laid in a randomized complete block design. The lines were ABF_3, GOF_3, MF_3, SAF_3 and an advance breeding line IT93K503-1, used as a standard check. Data was collected on plant height, Leaf area, branch count at harvest, Chlorophyll Content, Days to 50% flowering, Days to 95% maturity, Number of seeds per plant, Pod weight per plant, Pod length per plant, Number of seeds per pod, Hundred seed weight, Dry matter, and grain yield. Data was analyzed using Gen Stat Statistical package 12th edition and treatment means were separated at 5% probability level. Results showed significant differences in eight parameters measured. SAF_3 recorded the highest plant height and leaf area. SAF3 recorded the highest chlorophyll, while GOF_3 recorded the lowest chlorophyll content. Again, GOF3 flowered early compared with the check but SAF_3 recorded the longest days to flower. GOF3 matured early, whilst SAF3 took the longest days to pod maturity. SAF_3 had the highest grain yield. The results obtained in the study showed that, planting time had significant influence for grain yield of cowpea.

**Corresponding author: E-mail: msanatu@uds.edu.gh;*

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1. INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is a highly significant grain legume of economic benefits and form part of oilseed legumes including soybean and groundnut growing in the tropical regions of Africa [1]. The domestication of cowpea occurred about 2000BC and has its origin in Africa as well as its wild forms [2]. The center of diversity is said to have begun in southeastern and in northeastern parts of Africa [3]. Cowpea serves as a sustainable means of solving nutrient deficiency problems by supplying proteins, carbohydrates, vitamins, amino acids [4]. Minerals and fiber which form part of the diets is supplied in adequate amounts by cowpea when consumed as grain and or as vegetable [5]. The crop is often known to be a cheap protein source for the poor [6]. Cowpea seeds contains carotenoids, phenolic and adequate antioxidants (A *et al*., 2017). Leaves and stems are also used as quality hay for livestock in Africa most often in the dry season [7]. Every component of cowpea is useful including both dry and fresh grain is used before and at harvest and this is common in the south Eastern part of Asia. The leaves of cowpea is widely used as a herb in East Africa [8]. Cowpea plants form nodules which contribute to atmospheric nitrogen fixation and also used as a good green manure crop in commercial farms [8].Creeping cowpea varieties has adequate canopy and are highly useful to avoid soil erosion and smothering effect of invasive weed plants such as *striga hermontheca* over crops [9]. The crop also serves as a replacement for cereals and tubers which are deficient in proteins [10]. About 240 kg/ha of nitrogen is supplied annually with 60 to 70 kg remain usable for crops in rotation in the coming seasons [11]. This helps to curb the dangers associated with the over use of nitrogen fertilizers in our environments thereby encouraging the use of biological nitrogen fixation to maintain agricultural productivity [12].

Appropriate timing of planting cowpea lines remains a better alternative ameliorate serious drought effects most especially in the tropics. Knowing the appropriate planting time for cowpea is a prominent agronomic need to make the production process feasible [13]. It is therefore, important to research into finding appropriate means of developing lines that will be suitable to the needs of varied environments and their associated threats to production [14]. The objective of the study was to determine the impact of late planting on the growth and yield of a locally developed cowpea F_3 inbred lines or the guinea and Sudan Savanna agro-ecologies of Northern Ghana.

2. MATERIALS AND METHODS

2.1 Experimental Site Description

The experiment was conducted at the University for Development Studies, Nyanpkala. The study area lies on (9^0 42'N latitude and 0^0 92' W longitude and 184 altitude). The experiment was carried out in the late season from September to November in which minimal rainfalls occur The area is found in the Guinea savannah agro-ecological zone of Ghana. The study area is located under the Tolon District in the Northern region of Ghana. The soils of the area are made from the voltaic sandstone and are not compacted. The study area is also characterized by a single raining season which starts from May and ends in October but with the highest peak of rains in the season occurring at August to early September. November to around March constitute the dry season with no rains recorded. The area comprises of wet and dry season. The study area records about 40^0 C as highest temperatures in March and 18^0C as lowest temperatures in December. Average temperatures for a day range from 26 to 45 ^{0}C. The Soil of the study area is brown in colour with a mixture of few gravel and a moderately drained clay loam in texture. The area is characterized by vegetation and mostly dominated by grasses with some few shrubs and trees. [15].

2.2 Experimental Design

The experiment was a single factor and laid out in a randomized complete block design and replicated three times. Each replication contains 5 experimental units in a block given a total of 15 experimental units. Recommended plant spacing of between and within plants were 60 cm x 20 cm respectively. Each replication was separated by an alley of 2 m between blocks. Four F_3 cowpea lines GOF_3, ABF_3, MF_3, and SAF_3 and an advanced breeding line as a standard check IT93K-503-1 as a check were planted on 17th September, 2020.

2.3 Development of F_3 Inbred Lines

Four F_3 cowpea inbred lines which were used in the study were obtained from a cross between 4 farmer-preferred local germplasm used as females were Gorigori(G), Ablajagbadow, (AB), Milo(M), and Sanzi (S) and a male parent obtained from the international Institute for Tropical Agriculture, Nigeria. The first filial generation obtained from the parents were screened in pots and selection were subsequently done for drought in pots to obtain F2. F2 were evaluated under terminal drought to generate the F3 population. The F3 were then designated as, Gorigori (GOF3) Ablagbajadow (ABF3) Milo (MF3) and Sanzi (SAF3) upon advancement of generations.

2.4 Treatment Description

In the study, the experimental material namely; GOF3, ABF3, MF3, SAF3 and IT93K5O3-1 were randomized and replicated three times. Two weeks after planting (WAP) and upon successful emergence, the seedlings were thinned to one per stand giving a plant population of 4, 0909 plants per ha. Manual weed control was carried out on all experimental units at weeks 2 and 4 after planting using a hoe. 10 ml of K-optimal with 8 litres of water in knapsack sprayer was used to control insect pest weekly. No fertilizers were applied in maintaining the practices of the farmers in the area.

2.5 Data Collection

2.5.1 Plant height

Plant height was measured using meter rule at weekly intervals but begun at 2 weeks after planting. The measurement was taken from the base of the plants on the soil surface to the youngest trifoliate expanding leaves on the terminal shoot.

2.5.2 Number of branches at harvest

The average number of branches per plant within each plot was obtained by a final branch count at maturity on number of plant branches of five tagged plants from each plot at harvest

2.5.3 Chlorophyll content

Chlorophyll content was determined per plot by using the Spad Meter to take readings on the tagged plants leaves as many as 13 to 17 leaves per plant to obtain their average values. Starting from 2 WAP to 5 WAP.

2.5.4 Leaf area

The leaf area was determined using a meter rule on five tagged plants. The measurements were taken on three leaves per plant on all experimental units weekly. The leaves were measured by taken the estimates of length x breadth (LXB) of the leaves at various stages of the plants starting from 2^{nd} to 5^{th} week after planting (WAP) and averages computed for each plot using the indicators Area (A cm^2) = length(L)cm x width(B)cm.

2.5.5 Number of days to 50% flowering

The number of days to 50% flowering was determined by observation and days count from planting date to about half of plants in all plots flowering.

2.5.6 Number of days to 95% maturity

The number of days to 95% was taken from the time when matured pods where observed in the plots up to days where almost all the plants have matured pods and express as a percentage.

2.5.7 Pod weight per plant

At harvest ten [10] healthy pods were selected randomly from each of the tagged plants per plot and weighed using an electronic scale to get their weights were recorded. Average pod weight was then computed per each plot.

2.5.8 Pod length per plant

Ten [10] healthy pods were selected from the tagged plants in the net harvest area of plots and their lengths were taken using a meter rule. However, pods that are not straight was measured using the manual rope method.

2.5.9 Number of pods per plant

Matured pods from five plants were harvested from the net harvest area and counted to obtain the number of pods per each plant and means were taken [16].

2.5.10 Number of seeds per plant

Five plants were randomly selected from each experimental unit from the net harvest area and the pods were cracked. The seeds from the pods of the five plants were counted. The averages were computed and represent the number of seeds per plants.

2.5.11 Number of seeds per pod

The average number of seeds per each pod was determined by cracking and revealing the grains from the already ten selected healthy pods from the tagged plants. The seeds were counted and average seeds per pod were calculated for each plot.

2.5.12 Hundred seed weight

The pods were harvested, dried and threshed to reveal the seeds in each pod. Hundred seeds were randomly counted from the harvest of each experimental unit and weighed using an electronic balance to obtain the hundred seed weight in grams.

2.5.13 Dry matter per plot

The dry matter per plot was obtained by oven drying plants biomass taken from plots at 80^{0}C and the weights were recorded using electronic balance in grams and later converted to kg / ha.

2.5.14 Grain yield

Pods from the experimental units were harvested and dried. The pods were also threshed, winnowed and weighed in kilograms.

2.5.15 Data analysis

Data collected were analyzed using GENSTAT statistical package (12th Edition). Treatment means were compared and separated using least significant difference (LSD) at 5% significant level. Results were presented in graph and Tables.

3. RESULTS

3.1 Plant height

There were significant differences (*P*<0.01) for plant height among inbred lines and standard check for the 2, 3 and 4th week after planting. For week 2, ABF3 recorded the highest height of 15.60 cm, with GoF3 having lowest height as 13.89 cm. At 3 WAP, ABF3 had the highest height of 22.39 cm and GOF3 with lowest as 21.07 cm. ABF3 recorded 24.39 cm as highest plant height and SAF3 recorded 21.56 cm as the least plant height Fig. 1.

3.2 Number of Branches at Harvest

They were Significant differences (*P*< 0.013) among inbred lines and standard check for number of branches at harvest due to late planting. Treatment GoF3 recorded the highest number of branches per plant as 7. However, SAF3 recorded the least number of branches per plant of 4.

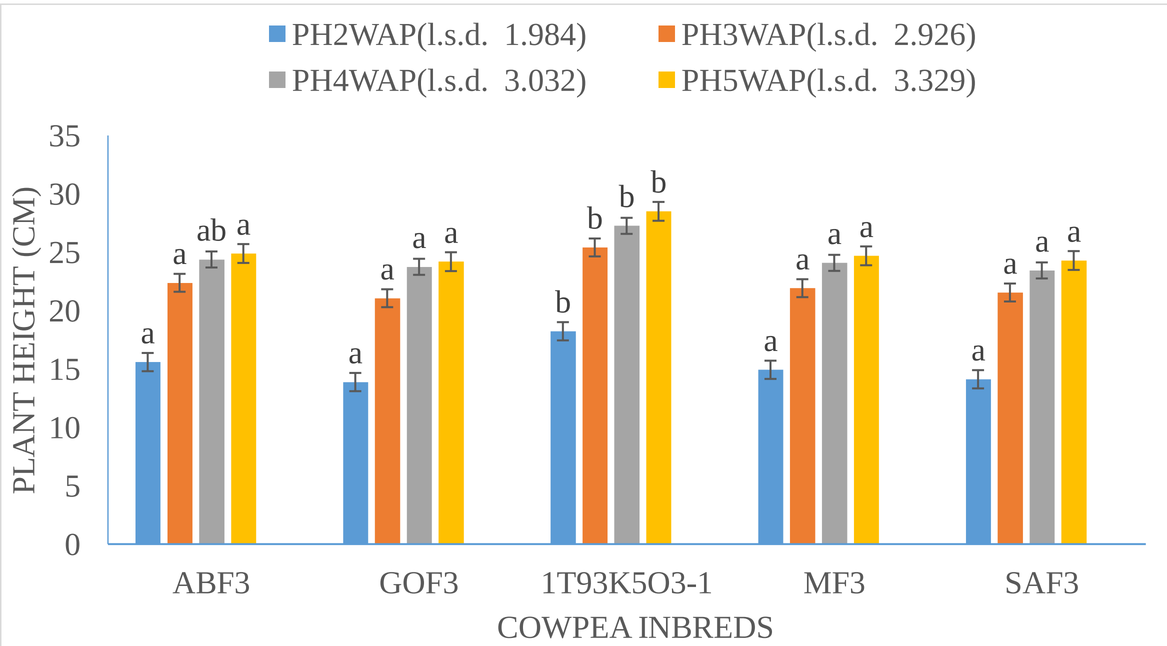

Fig. 1. Response of inbred lines on plant height to late planting

3.3 Chlorophyll Content

There were significant differences (*P*<0.001) among lines for chlorophyll content at 3WAP. IT93K-503-1 recorded 49.93, SAF3 followed with 46.97, MF3 also had 46.90, ABF3 recorded 44.93 and GOF3 with less chlorophyll for the week at 44.47. There were significant differences (*P*<0.01) for chlorophyll content in 4 WAP among inbred and the check in the late planting. MF3 recorded the highest chlorophyll as 47.97, ABF3 with 47.83, SAF3 recorded 46.87 and GOF3 has the least for the week with 44.53 compared to the standard check. There were significant differences (P<0.056) among the inbred lines and the standard check for chlorophyll content at 5 WAP. SAF3 had 40.87as highest chlorophyll and MF3 with least chlorophyll of 39.23.

3.4 Leaf Area

There were significant differences (*P*<0.001) among inbred lines for leaf area at 3 wap. Genotype SAF_3 also recorded 53.14 cm as highest leaf area and ABF3 MF_3 had 50.14 cm and GoF_3 with least area as 40.63 cm compared to the check. The genotype MF_3 recorded 61.25cm as highest leaf area whilst SAF_3 with 60.08cm². ABF3 obtained 51.78cm as leaf area. There were significant differences (*P*< 0.002) among the inbred lines to leaf area for 5 wap. MF3 had 66.38cm as highest. SAF3 also recorded 65.11cm². ABF_3 and GOF_3 recorded 57.42cm and 44.17cm accordingly with GOF3 receiving the least leaf area for the week as shown in Fig. 4.

3.5 Number of Days to 50% Flowering

There were significant differences (*P*<0.001) among inbred lines and the standard check in the late planting for days to 50% flowering. SAF3 highest numbers of days to 50% as 43 whereas GOF3 recorded the least days to 50% flowering as early as 37 days compared to the check.

3.6 Number of Days to 95% Pod Maturity

Significant differences (*P*<0.001) were observed among the inbred lines and the standard check during the late planting for number of days to 95% pod maturity. SAF3 and MF3 recorded the highest number of days as 61 whilst treatment GOF3 and ABF3 recorded 56 and 53days respectively with GOF3 being the least score for number of days to 95% pod maturity compared to the check.

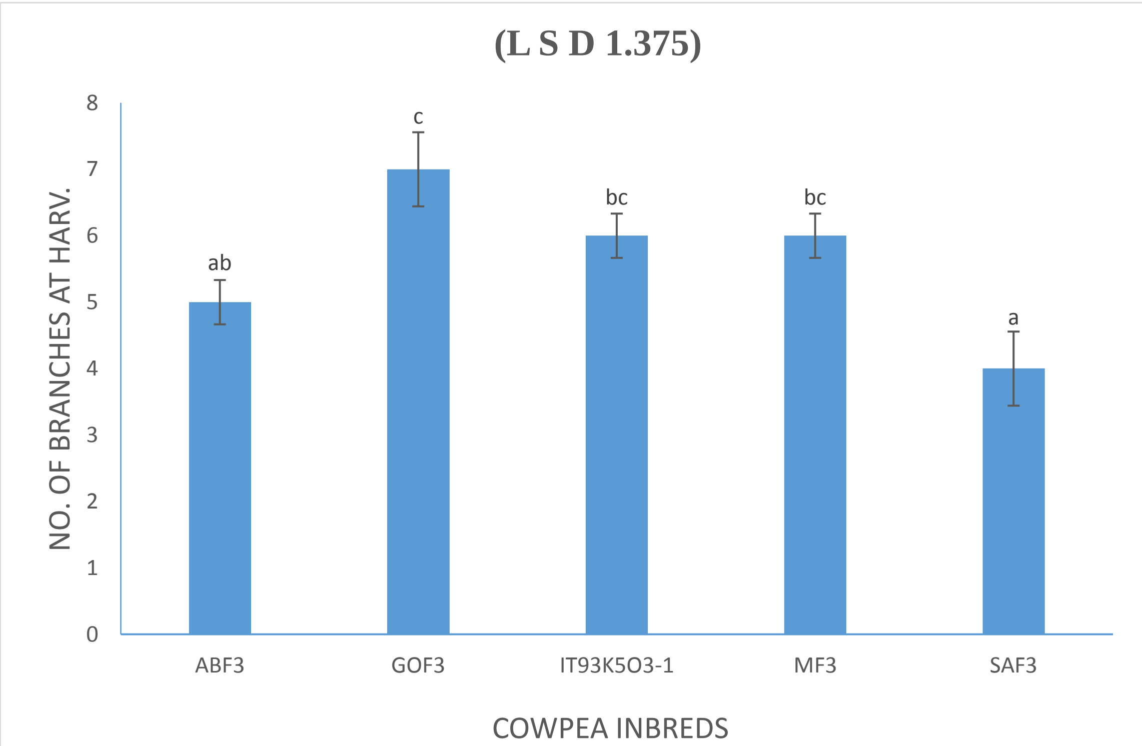

Fig. 2. Response of inbred lines to number of branches at harvest for late planting

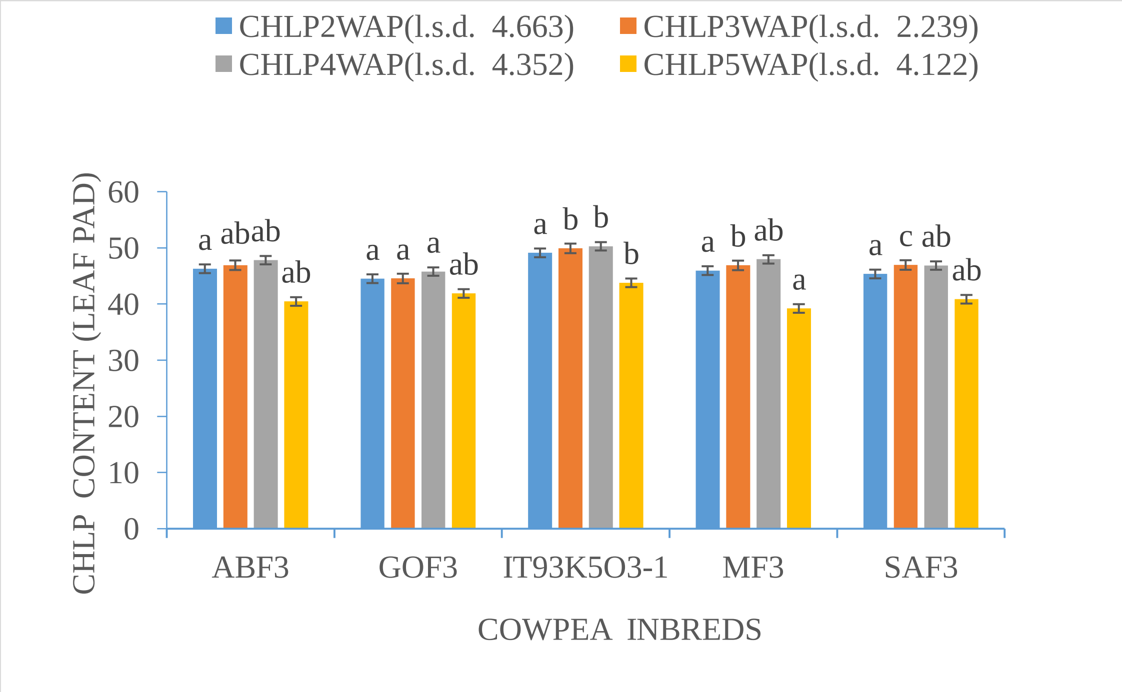

Fig. 3. Response of inbred lines to chlorophyll for late planting

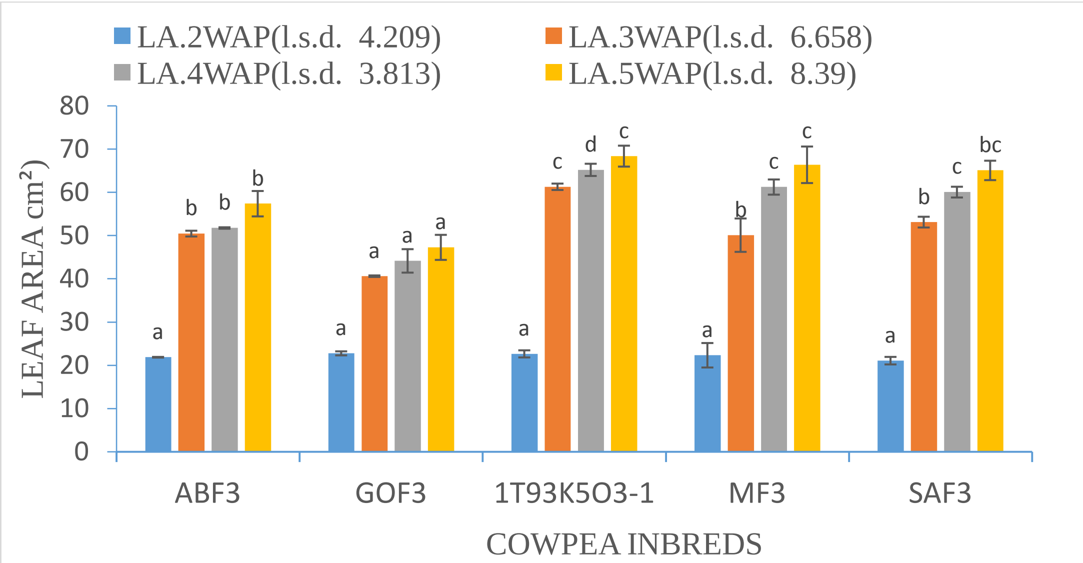

Fig. 4. Response of inbred lines to leaf area for late planting

3.7 Grain Yield per Ha (kg/ha)

Significant differences (*P*<0.017) were recorded among inbred lines for grain yield. SAF3 recorded 1060.2 kg/ha as highest grain yield per ha. MF3 and ABF3 recorded 9.27.7 kg/ha and 877.3 kg/ha respectively. However, GOF3 recorded the lowest yield of 447.2 kg/ha as shown in Fig. 7.

3.8 Number of Pods per Plant

There were no significant differences (*P* ≥ 0.323) among inbred lines and the standard check to the late planting for number of pod per plant. Treatment GOF3 has the highest number of pods per plant to be 16 followed by ABF3 with 14 pod per plant. However, SAF3 had 13 as number of pods. MF3 recorded 10 pods per plant as the least compared to the standard check.

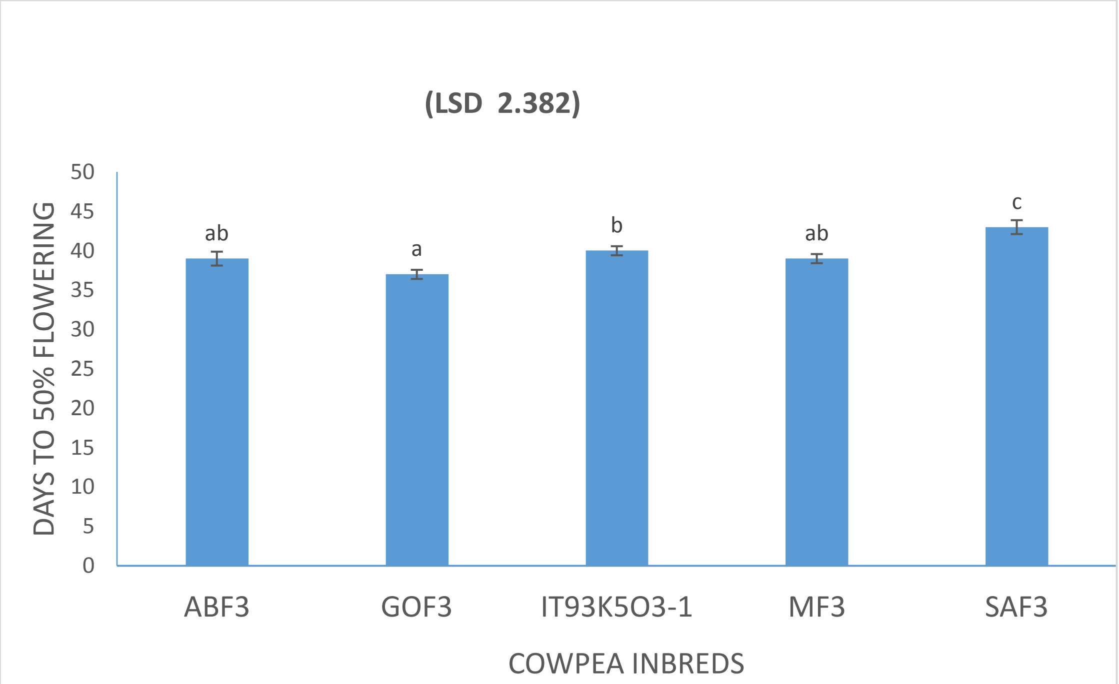

Fig. 5. Response of inbred lines to number of days to 50% flowering

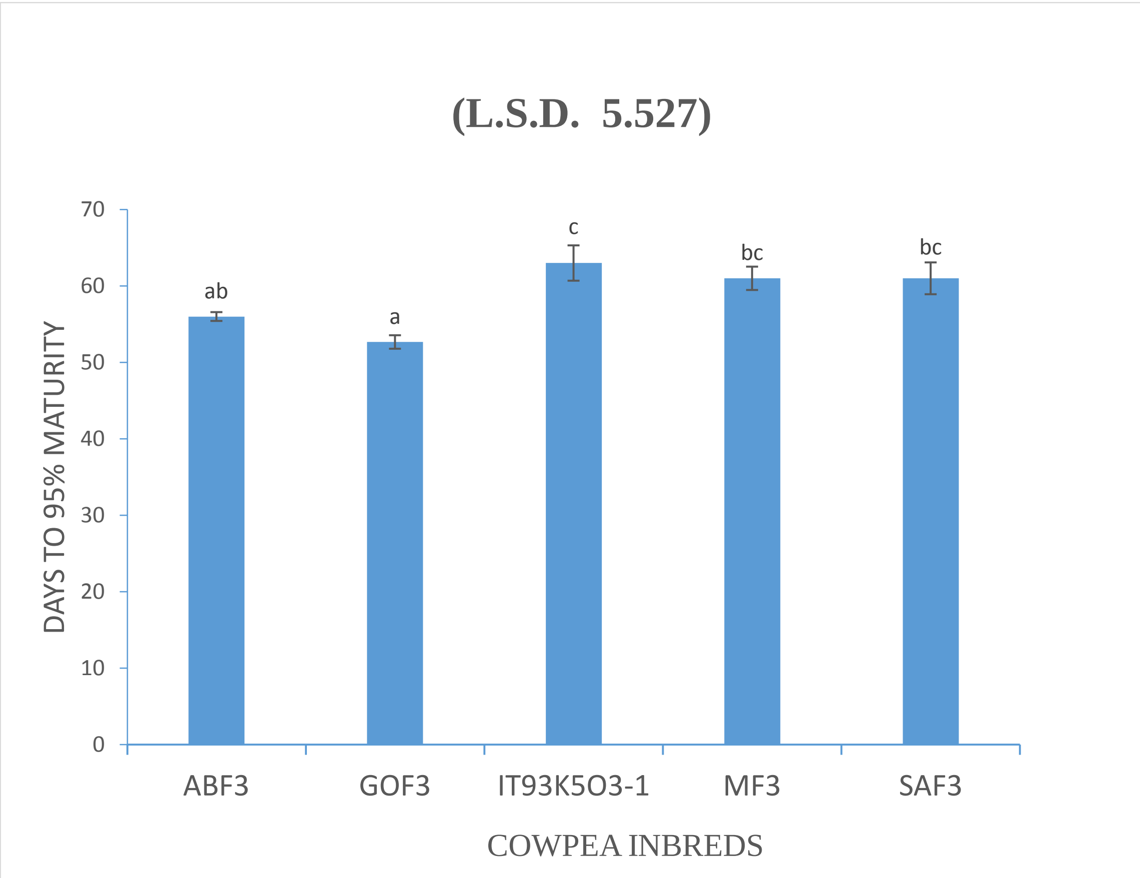

Fig. 6. Response of inbred lines on number of days to 95% pod maturity to late planting

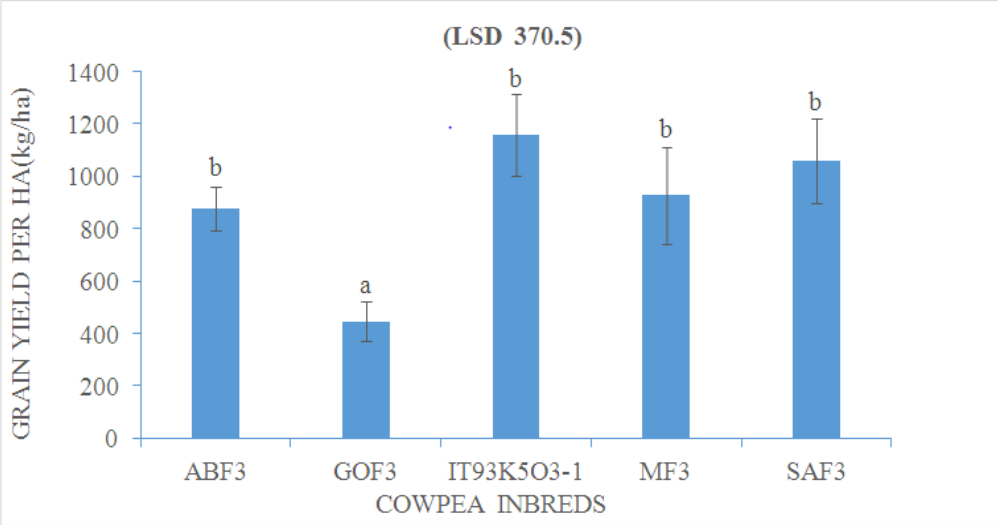

Fig. 7. Response of inbred lines to grain yield per /ha for late planting

Table 1. Response of inbred lines on number of pods per plant to late planting

Inbred lines	Number of pods per plant	LSD
Treatment	MEAN	
ABF3	14a	
GOF3	16a	
IT93K5O3-1	12.67a	**(5.768)**
MF3	10.33a	
SAF3	12.67a	

Table 2. Response of inbred lines for hundred grain weight

Inbreds	Hundred /Grain Weight(g)	LSD
Treatments	MEAN	
ABF3	26.1a	
GOF3	20.4a	
IT93K5O3-1	26.9a	**(8.06)**
MF3	25a	
SAF3	21.2a	

Table 3. Response of inbred lines on dry matter per ha to late planting

Inbred lines	Dry Matter (kg)	LSD
Treatments	MEAN	
ABF3	671.5a	
GOF3	557.5a	**(195.6)**
IT93K5O3-1	781.8a	
MF3	696.7a	
SAF3	683.7a	

3.9 Hundred Grain Weight

There were no significant differences ($P \geq 0.313$) among inbred lines and the standard check in the late planting for hundred grain weight. ABF3 recorded the highest grain weight of 26.07 g followed by the remaining treatments MF3, SAF3 and GOF3 which recorded 24.97g, 21.17 g and 20.43 g respectively compared to the check. Treatment GOF3 recorded the lowest seed weight.

3.10 Dry Matter per Ha

There were no significant differences ($P \geq 0.474$) among inbred lines and the standard check to the late planting for dry matter content per ha. The dry matter varies among the inbred with MF3 recording the highest for dry matter of 696.7 kg/ha, SAF3 and ABF3 also recorded 696.7kg, 683.7 kg/ha and 671.5 kg/ha accordingly. Treatment GOF3 recorded 557.5 kg/ha. As the least dry matter per hectare. 557.7 kg/ha (Table 3).

4. DISCUSSION

4.1 Plant Height

The results indicated that there were significant variations in plant height across all weeks among the inbred lines and the parental check. IT93K503-1 (check variety). ABF3 recorded the highest average plant height for all weeks throughout the growing season followed by SAF3, MF3, with GOF3 having the lowest plant height in the season. The difference in the heights is due to the growing habits of the varieties and the genetic potential of the varieties with reference to their phenology. Hybridization of species accompanied with inbreeding allows the identification of linked characters that brings about heterosis or vigor in plants which does not degenerate the growth of individual species [17,18] also studied on the Performance of cowpea genotype at higher altitude and concluded that plant height as yield indicator could be influenced by adverse environmental factors. He further postulated that cowpea varieties with lower height produce less seed yield than adequate growing varieties which agrees with the results that significant differences existed for the inbred lines and the check leading to an increase in plant height.

4.2 Number of Branches at Harvest

The results obtained indicated that significant differences were among inbred lines compared with the standard check for number of branches at harvest. Treatment GOF3 recorded the highest number of branches per plant. Followed by MF3 with SAF3 recording the least number of branches per plant. The results is in agreement with [19]who concluded that significant differences exist for number of branches at harvest among cowpea varieties.

4.3 Chlorophyll Content

The results on chlorophyll content significantly varied among the parental check and the lines for late planting. SAF3 recorded the highest chlorophyll across all weeks, where by, GOF3 had the least chlorophyll. High chlorophyll contents were recorded in the early stages of the plant growth since chlorophyll correlate with photosynthetic activities of the plants but later diminished due to senescence, chlorosis and drought conditions. [20] in a study on the effect of water stresses on cowpea varieties discovered that, inadequate moisture at vegetative stage significantly reduced cowpea chlorophyll content. This observation confirms the results as drought had a great impact on losses of large volumes of soil moisture. The study also reported 100% reduction in the chlorophyll content of the cowpea genotypes under severe water stress. Chlorophyll is an associate of morphological, biochemical and physiological traits for drought screening in cowpea. It is however noticed that, the response to drought in terms of chlorophyll content was, not dependent on the cowpea variety.

4.4 Leaf Area

The results obtained indicated an increase in leaf area among the parental check and the inbred lines under the late planting. SAF3 recorded the highest leaf area across all weeks of data collection, with GOF3 recording the least leaf area among the genotypes compared with the standard check. This result supported the findings of [21] who reported that there was an increment of leaf area in cowpea genotypes which were subjected to late planting accompanied with droughts. [22] in their studies also reported that, reduction in soil moisture result in slow leaf growth exhibiting sensitivity to moisture reductions. Though there was an increase in leaf area which might lead to high transpiration causing a decrease in soil moisture, the survival rate was high. This indicates that the lines are drought promising. A related discovery was made by [23] who stated that drought tolerant lines exhibit greater maintenance of leaf area under droughty condition. Maintenance of leaf area in plants under drought situations is a survival mechanism due to stomatal closure which limit transpiration during severe drought and conserve moisture. Leaf area is an important drought parameter that measure the amount of radiations, precipitation ,energy conversion in a form of sunlight to perform photosynthesis and water balance in plants to conserve moisture due to environmental stresses such as drought [24].

4.5 Number of Days to 50% Flowering

The results indicated significant differences existed among inbred lines and the parental check for late planting for days to 50 % flowering. The longest number of days to flowering was 43days which was recorded by SAF3. MF3 and ABF3 both recorded the same number of days to 50% flowering as 39. GOF3 was noticed to have the least days to 50% flowering as early as 37 days. However, the time of flowering of a plant is a pre-indication of early or late maturity and hence not an indicator enough for good yield .This results is in agreement with [25] who conducted a research on varietal response of four cowpea cultivars and found out that significant differences occurred for 50% flowering. In a related development, Marfo and Hall, (1992) observed that floral bud development in beans is inhibited by temperature variations and prolonged number of flowering days resulting in few flower productions.

4.6 Number of Days to 95% Pod Maturity

Significant differences were observed among the inbred lines and the standard check due to the late planting for days to 95% pod maturity. The maturity period of a crop is an important agronomic need to take advantage of the season to maximize productivity of the crop. The SAF3 recorded the highest number of days to 95% pod maturity and GOF3 being the least score for number of days to 95% pod maturity as compared to the check. The variations on the pod maturity times could have been influenced by the earliness of the varieties to flowering. Since days to flowering significantly correlates with number of days to 95% pod maturity which also significantly correlated with related pod yield parameters [26]. There was high and positive indirect effect which was observed for days to 95% physiological maturity in two seasonal plantings for Bambara groundnut [27]. In a related study on the defoliation of cowpea varieties and its contribution to yield parameters, it was however reported that, number of days to 95% pod maturity were significantly increased by defoliation at the vegetative stage while number of flower production was inhibited. The high level of defoliation significantly increased days to flowering while number of days to pod maturity was increased by 100% defoliation in cowpea and this was attributed to droughts [28].

4.7 Number of Pods per Plant

There were no significant differences among inbred lines and the parental check for number of pod per plant. This result match with the findings of Adcock and Lawes, (1976) which stated that four pods are usually present in the peduncles and the cowpea varieties produce varying number of pods per plant between 8 and 22 seeds per plant. Pod number among cowpea varieties is largely due to the genetic composition of the plant. It was also observed that the podding was also hindered by some amount of terminal drought.

4.8 Total Number of Pods Harvested

The results from the analysis displayed no significant differences among the inbred lines and the parental check for number of harvested pods per plot in the late planting. In a study on the yield and harvesting periods of some cultivars of beans, seed yield and pod number per plant was reported to have no significant variation due to the effect of terminal droughts leading to poor formation and less pods at the peduncles [29].

4.9 Hundred Grain Weight

The results indicated no significant variations among inbred lines and the parental check for hundred grain weight. [30] said drought stress significantly reduce grain weight of cowpea varieties. He also found out that, Plants battling with drought during flowering stages had a lower grain weight than at vegetative stages of plant growths. It is also mentioned that application of nutrients (phosphorus) increased 100 seed weight [31].

4.10 Grain Yield

Results presented from analysis showed significant differences were recorded among inbred lines to late planting for grain yield. SAF3 recorded the highest grain yield with 1060.2 kg/ha whilst GOF3 recorded the lowest yield of 447.2kg/ha. There were no significant differences statistically between, MF3, SAF3 and ABF3 compared with the check, but there were significant differences among the inbred lines and GOF3 in yield. The significant differences recorded was due to adverse environmental conditions that hinder adequate growth of the cowpea varieties and also varietal differences [32] reported on cowpea genotypes that, late planting of cowpea contribute much more yield than early planting since early planting promote vegetative growth with fewer pods. Marfo and Hall in 1992 postulated that both early or late planting season, enhance the lines ability to escape from hot weather conditions at reproductive growth stages and contributing to higher yields.

5. CONCLUSION AND RECOMMENDATION

At the end of the experiment, SAF3, MF3 and ABF3 cowpea inbred lines were found to perform better in the parameters evaluated compared with the standard check and promising for the late season planting. The results obtained in the study demonstrated that, planting time had significant influence for grain yield in the developed cowpea inbred lines. Subsequent evaluations should be done in the next generations. Also, late season planting is good for cowpea cultivation since the crop's maturity is likely to coincide with the dry period offering the farmer a better opportunity for good quality seed and thus very important to cowpea farmers and seed traders if adopted in the Guinea Savanna Agro ecology of Ghana.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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