Evaluation of cowpea (Vigna unguiculata (L.) Walp.) genotypes for variation in root length mass

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Abstract

Selection of cowpea genotypes with enhanced root growth would be a strategy for increasing moisture availability and high grain yield under water stress condition. The aim of this study was to evaluate some cowpea genotypes for variation in root traits in the screen house under water stress and non-water stress conditions. Three cowpea genotypes (TVNU 7778, UAM09 1051-1 and B413) were used for this study. They were selected based on their distinct growth habit and sensitivity to drought. The experimental condition in the screen house was not homogeneous; therefore the experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Result shows that there was highly significant ($p < 0.001$) variation among the cowpea genotypes, water regime treatments and interactions. It was found that water stress significantly increased root length, root weight, shoot length in cowpea genotype UAM09 1051-1.

Under water stress condition, UAM09 1051-1 had longer root length and plant height compared with the other genotypes suggesting that this genotype would tolerate drought due to high massive root system. On the other hand, the cowpea genotypes TVNU 7778 and B413 recorded low root-shoot ratio as the plant height increased with increase in water regime. This shows that shoot length is a survival strategy for cowpea plants under limiting water condition. In conclusion, selection for root traits in cowpea genotypes should preferentially be performed under water stress environment.

Keywords: Genotype, water stress, root system, water regime.

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp] is a popular leguminous staple food in Nigeria.[1,2] Cowpea belongs to the family fabaceae and sub-family Faboideae. Cowpea is of major importance to the livelihoods hoods of millions of relatively poor people in less developed countries of the tropics.[13] In fresh form, the young leaves, immature pods are used as vegetable while several snacks and main dishes are prepared from the grain.[20]

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Cowpeas are cooked together with spices and palm oil to produce a thick bean soup which is either eaten alone or as adalu with yam, maize or rice. They are also ground into flour and mixed with chopped onions and spices and made into cakes which are either deep fried (akara balls) or steamed (moin-moin).[10,27]

Cowpea is of great nutritional value and readily adds to the dietary protein need of the rural and urban dwellers. It is rich in proteins and mineral elements.[7,8,23,26] The seeds make up the largest contributor to the overall protein intake of several rural and urban families, hence Agbogidi[4] regarded cowpea as the poor man's major source of protein.

FAO reported that about 7.56 million tons of cowpea are produced annually on about 12.75 million hectares of land.[16] Sub-Saharan Africa was reported to account for about 70% of the total world production.[16] Nigeria is still said to be the world largest cowpea producer where about 2.1 million tons are produced per annum. This is followed by Niger (650,000 tons) and Mali with 110,000 tons.[16] A more recent and reliable statistics by FAO, 2014 showed that cowpea production stands at 5.72 million tons from an estimated 11.32 million hectares, while production in Africa stands at 5.42 million tons from an estimated 11.08 million hectares.[14] Nigeria produces over 2.5 million tons, which is about 43.2% of the total world production.[14]

In Africa, cowpea is the most economically important indigenous food legume. Egho[12] reported that Nigeria is the 2nd greatest consumer of cowpea in the whole world. Other researchers such as Philips and McWalters[27], Ogbo[24] and Agbogidi[4] have all reported that among the legumes, cowpea is the most extensively grown, distributed and traded food crop consumed. According to Agbogidi[4] the extensive cultivation, distribution and trading of cowpea are because the crop is of considerable nutritional and health value to man and livestock. Cowpeas form a major staple in the diet in Africa and Asian continents[6] and are consumed in different forms with many local variations in their preparation.

Cowpea is a drought-tolerant with better growth character in warm climates. According to Ribeiro et al,[28] cowpea is more resistant to drought than the common bean. Hence the reason it is been grown in most countries from tropical regions. Developing "drought" tolerant cultivar has then become a critical agenda to breeding programs in many crops species. The root system is the plant organ in charge of capturing water and nutrients. Besides anchoring the plant in the

ground, it is naturally seen as the most critical organ to improve crop adaptation to water stress.[31]

Roots are potentially important for plants under drought stress, they do not contribute to drought adaptation in all stress conditions since in many cases the degree of differences in root growth among genotypes does not explain the degrees of differences in yield.[31] Roots are usually the site showing the highest resistance in the pathway for liquid-phase movement of water through the soil-plant-atmosphere continuum.[18]

The efficiency of soil water uptake by the root system is, therefore, a key factor in determining the rate of transpiration and the varying strategies of adaptation to drought. Water uptake by the root is a complex process which depends on root structure, root anatomy and the pattern by which different parts of the root contribute to overall water transport.[9]

Due to climatic change, it is becoming imposible in most part of the world to accurately predict the time and duration of rainfall. Cowpea producing farmers in Nigeria have been encountering unpredictable drought that has been limiting their production. It has been reported that selection for root mass in cowpea would contribute to the performance of the crop adaptation under drought condition.

Identification of cowpea varieties with high root mass will help plant breeders to improve cowpea varieties for adaptation to drought in Nigeria. Therefore, this study was designed to identify cowpea varieties with high root mass under water stress that could be selected for use in plant breeding programme and to determine if high root mass in cowpea confers adaptation under water stress.

Material and Methods

The cowpea lines used for this study were obtained from the Molecular Biology Laboratory of the University of Agriculture Makurdi. Three cowpea genotypes of diverse genetic background viz. TVNU7778, UAM09-1051-1 and B413 were used to evaluate for root mass and plant height under different watering regimes (water stress, watering once in two days and non-water stress: optimum watering condition).

The experiment was carried out in the screen house of the Molecular Biology Laboratory of the University of Agriculture, Makurdi Benue State. The experimental condition in the screenhouse was not homogenous, so the experiment was arranged in a Randomized Complete Block Design (RCBD) with four (4) replications. The seeds were planted in plastic pots (measuring 90 cm depth and 15.1 cm diameter) filled with top soil. NPK fertilizer at the rate of 1 gram was applied per pot at seven days after planting. Observations were recorded for plant height at 7, 14, 21 and 28 days after planting, root length, fresh root weight and dry root weight.

Data was subjected to Analysis of Variance (ANOVA) using SAS (2009) and significant means were separated using LSD at 95% level of significance ($P<0.05$).

Results and Discussion

Mean squares for variation of root mass in cowpea: The mean square values for plant height at 7, 14, 21 and 28 days after planting, root length, fresh root weight and dry root weight are presented in table 1. The result showed that cowpea varieties are highly significant affecting on measured parameters except for dry root weight. Watering regime had highly significant effects on plant height at 7 days after planting and fresh root weight and significant effect on plant height at 28 days after planting. Cowpea variety by watering regime interaction had highly significant effects on plant height at 7 and14 days after planting and significant effects on plant height at 21 days after planting.

Table 1
P values of effect of Watering regime and Variety on measured parameters

Source of variation	Df	PH7	PH14	PH21	PH28	RLT	FRWT	DRW
Replication	3	0.55	7.5	24.7	18.5	56.3	0.03	0.74
Variety	2	297.5	536.7	2169.4	9034.4	1112.7	0.16	0.67
WR	2	22.4	10.25	84.34	166.7	69.94	0.63	0.72
Variety X WR	4	16.15	18.11	83.36	139.45	90.96	0.014	0.67
Error	24	3.34	3.39	23.15	67.05	120.2	0.027	0.67
CV		13.17	10.2	19	20.9	27.5	21.53	308.3
P Val (V)		<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	0.0082**	0.3849ns
P Val (WR)		0.0048**	0.0671^{ns}	0.0416^{ns}	0.1044^{ns}	0.5666ns	<0.001**	0.3614ns
P Val (V*WR)		0.0053**	0.0032**	0.0195*	0.115ns	0.5636ns	0.7096ns	0.4297ns

Note: *= significant at P≤ 0.05; **= highly significant at P≤ 0.001; ns= not significant

Interaction between shoot length and root length of cowpea at different watering regime: Root length decreased with increase in watering regimes for cowpea varieties B413 and TVNU7778. UAM09 1051-1 increased in root length with increase in watering regimes. There was a reduction in shoot length with increase in watering regimes for both B413 and TVNU7778 (Fig. 1). Both varieties produced the shortest shoot length (20.5cm and 59.1cm respectively). Shoot length of TVNU7778 was longer at all wetting regimes than B413 and UAM09 1051-1.

Effect of variety on plant height: Generally, cowpea plant height increase progressively up till 28 DAP (Fig. 3); plant height increases with increased in number of weeks for all the varieties. Variety TVNU7778 recorded the highest value for plant height among the varieties evaluated with plant height of 70.8cm at 28 DAP, while B413 and UAM09 1051-1 had plant height of 21.9cm and 24.8cm respectively at 28 DAP.

Effect of watering regime on plant height: The results show that plant height reduced with intensity of watering regime. Cowpea at WR3 produced the shortest plants at each stage of development as shown in the graph.

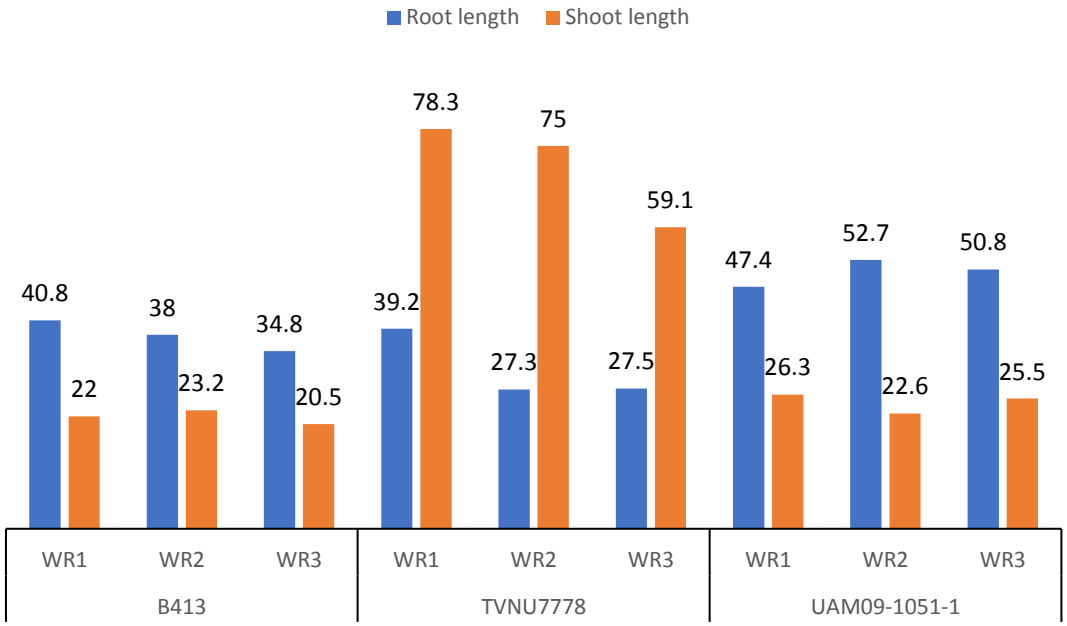

Figure 1: Relationship between shoot and root length of cowpea subjected to different watering regimes

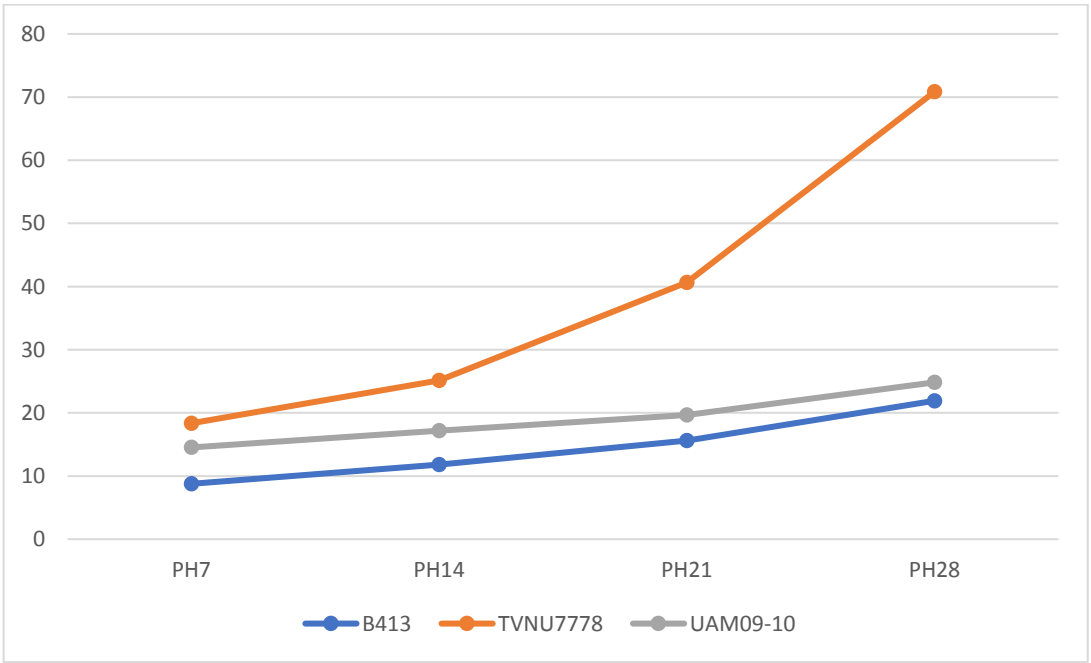

Figure 2: Effect of variety on Plant Height

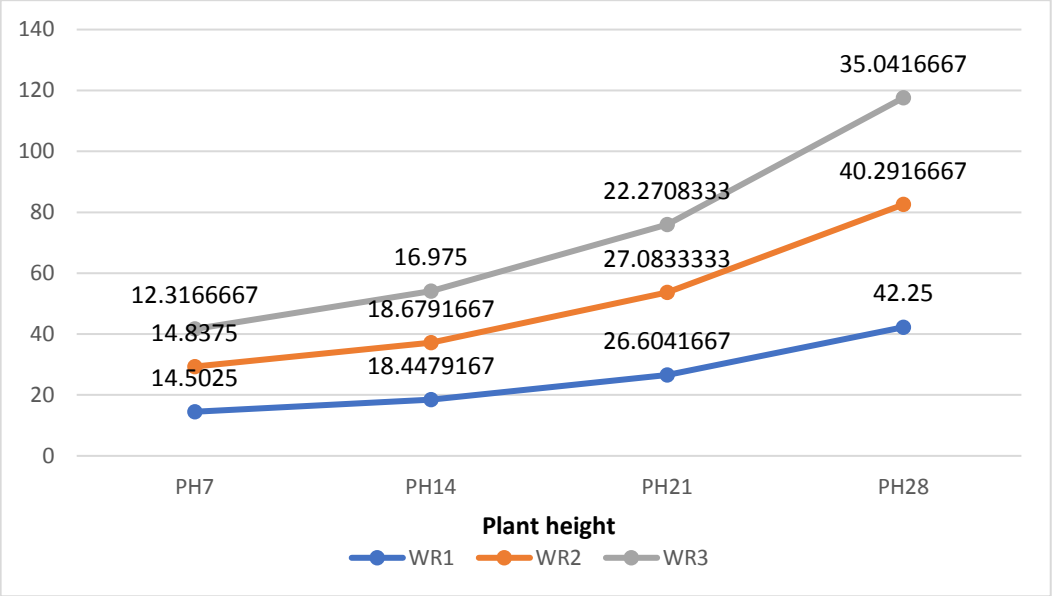

Figure 3: Effect of watering regime on Plant Height

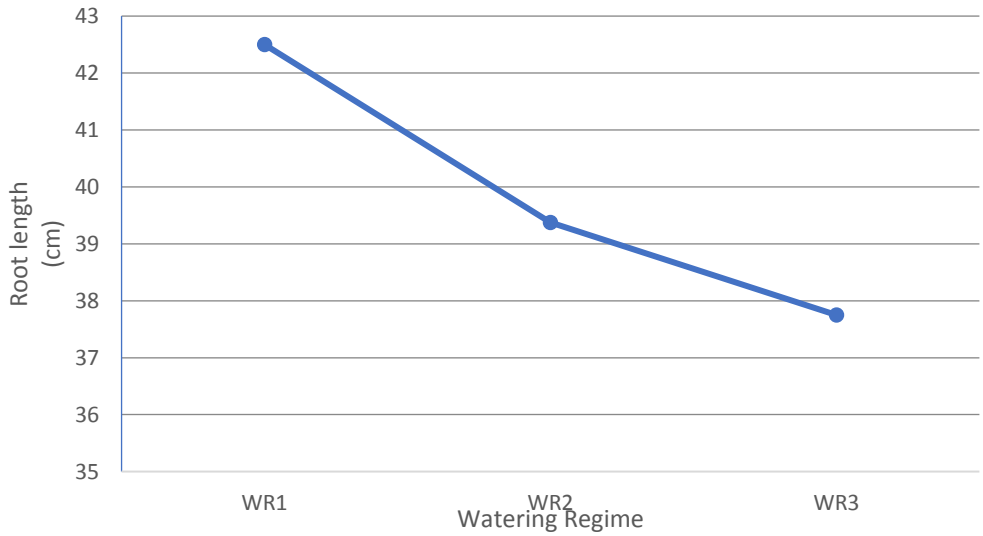

Figure 4: Effect of Watering regime on root length of 3 cowpea varieties

Effect of watering regime on root length of three cowpea varieties: Root length decreased with increase in watering regime. Watering regime one produced longer root compared to roots produced by other watering regimes.

Drought is the most important abiotic factor limiting growth, adversely affecting growth and crop production.[15] According to Duan et al,[11] plants show certain changes in their growth patterns and physiological process to cope with the drastic effects of drought stress. The significant effects of cowpea variety and watering regime on root length and shoot length in this study show that change in shoot and root length is a survival strategy for cowpea plants under limiting water condition. This is in line with the findings of Loka et al[21] who stated that many aspects of plant growth are affected by drought stress, these include plant height, root length, stem elongation and shoot length.

This behaviour could be attributed to the fact that plants growing under water stressed conditions will tend to elongate their roots around the growth environment in an attempt to capture water and absorb water from the rhizosphere, thus elongating their stems and roots more than normal.[25]

The study found that UAM09 1051-1 had longer root length under water stress and this suggests that this cowpea variety may be more drought tolerant than the other varieties. This may be attributed to cowpea drought avoidance mechanisms which allows cowpea to endure long periods without significant rainfall and continue with their normal metabolic activities.[19] Plants "escape" drought by altering phenological development, often modifying the duration of a specific growth stage.[3] Avoidance mechanisms are primarily morphological and physiological adjustments to withstand

water deficit while maintaining relatively high tissue moisture and include increased root density or depth.[29]

There is a wide consensus that water stress leads to substantial physiological and morphological changes in plants, which are reflected on the yield.[30] Morphological changes include growth parameters such as leaf number and plant height.[5] In this study, plant height was not adversely affected by water stress. Previous studies on other legumes[5,22] also reported that water stress does not really affect plant height depending on the variety. In the current study, plant height reduced with intensity of watering regime.

Conclusion

It can be concluded that cowpea varieties responded differently to watering regimes. Root length of UAM09 1051-1 increased with increase in WR while that of TVNU7778 reduced. UAM09 1051-1 may be more suited to drought than the other varieties. Increased root length is a good strategy for adaptation to water stress.

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