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Growth and Yield Performance of Improved Cowpea (*Vigna Unguiculata* L.) Varieties in Ghana

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Abstract

Cowpea is well adapted to environmental conditions that affect crop production such as drought, high temperatures and other biotic stresses compared with other crops. Notwithstanding, growth and development of many cowpea cultivars are affected by drought and high temperatures, especially during floral development. This is because cowpea cultivars tend to have narrow range of adaptation as cultivars developed for one zone usually are not very productive in other zones. A study on the growth and yield performance of seven cowpea varieties was conducted during the 2012 major and minor rainy seasons at the CSIR-Crops Research Institute, Kwadaso-Kumasi, Ghana to compare the performance of the seasonal variation on each variety. These improved varieties Nhyira, Tona, Asetenapa, Asomdwe, Hewale, Videza and IT 89KD374-57 were evaluated using a randomized complete block design and replicated three times. The results showed that varieties Hewale, Videza and Nhyira gave higher seed yields, whereas IT 89KD374-57 and Asetenapa had lower seed yields. Nhyira and Hewale gave comparatively better seed yields under both conditions. Hewale was the highest seed-yielding genotype under both major and minor raining season. Cowpea production could be a profitable agribusiness for cowpea growers in Ghana considering the higher returns in terms of grain yield obtained in both seasons.

Keywords: seed and dry matter yield, legume and minor season

1. Introduction

Cowpea (*Vigna unguiculata* (L.) Walp) is one of the most ancient human food sources and has probably been used as a crop plant since Neolithic times (Summerfield, Huxley, & Steel, 1974). Cowpea is grown extensively in 16 African countries, with the continent producing two-thirds of the world total (Winrock, 1992). The crop is of major importance to the livelihoods of millions of people in the tropics. For resource-poor small-holder farmers, the crop serves as food, animal feed, cash and manure. Going beyond its importance for food and feed, cowpea can be regarded as a pivot of sustainable farming in regions characterized by systems of farming that make limited use of purchased inputs like inorganic fertilizer. The crop can fix about 240 kg ha^{-1} of atmospheric nitrogen and make available about 60-70 kg ha^{-1} nitrogen for succeeding crops grown in rotation with it (Crops Research Institute [CRI], 2006; Aikins & Afuakwa, 2008).

Cowpea is well adapted to environmental conditions that affect crop production such as drought, high temperatures and other biotic stresses compared with other crops (Martin, Blake, & Hockett, 1991). The aforesaid growth and development of many cowpea cultivars are affected by drought and high temperatures, especially during floral development (Dadson *et al*., 2005).

In Ghana, cowpea covers 156,000 ha (International Institute of Tropical Agriculture [IITA], 1993). The yields of the crop, however, are among the lowest in the world, averaging 310 kg/ha (Ofosu-Budu, Obeng-Ofori, Afreh-Nuamah, & Annobil, 2008). Meanwhile, the crop is one of the widely cultivated legumes, mainly in the savannah and transition zones of Ghana (CRI, 2006). Hence, efforts have been made to improve cowpea production in all agro-ecological zones of Ghana through various means including the introduction of new varieties such as those used in this study.

In recent years, several studies have evaluated the performance of cowpea genotypes in several ecological zones of Ghana. In selecting appropriate genotypes for different agro-ecological environments, it is important to know how various soils and climatic factors affect the growth and development of these new varieties in order to interpret the observed yields under these environments.

Appropriate agronomic practices to improve the performance of new varieties of improved and dual-purpose cowpea under different agro-ecological zones are generally important for breeding and production purposes. Yield and growth performance could be increased through the evaluation of all these varieties under different agro-ecological zones for a better understanding of their morphological, physiological and biochemical response to the environment. This underscores the importance of evaluating the agronomic performance of cowpea varieties as a food security crop under the current and foreseeable future scenarios. The objective was to evaluate key yield related parameters among seven cowpea genotypes in the Forest zone of Ghana.

2. Materials and Methods

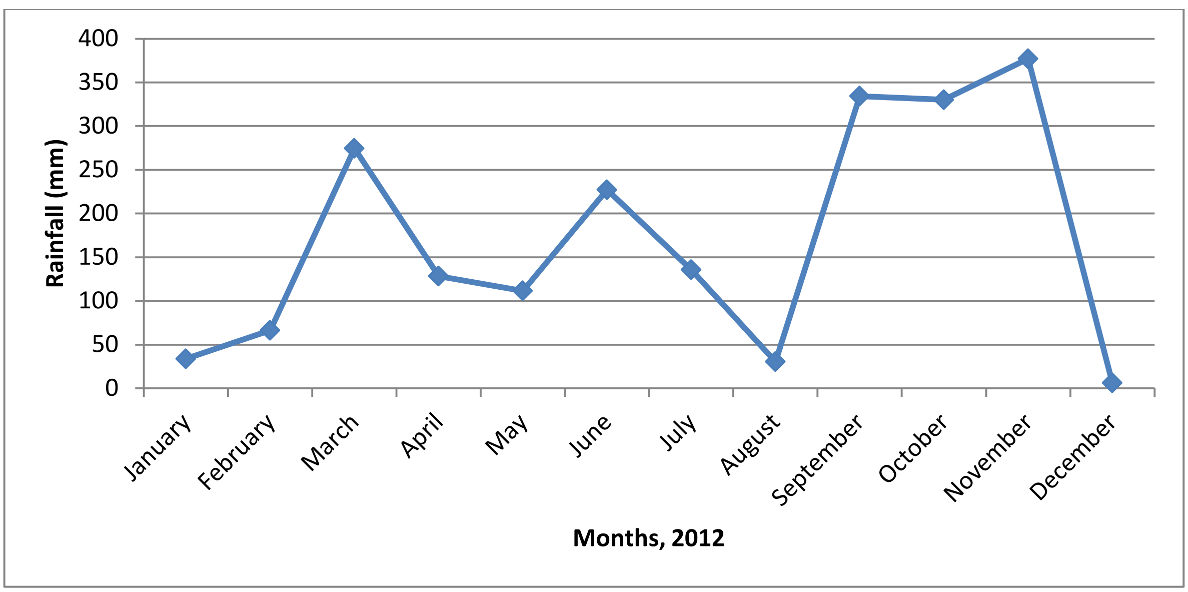

Figure 1. Rainfall distribution in 2012

The study was carried out at the research field of the CSIR-Crops Research Institute, Kwadaso-Kumasi, Ghana. The area has a bimodal rainfall pattern, the major season (April to July) with maximum rainfall normally in June and the minor season (September to November) with the maximum normally in October. Figure 1 shows the rainfall amount and distribution during the study year of 2012. The area receives a mean annual rainfall of 1500 mm with an average monthly temperature range of 24 – 28 ^{o}C.

2.1. Soil Analysis

Soil samples were randomly collected before planting from four different cores at 0-15 cm and 15-30 cm for determination of soil physical and chemical properties using soil auger. The soil is a sandy loam classified as Ferric Acrisol (Food and Agriculture Organization [FAO], 1990), equivalent to Typic Haplustult in the USDA soil classification system. Table 1 gives the initial soil analysis.

Table 1. Chemical properties of soils at horizons 0-15cm and 16-30 cm at Kwadaso

					Bray's Available		Exchangeable Cations m.e. 100^{-1}g							
Depth	**PH**	**O.C**	**O.M**	**N**	**ppmK**	**ppmP**	**Ca**	**Mg**	**K**	**Na**	**TEB**	**Ex. Acidity**	**ECEC**	**% B.S**
0-15cm	5.3	1.87	3.2	0.12	100.4	106.3	3.5	0.8	0.1	0.04	4.42	0.45	4.87	90.76
15-30cm	5.4	1.56	2.7	0.1	55.8	3.75	2.9	0.8	0.1	0.03	3.82	0.4	4.22	90.52

2.2. Experimental Materials, Design and Treatments

Cowpea varieties Tona, Nhyira, Asetenapa and newly developed genotypes; Asomdwe, Hewale, Videza and IT 89KD374-57 used in this study were collected from the CSIR-Crops Research Institute, Kwadaso-Kumasi, Ghana. Seeds of the varieties were planted during the major and minor seasons after the experimental sites have been disc-ploughed and disc-harrowed. The seeds were sown in March and August, 2012 for the major and minor seasons respectively. Each of the genotypes was grown into a six-row plot of 3.0 m × 5.0 m with a spacing of 50 cm and 20 cm between and within rows respectively. The experimental design was a randomized complete block design with three replications. Two inner rows were harvested to determine the final seed yield. Other parameters such as plant height, root length, nodule count and number of branches were measured on 10 randomly selected plants from each plot.

2.3. Data Collection

Table 2. Yield potentials and general description of the seven Cowpea varieties used

Varieties	Yield potential (t/ha)	Seed coat texture	Growth habit	Seed shape	Maturity date
Asomdwe	2863 kg/ha	Smooth	Semi-erect	Globose	65-72 days
Videza	3043 kg/ha	Smooth	Semi-erect	Ovoid	68-77 days
Hewale	3130 kg/ha	Smooth-rough	Semi-erect	Rhomboid	64-72 days
Tona	2390 kg/ha	Smooth	Erect	Ovoid	71-80 days
Nhyira	2460 kg/ha	Rough	Erect	Globose	65-68 days
Asetenapa	2500 kg/ha	Smooth	Erect	Ovoid	63-70 days
IT 89KD374-57		Smooth	Semi-erect	Globose	65-72 days

(Crops Research Institute [CRI], 2010, p13)

Using the stratified sampling method, plants from an area of 1 m^2 were carefully uprooted from each plot. In all, 21 plots were sampled and for each sample, the roots were cut using a pair of secateurs, placed in an envelope and labelled before they were sent to the laboratory for dry matter analysis. The roots were carefully washed to remove attached soil. Fresh weight, root length and dry matter were taken from the sampled plants. Plants were placed in an oven maintained at 80°C for 48 hours. Samples from the 21 plots were sent to the laboratory for dry matter analysis

2.4. Statistical Analysis

Data were subjected to analysis of variance (ANOVA) using the Genstat Discovery 4th Edition statistical package with subsequent mean separation using LSD at 5 % level of significance.

3. Results

Results of the seasonal variation studies on the agronomic and yield performance of the improved cowpea varieties are presented in Tables 3 and 4. Significant differences (P<0.05) were observed among the varieties for grain and fodder production (Table 3).

The average seed yield of the seven cowpea varieties varied between 1499.2 kg/ha and 2261.0 kg/ha for the major season and 1208.3 kg/ha to 2091.0 kg/ha for the minor season. The maximum yield was obtained from Nhyira (2091.7 kg/ha) for the minor season and Videza (2261.3 kg/ha) for the major season with IT 89KD374-57 producing the least seed yield of 1208.0 kg/ha for the minor season. The trend however, was not replicated during the major season. Videza recorded the highest seed yield (2261.3 kg/ha) for the major season with IT 89 KD374-57 recording the lowest seed yield (1499.2 kg/ha). During the minor season, Nhyira produced seed yield (2091 kg/ha) superior to the recently released Videza and Hewale varieties (1375 kg/ha and 1625 kg/ha) respectively.

Dry matter yields were highest in Hewale (30.6 g) and Asetenapa (32.3 g) compared to the other varieties for the major and minor seasons respectively (Table 3). Hundred seed weight (HSW) ranged from 14.1 g to 19.2 g with a mean of 15.8 g for the minor season and 16.2 g to 25.1 g for the major season. The highest 100 seed weight was obtained from Videza for both the major and minor growing season (Table 3). Plant height was higher during the long rainy season compared to the short rainy season (Table 3).

Table 3. Seed and dry matter yields of seven cowpea varieties in the major and minor rainfall seasons of 2012

Treatments	Seed yield (Kg/ha)		100 Seed weight (g)		Dry matter		Plant height (cm)		Days to 50% Flowering	
	Minor	Major	Minor	Major	Minor	Major	Minor	Major	Maj	Min
Nhyira	2091.7	2179.0	14.8	19.2	19.2	20.6	54.7	65.6	48	48
Tona	1895.8	1910.7	14.5	17.7	24.6	24.5	63.6	64.2	48	48
Hewale	1625.0	2250.3	17.3	24.2	25.5	30.6	58.3	73.3	53	54
Asomdwe	1437.5	2105.4	14.1	17.53	17.5	18.3	61.6	61.3	49	48
Asetenapa	1291.7	1606.7	15.5	22.2	32.3	24.0	70.0	63.3	49	49
Videza	1375.0	2261.3	19.2	25.1	14.2	24.3	56.6	82.3	41	42
IT 89KD374-57	1208.3	1499.2	14.8	16.23	16.3	19.0	67.0	68.9	47	48
Mean	1560.7	1973.2	15.7	20.3	21.4	23.0	61.7	68.4	47	48
Lsd (0.05)	581.9	148	1.8	0.51	15.7	1.23	6.4	1.1	0.6	0.7
CV (%)	20.58	4.22	6.58	1.42	25.3	3.01	5.2	5.8	6.7	7.4

Tap root length was significantly higher in Nhyira (21.8 cm) and least in IT89KD374-57 (15.3 cm) in the major season (Table 4). Nhyira again maintained the greatest root length in the minor season (19.0 cm) however this was only significantly different from IT89KD374-57 which had the least root length ((13.7 cm) ($p<0.05$) (Table 4).

Nodule count ranged from 15 to 20 and 12 to 20 for the major and minor seasons respectively. Videza recorded the highest nodule count for both the major and minor seasons (20.3 and 20.0 respectively), ($p=0.05$). In both seasons, there was a negative correlation between nodule count and dry matter yield (Figures 3 and 4).

Nhyira produced the highest stem diameter (0.86 and 0.88 mm) for the minor and major seasons respectively with Asomdwe recording the lowest (0.56 cm and 0.72 cm) for the minor and major seasons respectively (Table 4). Number of branches per plant (NBP) among the cowpea varieties ranged from 5.0 to 8.0 and 5.0 to 7.0 for the minor and major seasons respectively (Table 4). Videza attained the highest number of branches in both the major and minor season (Table 4).

Table 4. Root length, nodule count, stem diameter and number of branches for cowpea varieties

Treatments	Root length (cm)		Nodule count		Stem diameter (m)		Number of branches	
	Major	**Minor**	**Major**	**Minor**	**Major**	**Minor**	**Major**	**Minor**
Nhyira	21.8	19.0	15.3	12.0	0.86	0.88	6	5
Tona	18.3	16.6	15.3	13.2	0.63	0.80	6	6
Hewale	18.4	17.6	16.3	12.0	0.83	0.83	6	5
Asomdwe	17.9	16.7	17.3	13.0	0.56	0.72	6	6
Asetenapa	18.8	18.3	15.3	14.0	0.84	0.84	5	5
Videza	18.5	15.7	20.3	20.0	0.68	0.78	7	8
IT89KD374-57	15.3	13.7	18.7	15.0	0.80	0.86	5	5
Mean	**18.4**	**16.8**	**16.9**	**14.2**	**0.7**	**0.8**	**5.8**	**5.7**
Lsd (0.05)	**0.96**	**4.6**	**1.5**	**9.5**	**0.16**	**0.08**	**1.2**	**1.2**
CV(%)	**2.92**	**15.3**	**5.14**	**37.3**	**5.93**	**4.48**	**11.13**	**13.75**

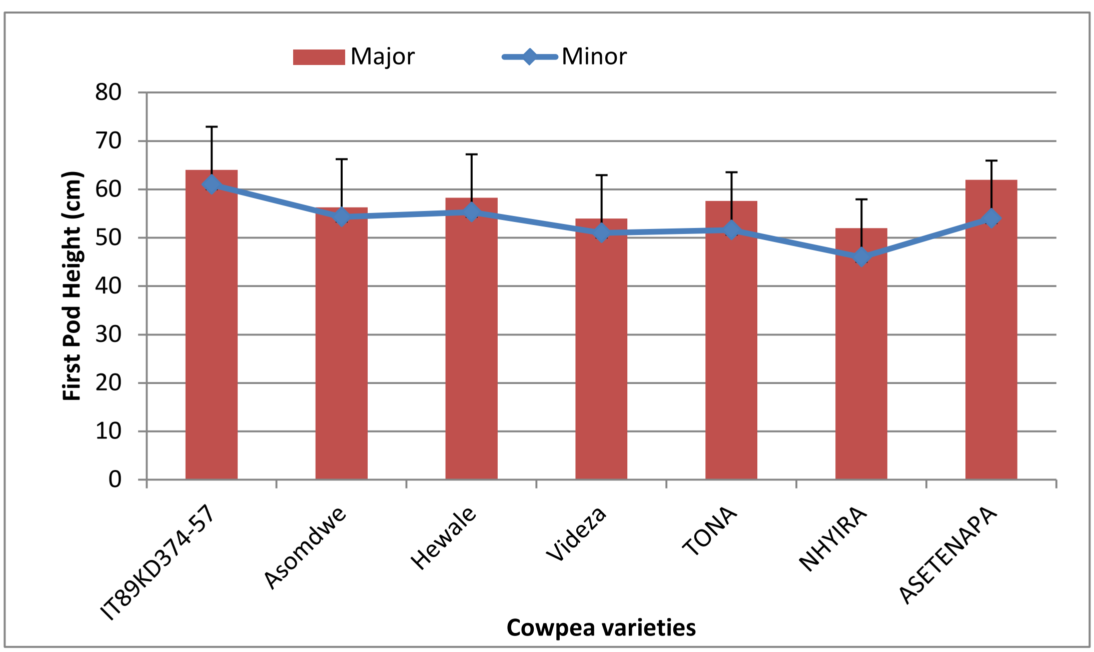

Figure 2. First pod height of the seven cowpea varieties

First pod height for the minor season was not significantly different among the seven cowpea varieties (Figure 2). The major season produced first pod heights which were higher than the minor season. IT 89KD374-57 produced the highest first pod height (64cm) and Nhyira producing the lowest FPH (52cm).

On the other hand, final plant height at harvest was significantly different among the seven varieties for both seasons (Table 3). Videza recorded the highest height plant height of 82.3 cm whiles Tona recorded the lowest plant height of 54.2 cm for the major season.

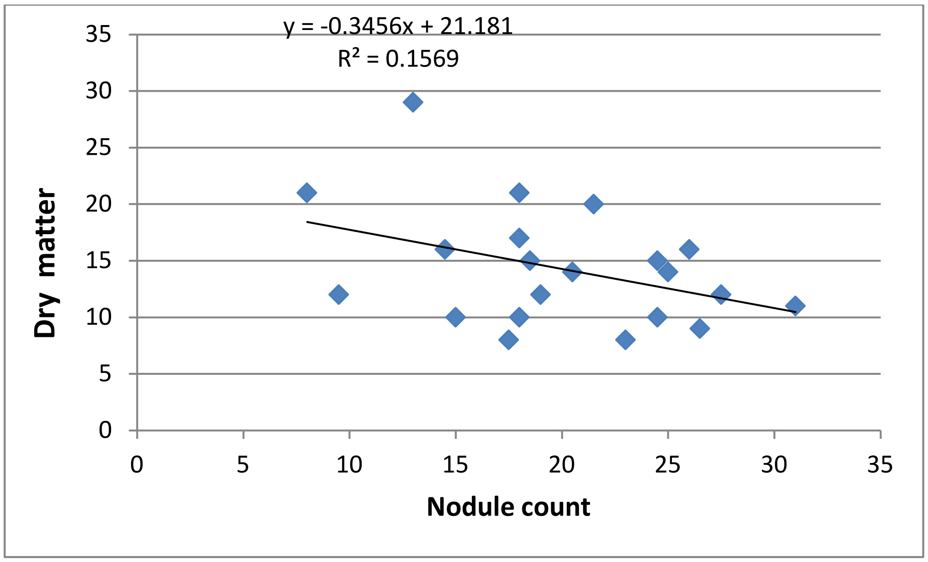

Figure 3. Relationship between Nodule count and Dry matter for the short rainy season

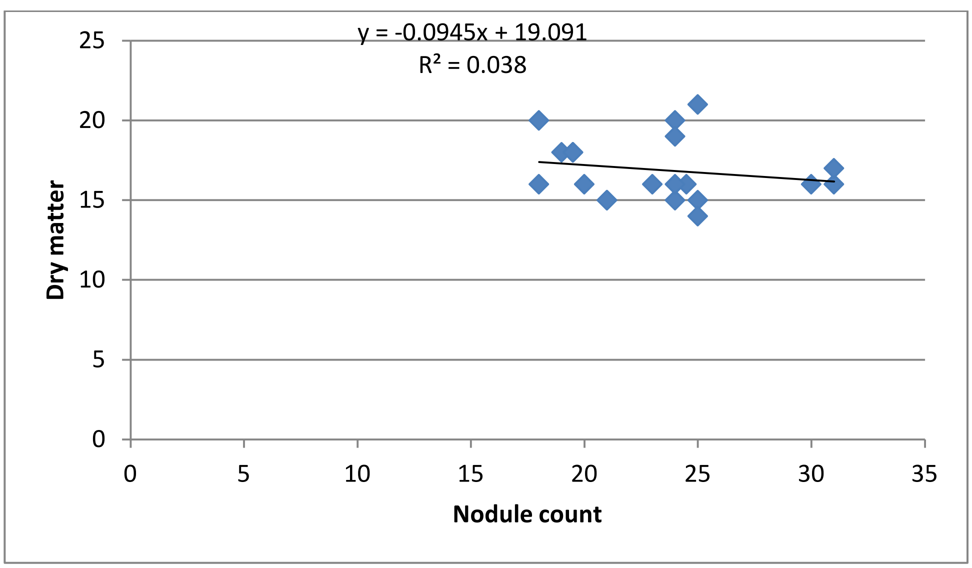

Figure 4. Relationship between Nodule count and Dry matter for the long rainy season

4. Discussion

The results of this study showed that rainfall is enough to support the growth and yield of cowpea in Kwadaso-Kumasi, Ghana, if other enabling factors are present in both the minor and major rainfall seasons. However, the cowpea varieties used in this study responded differently to the prevailing soil and climatic conditions.

The highest yield of Videza was related to the continuous water supply. The results indicates that Nhyira and Videza will be more profitable than the other varieties in the minor and major seasons respectively and could serve as an alternative crop because of its desirable attributes and resistance to major biotic and abiotic constraints.

Videza, Hewale and Asomdwe in this study gave lower seed yield under short raining season than the seed yield of the same variety grown under long raining season (Table 2). This is because cowpea cultivars tend to have a narrow range of adaptation, as cultivars developed for one zone with distinct climatic factors usually are not very productive in other zones with different climatic factors (Hall *et al*., 2003). Irrespective of the potentials of these varieties as a drought resistant crop, failure of rainfall or lack of irrigation is a frequent cause of shortfall in production especially in Ghana where cowpea production is primarily grown in dry areas. Drought could be considered as an important factor among several seed yield-reducing factors. Clearly, there is a potential for further increase in seed yield by planting high-yielding genotypes, providing optimum irrigation, adding fertilizers (Quin, 1997), planting early and spraying with suitable insecticides. Therefore, selection of cowpea genotypes that have higher tolerance to drought is needed to obtain higher and more stable seed yields and in this regard Nhyira, Tona and Hewale appear to have some drought tolerance potential due to their higher yield during the minor season.

IT89KD-374-57 was observed to be low yielding due to its production of fewer nodules and dry matter. Low production of nodules means less nitrogen fixation by the variety. Production of relatively more leaves and branches with erect leave architecture in most cases reflect higher light interception and more photo-assimilate production that may result in increase yield.

In the development and growth of most cowpea varieties in the Sub Saharan Africa, yield and seed development require the production of assimilates in leaves, translocation of these assimilates to the fruits, unloading of assimilates from phloem of the seed coat into cells of cotyledons and synthesis of the various seed storage compounds. Yield losses resulting from water stress are generally associated with decreases in the activity of these physiological factors and dry matter production. Among the varieties that provided the highest biological yield under short raining season conditions in 2012 were Asetenapa and Hewale, whereas under the long raining season conditions the highest biological yield was provided by Hewale and Tona. The growth habits of these genotypes were bushy, erect or semi-erect, characteristic which can be used as a cover crop as well as for grain.

As observed in the grain yield, the biomass of the cowpea varied between the two seasons but the magnitude of the variation within the minor season was less than that observed in the major season. Differences in the seasonal fodder production of some varieties were not significantly different which showed that apart from rainfall some climatic factors like sun radiation might have influenced biomass production. Differences in day length between the major season and minor season in Ghana are that significant to affect crop production (Berchie *et al*., 2013).

The significant differences observed with the dry matter showed that attainment of reproductive phase was a varietal characteristic related to the genetic constitution of the varieties. Dry matter production in the minor season was more affected by genetic composition of the variety than the seasonal variation. This perhaps may be due to the ability of cowpea to survive under extreme water limiting conditions and could respond against the later drought. This was mainly achieved by slowing growth and reducing transpiration, as reported by Vianello and Sobrado (1991) that drought stress during vegetative stage provides diminution of the growth in most crop leaves and stems.

In this study, nodule numbers usually were lower at harvest than at earlier stages. The decline in number was especially noteworthy for nodules from taproots. Varietal differences account for nodule differences since the pattern of nodulation, most often, reflects the physical distribution of the root system in the soil. As reported by (Hansen, 1994), nodulation capacity is known to vary between and within legume species rather than rainfall variations as observed in this study. Varieties producing more nodules possess the capacity to fix nitrogen into the soil. However, the near zero coefficient of determination (R^2) observed between nodule count and dry matter yield indicates that only a small variation in dry matter yield in both seasons could be explained by the number of nodules. This could be expounded in terms of the known complex genotypic effects on determinants of N_2 fixation resulting from nodulation. Lawn, Fischer, and Brun (1974) suggested that the control of soybean nodule initiation occurs primarily in the root itself, but the control of nodule fresh weight occurs solely in the shoot and is related to the supply of assimilates.

The result of this study has shown better crop performance in terms of vegetative and grain yield during the long rainfall season than the short rainfall season. The reason could be attributed to relatively higher rainfall and milder temperature experienced during the production season of major rainfall. According to the annual report of the Basque Research (2008), plants growing under water limiting conditions tend to grow taller in an effort to scramble for below nutrients around the growth environment. These present results are consistent with previous study on cowpea by Hayatu and Mukhtar (2010), who reported that the results for plant height at final harvest showed that, increases in plant height under both moderate and severe water stress were recorded at the expense of seed yield in IT00K-835-45 and IT98K-819-118.

Plant population is reported to have effect on stem diameter, however, the results obtained from this study may be attributed to the better soil moisture availability, decreased plant competition and increased light penetration through plant canopy at such low plant population. The variation in stem diameter among cultivars might be due to genotypic differences.

5. Conclusion

From the results obtained in this study, it could be concluded that the performance of the three local and four improved varieties in terms of yield was higher in the major than minor season. Hewale and Videza are more suitable for high rainfall areas whereas Nhyira and Tona will be more productive and profitable in the drier areas. This study supports the clarion call that cowpea should become a successful legume crop for dry regions of Ghana.

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