Exploitation of Genetic Variability in Cowpea Improvement to High Soil Moisture Tolerance: 1. Effects on growth and yield in diverse environments

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Abstract: The adaptability of a genotype over diverse environments is evaluated by the degree of its interaction wth different environments in whch it is grown. In this paper, twenty-five germplasm lines together with three local cultivars of cowpea were assessed in four environments (E1, E2, E3 and E4) for vegetative, grain yields and related traits. Variance mean squares indicated highly substantial significant differences among germplasm for all characters and resulted in genotype-environment interaction for days to 50% maturity, pods per plant, pod length, seeds per pod, seed size and grain yield. Mean effects for yield and its attributes over the four pooled environments revealed substantial genotypic difference as influenced by high soil moisture in the expression of the characters with changes in environments. Most of the characters expressed highest mean performance in E2 for plant height (87.47 cm), leaf area index (LAI) (7.08), days to 50% maturity (84.33), pod length (21.87g), seeds per pod (16.87) and grain yield (541.8kg/ha). The wide genotypic variations observed in characters in the diverse environments in the germplasm tested can be explored in improvement and selection programmes to high moisture tolerance in cowpea. [Report and Opinion 2010:2(1):74-77] (ISSN: 1553-9873).

Keywords: Cowpea germplasm, environments (E1, E2, E3 and E4), high moisture tolerance, grain yield.

1. Introduction

The humid tropical areas of Nigeria experience a bimodal rainfall pattern of high intensity leading to high moisture availability for plant use in the soil. High soil moisture caused by high water table coupled with poor soil drainage constitute important abiotic factor as production constraints for cowpea crop in the southern Nigeria. Excess or high soil moisture refers to water in the root zone exceeding the freely drained condition (Timsina *et al.*, 1994). Srivivasan *et al*. (2004) reported that a common phenomenon is that most of the time, average rainfall during the cropping season may appear stable, but weekly precipitation levels are highly variable which result in crops having both too much and too little water at critical stages of growth during one cropping season. This is because different crop plant species express different rates and seasonal patterns of water utilization.

The environment constitutes the non-genetic factors that influence the expression of character(s) in a genotype (Comstock and Moll, 1963) and these may be considered as the set of biophysical factors among which is water that impinge on the growth and development of individual genotype charcters. Expression of stress adaptive genes under adverse condition protect heavy yield losses (Zaidi *et al.*, 2008). Thus, the adaptability of a genotype over divergent environments is evaluated by the degree of its interaction with different environments in which it is grown.

The study objective was to determine the effects of high soil moisture on the performance of cowpea germplasm charcters over four environments across two locations.

2. Materials and Methods

Twenty-five lines of cowpea germplasm with divergent geographical origin obtained from IITA, Ibadan together with three other local cultivars were sown at two different locations simultaneously in the Teaching and Research Farm, Ambrose Alli University, Ekpoma and Benin-Owena River Basin Development Authority, Obayantor, near Benin on 1st and 6th May; 7th and 12th August, 2006, respectively. Ekpoma has a mean annual precipitation of 1200m to 1556mm and a mean temperature of 27°c. Obayantor has a mean annual precipitation of 2,032mm to 2540mm and mean temperature of 25.3°c. Both locations experience a bimodal rainfall pattern.

The cowpea germplasm were assessed in a randomized complete block design (RCBD) in three replications of plot size 3m x 2m with 1m inter-plot distances under four different environments namely E1, E2, E3 and E4. Plant spacing was 60 cm inter– and 30 cm intra rows

with two seeds per hole and later thinned to one seedling per stand 14 days after sowing (DAS). Soil moisture level was determined on weekly intervals in each replicate throughout the period of each experiment. Soil samples obtained from top soil surface (0–15 cm) were oven-dried for 24hours at 105^{o}c for moisture determination (Igwilo, 1982) and data in percentages were transformed using arcsine (Gomez and Gomez, 1984). Moisture tolerance scale rating 1–9 (IBPGR, 1983) for cowpea was used to score stress susceptibility level. All agronomic and plant protection practices were adopted.

All parameter data were recorded from 10 randomly selected stands in each plot and subjected to appropriate statistical analysis of variance using SAS software model. Per se mean performance of genotypes was separated using Student–Newman–Keuls Test at 0.05 confidence level.

Table 1. Means of different characters evaluated in cowpea genotypes in separate and pooled environments

Environment	Plant Height (cm)	LAI	Moisture Tolerance	50% Flowering	50% Maturity	Pods Per Plant	Pod Length (cm)	Pod Weight (g)	Seeds per Pod	100-seed Weight (g)	Grain Yield (kg/ha)
Mean											
E1	26.02	1.75	3.41	43.24	49.23	5.93	11.13	3.17	9	7.79	188.63
E2	38.35	4.08	2.32	44.43	60.57	4.78	13.1	1.42	10.94	8.7	210.23
E3	33.36	1.21	5.02	39.32	43.06	2.58	8.69	0.93	6.82	5.58	38.12
E4	33.91	2.18	3.69	47.44	57.27	2.8	11.46	1.1	8.27	7.36	79.65
Pooled	32.89	2.31	3.61	43.61	52.53	4.07	11.1	1.66	8.76	7.36	129.16
Max range											
E1	51.17	3.4	7	79.33	84.33	15	21.87	2.98	16.1	14.2	613
E2	87.47	7.08	6.1	60	80.33	14.13	19.27	2.51	16.87	13.1	541.8
E3	77.6	2.14	7	65.67	81.67	9.5	17.9	2.22	15.4	11.6	136.2
E4	66.47	5.09	7	64	79	7.87	18.43	2.12	15.83	14.07	269.5
Pooled	64.73	3.5	5.78	61.83	77.83	9.53	18.29	2.6	15.6	12.77	310.3
Min range											
E1	12.43	0.83	1	37.67	54.67	2.47	9.6	1.1	9.33	6.67	5.3
E2	17.17	1.83	1	44.33	22	2.1	5	0.49	4.1	3.1	53.3
E3	14.17	0.53	1.93	20.33	23.67	0.43	4.77	0.83	2.77	3.3	3.7
E4	18.3	0.27	1.1	40.33	61.33	1.4	9.67	0.06	1.63	3.03	0.2
Pooled	16.08	0.65	1.48	29.67	34.58	1.63	7.27	0.73	5.95	3.99	2.6

3. Results and Discussion

There was a significant response of germplasm to high soil moisture tolerance in each of the four and combined environments. The variance mean squares estimate indicated highly substantial significant differences among the germplasm for all the characters evaluated except for pod weight which showed no significant difference. Although location had no significant effects on days to 50% flowering and pod weight, but, its effects were greatly significant on all other characters and resulted in genotypic × environment interaction for days to maturity, pods per plant, pod length, seeds per pod, seed weight and grain ield, respectively. The extent of variability in character expression differed greatly with differences in environments. In this study for instance, environment (E2) was observed to be more ideal for the expression of most yield attributes such as pods per plant, pod length, seed weight and grain yield (Table 1). With respect to vegetative growth and development such as plant height and leaf area index (LAI), E2 was also observed to be more favourable.

An observation of the mean effects for yield and its attributes over the four environments revealed substantial genotypic differences as influenced by high moisture in the expression of characters with change in environments. It is well recognized that crops differ in their water requirements and that different reaction of lines

to different moisture level indicated genotypic differences in sensitivity to high moisture (Sexena, 1987). The lowest overall mean performance effects were observed for plant height in E1 (26.02cm), LAI in E3 (1.21), days to 50% flowering in E3(39.32), days to 50% maturity in E3(43.06), pods per plant in E3(2.58), pod length in E3(8.69cm), pod weight in E1(3.17g), seeds per pod in E2(10.94), 100–seed weight in E1(7.79g), grain yield in E2(210.23Kg/ha) and moisture tolerance in E3(5.02). Observation of mean effect ranges for yield and its attributes in the four environments (Table 1) further revealed the wider range of differences in the expression of charcters due to high moisture effect for pods per plant in E1, pod length in E1, pod weight in E1, seeds per pod in E2, seed weight in E1 and grain yield in E1, days to 50% flowering in E1, days to 50% maturity in E2, plant height in E2, LAI in E2 and moisture tolerance in E1, E3 and E4. Growth and development of a plant in an environment is the result of the interaction of two major components, the genetic potential of individual and the external environment (Nalayini and Kandasamy, 2003). Hence, Hartwig (1973) reported that most soyabean cultivars that make adequate growth under tropical condition are indeterminate. Thus, in this study, the higher LAI obtained in E2 could be as a result of those indeterminate types performance which could have accounted for the high grain yield. Lawn (1983) and Turner (1986) had reported a decrease in LAI with increasing moisture stress. Hence the reduction observed in E3 and consequently the low grain yield recorded.

The overall mean performance of the genotypes with regards to moisture tolerance in the four environments showed that E3 and E4 experienced severe rainfall effects and consequently affected the overall performance of the genotypes in yield character and its attributes expression whereas, E1 and E2 indicated some measures of tolerance to high soil moisture. According to Blanche and Myers (2006), a highly discriminating location (environment) is one that maximizes the observed genotypic variation among genotypes for a given character. Umaharan (1990) reported genetic variability for tolerance to waterlogging during vegetative phase in cowpea and suggested that selection could be used in breeding for environments prone to high soil moisture.

The mean values for pods per plant over the four environment indicated profound genetic variability. E1, E2 and pooled environments had the highest pods per plant which may have influenced the high grain yield recorded in the environments. Similar high number of pods per plant was reported in mung bean in different environments (Raje and Rao, 2000). Overall mean value for pod length character was observed to be longer in E2 than in any other environments although the highest range value was observed in E1 (Table 1). The short pod length observed in those environments could be possibly due to high moisture as the reproductive (pod development) phase may have been affected. This may be due to cowpea plants' inability to adapt during the reproductive phase (Ojomo and Raji, 1976). Seeds per pod in E2 was found to be higher as most of the germplasm used belong to low seed category (Ojomo and Raji, 1976) attributable to the relative magnitude of genetic variability and to higher degree of environmental fluctuations.

Seed size in cowpea is important because it directly influences productivity. On individual environmental basis, the highest mean performance was recorded in E2. Udosen and Adesiyan (1986) reported that seed size and not the number of seeds determined the final seed yield eventhough more seeds could have been formed in certain genotypes than others, less number of pods were being filled. The mean performance of genotypes in the four environments and pooled environments showed significant differences for grain yield character. The low grain yield observed in E3 and E4 was due presumably to substantial high moisture effect. Usually, when moisture potential attainable by a genotype is exceeded, grain yield suffers. Timsina *et al.* (1994) had reported high grain yield loss under most severe stress of high moisture in cowpea. Singh and Mishra (2003) reported that a variety producing stable and high yield over different environments is desirable for wider adapatability with relative value which is determined by the degree of stability and that of productivity (yielding ability) of respective varieties under different environments. Thus, the higher general mean seed yield value observed in E2 is attributable to the efficient use of soil moisture which may have favoured more seed production (Table 1).

4. Conclusion

Sufficient genotypic variations in character expression in diverse environments were observed in the materials tested which can be explored in improvement programme and selection to high moisture tolerance in cowpea.

Environment (E2) was found to be most suitable in the expression of yield and its attributes.

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