



SCREENING FOR DROUGHT TOLERANCE UNDER NATURAL *STRIGA GESNERIOIDES* INFESTATION IN SELECTED COWPEA (*VIGNA UNGUICULATA* L. WALP) GENOTYPES IN KANO, NIGERIA

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ABSTRACT

Drought stressed and *Striga gesnerioides* (L.) are some of the abiotic and biotic factors affecting cowpea production in the semi-arid and sub-humid tropics. The aim of this research was to screen for drought tolerant in selected cowpea genotype infested with *Striga* under natural condition. Sixteen (16) cowpea genotypes were evaluated in IITA experimental farm Minjibir in Kano, Nigeria. The experiment was conducted in Randomized Complete Block Design with water stressed and well watered (as control). The parameters measured are chlorophyll, leaf canopy temperature, *Striga* growth and grain yield. The result showed that both chlorophyll content and Canopy temperature were reduced in the stress treatment. Varieties IT07K-292-10, IT98K-205-8, TVU-7778 and IT573-2-1 recorded the highest canopy temperature. IT98K-205-8 (70.56 SPAD value) recorded an increase in chlorophyll. The highest number of *Striga* emerged were recorded in IT98K-568-18 (12.00) and TVU-7778 (5.00), while IT98K-205-8, IT99K-573-1-1 and IT997-573-2-1 had no emergence of *Striga*. Highest *Striga* biomass was recorded in IT98K-568-18 (30.33g/plant), TVU-7778 (19.00g/plant) and Danila (11.33g/plant). Pod weight was found to reduce with water stress, varieties IT97K-499-35 (144.5g/plant), IT98K-1092-2 (7.0g/plant) and IT98K-506-1 (25g/plant) had the lowest pod weight, and similarly those varieties also recorded the lowest seed weight at water stress condition. The study concluded that water stress and *Striga* infestation reduced all the parameters measured and varieties IT98K-506-1, Danila, IT98K-1092-2 were found to be susceptible to water stress as well as *Striga* infestation, while varieties IT00K-1263, IT98K-131-2, IT98K-205-8, TVU-7778 were found to be tolerant to both water stress and *Striga* infestation.

Keywords: Drought tolerance, *Striga*, Screening, Cowpea

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp.] is one of the most important food legumes in the tropical and sub-tropical regions where rainfall is low with mean annual range of 300-600 mm), variable in time and space and undependable (Fussell *et al.*, 1991). Globally, about 14 million hectares are planted with cowpea, West Africa alone accounts for about 9 million hectares (Singh *et al.*, 2003a). Cowpea is a major source of protein (about 25%), minerals and vitamins in daily human diets and is equally important as nutritious fodder for livestock (Singh *et al.*, 2003b). Despite the importance of cowpea in sub-Saharan Africa and its wide spread high potential, its growth and yield are constrained by several biotic and abiotic factors. Among the biotic stresses, *Striga gesnerioides* which is obligate, root-parasitic flowering plants of the family Orobanchaceae, is formidable constraints to cowpea production, especially in the dry savanna. It has been reported by (Cardwell and Lane, 1995) that Cowpea yield losses associated with *S. gesnerioides* was range between 83 and 100%. On susceptible local varieties, 100% yield losses on farmer's fields in the northern Guinea savanna of Nigeria has been reported by Emechebe *et al.* (1991). In a recent survey of the level of *S. gesnerioides* infestation on farmers' fields, Dugje *et al.* (2006) reported that more than 81% of the fields grown to cowpea in northeast Nigeria were

infested with *S. gesnerioides* and subject to serious crop losses. Various control measures, including cultural practices, chemical and biological means, and host plant resistance, have been suggested (Dube and Olivier, 2001; Boukar *et al.*, 2004) but no single field method seems to be fully adequate.

Moreover, the timing and intensity of drought stress represents the most important abiotic stress in relation to the crop phenology, sensitivity of flower, pod and seed development to high temperatures affecting cowpea production. Though cowpea is considered to be one of the most drought tolerant crops in semi-arid Africa, grain yield of the crop increases significantly where drought stress is minimal (Turk *et al.*, 1980; Padi, 2004). Despite its inherent capacity to survive levels of drought that would render comparable crops unproductive (Ewansiha and Singh, 2006), significant differences exist among cowpea genotypes in drought tolerance (Mai-Kodomi *et al.*, 1999a). These genotypic differences have been documented for different stages of phenological development of the crop, from emergence to pod maturity, in pigmentation and yield attributes (Fery and Singh, 1997). For example, Watanabe *et al.* (1997) reported some genotypic differences in the ability of cowpea to survive imposed drought beginning in the vegetative stage. On the other hand, Turk and Hall (1980)

showed that cowpea is highly sensitive to water stress during the flowering and pod-filling stages.

Drought stress represents the most important abiotic stress affecting cowpea production in the semi-arid zones of Africa where most cowpea is produced. Therefore, developing plants that have an advantage under drought stress conditions is a major challenge for cowpea breeding programs. Cowpea genotypes possessing the ability to withstand water deficit are potential candidates to ensure sustainable yield in these areas. Due to low or poorly distributed rainfall, thus field experiment for screening cowpea varieties enable us to determine the varieties that can adapt to drought and those that are susceptible. *Striga gesnerioides* has been a threat to the life of cowpea production, in view of this therefore, there is the need to study the varieties and identify resistant or tolerant to *Striga* infestation. The aim of the study was to screen for drought tolerant among some cowpea genotype infested with *Striga gesnerioides* in Sahelian region of Nigeria.

MATERIALS AND METHODS

Experimental Site

The research was carried out in the IITA experimental farm at Minjibir (longitude 8° 37' E and latitude 12° 11' N) Kano, Nigeria.

Seed Collection

Fifteen (15) varieties of improved seeds of cowpea and a local variety were collected from the seed store of the International Institute of Tropical Agriculture (IITA) Kano station. The seeds were sorted out to remove broken and unhealthy ones.

Experimental Design

The experiment was arranged in randomized completely block design (RCBD) with sixteen (16) cowpea genotypes subjected to two water regimes (water stressed and well watered as control) with three replications. Spacing between rows was 75 cm and within row was 20cm, roll length was 1m and alley was 1m.

The well watered and water stressed cowpea trials were planted on 11th September, 2015 and 12th September, 2015 respectively. Each plot was labeled with the name of the cultivar and plot number. The water stress treatment was imposed at last rainfall on the field which occurred on 8th October, 2015 till harvest to mimic terminal drought. While the well water treatment were irrigated weekly till harvesting time.

Land preparation

The land was cleared and stumped (i.e. removal of all kinds of stubborn and big roots by digging them up from the soil) and then followed by harrowing (i.e. the loosening of the top part of the soil in preparation for planting). The rows were constructed which is 0.7m between rows and 0.20m in between plants. The land was irrigated before planting to keep it moist.

Planting and Thinning

Three to four cowpea seeds were planted per hill at a space of 20cm within rows at the depth of about 3-5cm into the soil and covered. After two weeks of emergence, the seedlings

were thinned to two numbers of plants per hill as indicated upon the trial.

Weeding

In order to check competition between weeds and cowpea plant, weeding was carried out to keep the experimental area free from weeds. The first and second weeding were at 2 and 4 weeks after planting respectively using hoe. Subsequent weeds were done by hand at weekly interval.

Spraying

The crops were sprayed with KARTODIM 315EC insecticide in which 100ml of the insecticide were mixed with 20liter of water and then spray at two weeks interval to prevent damage to plant in case of severe infestation of beetles, leaf hoppers, aphids etc.

Irrigation

The irrigation for well watered treatment (i.e. control) was carried out weekly at the rate of five (5) hours until harvesting.

Fertilizer Application

NPK (15:15:15) fertilizer was applied at rate of 0.5kg/plot 3 weeks after planting. The application was done by making a hole close to the base 8-10cm away from the cowpea plant at 5-8cm deep, the fertilizer is then placed in the hole and covered with soil properly.

PHYSIOLOGICAL MEASUREMENT

SPAD Value Measurement

The chlorophyll contents were measured with chlorophyll meter (SPAD 502 plus). The meter was first calibrated using its reading checker and then simply clamp the meter over third matured leaf tissue from main stem. Three different SPAD values from the plants in each plot were recorded.

Leaf Temperature

The leaf temperatures were measured using infrared thermometer (fluke 579) which was carried out 5-6 weeks after planting. The measurements were done on the second and third fully expanded leaves from the top of the main stem. This was done by pointing the target leaf with red laser and by pressing the trigger until the amount of infrared energy emitting by the leaf which the radiant energy to an electric signal that later displayed in the unit of temperature (in °C) on the LED display. Three different leaf temperatures per plant were recorded and the average was taken.

Phenology

The phenological measurement include, stand at flower, Days to first open flower, days to 50% flower, days to 95% maturity, number of plant at harvest were recorded.

GRAIN YIELD

Parameters such as pod load score, *Striga* count, fodder dry weight, pod dry weight, seed dry weight, 100 seeds weight and number of seed <100 were estimated at physiological maturity to determine the yield.

Data Analysis

The data collected were subjected to statistical analysis using SAS software and significant means were separated using LSD at 5% probability level.

RESULTS AND DISCUSSION

The result of Canopy temperature and Chlorophyll content are presented in Table 1, the statistical analysis indicate that there are significant differences (P<0.05) in the varieties and

treatment, but no significant difference ($P>0.05$) in the variety by treatment interaction.

The result showed that there is reduction in the canopy temperature in the stress treatment. The varietal treatment indicates that IT07K-292-10, IT98K-205-8, TVU-778 and IT99K-573-2-1 recorded the highest canopy temperatures. However, IT98K-506-1 recorded the lowest canopy temperature. Increase in the canopy temperature may be due to reduction in stomatal conductance in the stress varieties. According to Afshari *et al.* (2013) reported that application of water stress in cowpea at flowering stage caused leaf temperature to increase. The result of chlorophyll content showed that water stress reduced the chlorophyll content in cowpea varieties, reduction in the chlorophyll was observed

in TVU-778 (43.86SPAD value). Reduction of chlorophyll content might be due to reduced carbon assimilation and damage of the photosynthetic apparatus in water stress condition. Increase in chlorophyll contents were found in varieties IT98K-205-8 (70.56 SPAD value). Reduction in chlorophyll content was further explained by (Niinemets, 2002) that some non-stomatal processes like the disturbance of the photochemical activities or damages of the photosynthetic apparatus (PSII) affect the efficiency of crops in assimilate. According to the present *Striga* infestations was found to reduced chlorophyll contents, this findings agrees with that of Mandumbu *et al.* (2019) while working on Sorghum reported that infestations reduced chlorophyll contents in non-mulching treatments.

Table 1. Effect of water stress on Canopy temperature and Chlorophyll SPAD value of some Cowpea genotypes under natural *Striga* Infestation

Variety	Canopy Temperature	Chlorophyll Content (SPAD)
IT99K-573-2-1	29.46 ^{aa}	59.95 ^{ebdc}
IT07K-292-10	28.63 ^{aa}	68.45 ^{ab}
IT98K-205-8	28.63 ^{aa}	70.56 ^{aa}
TVU-7778	28.53 ^{ab}	43.86 ^f
IT97K-499-35	28.35 ^{ab}	70.51 ^{aa}
IT99K-573-1-1	28.20 ^{ab}	62.56 ^{bdac}
DAN'ILA	27.95 ^{ab}	54.18 ^{edf}
IT98K-1092-2	27.91 ^{ab}	56.98 ^{edc}
IT98K-1111-1	27.83 ^{ab}	64.60 ^{bac}
IT98K-1092-1	27.61 ^{ab}	51.46 ^{ef}
IT98K-503-1	27.45 ^{ab}	62.50 ^{bdac}
IT98K-131-2	27.03 ^{ab}	60.43 ^{ebdac}
IT00K-1263	26.73 ^{ab}	59.70 ^{ebdc}
IT98K-568-18	26.68 ^{ab}	56.93 ^{edc}
IT07K-318-33	25.81 ^{ab}	67.55 ^{ab}
IT98K-506-1	24.91 ^{bb}	60.85 ^{ebdac}
Lsd	3.71	3.21
Trt		
W	28.95a	63.17a
WS	26.28b	58.21b
Lsd (5%)	1.31	3.66

Trt: treatment, W: well watered, WS: water stress, Lsd: Least significant difference. Mean followed by the same letter (superscripts) are not significantly different at 5% probability level using LSD

The results of Number of *Striga* and *Striga* biomass are presented in Table 2, the result of Analysis of variance showed that number of *Striga* attached was found to be significant ($P<0.05$) in the variety but no significant different was recorded in water stress treatment and variety by treatment interaction. The number of *Striga* attached was lower in the water stress treatment, variety IT98K-568-18 recorded the highest number of *Striga* attached (8), IT99K-573-2-1, IT98K-205-8, IT97K-499-35, IT99K573-1-1 and IT98K-1092-1 recorded no *Striga* attachment. The highest *Striga* biomass were recorded in TVU-7778 (23.83g) followed by IT98K-568-18(21.83g) (Plate 1b). from the present study its indicate that increase in *Striga* biomass in the susceptible varieties mighty due to the exudation of nutrients from the roots of the host, thereby decreasing nutrients flow and affect the growth of the host.

Table 2 : Number of *Striga* and *Striga* biomass at harvest

Variety	Number of <i>Striga</i> at harvest	<i>Striga</i> Biomass
IT99K-573-2-1	0.00 ^d	0.00 ^e

IT07K-292-10	1.00 ^{bcd}	4.33 ^{bc}
IT98K-205-8	0.00 ^d	0.00 ^c
TVU -7778	6.00 ^{abc}	23.83 ^a
IT97K-499-35	0.16 ^{cd}	0.66 ^c
IT99K-573-1-1	0.00 ^d	0.00 ^c
DAN'ILA	5.00 ^{abcd}	12.16 ^{bac}
IT98K-1092-2	2.00 ^{bcd}	9.00 ^{bac}
IT98K-1111-1	2.00 ^{bcd}	5.83 ^{bc}
IT98K-1092-1	0.3/3 ^{cd}	1.50 ^c
IT98K-503-1	1.00 ^{bcd}	4.66 ^{bc}
IT98K-131-2	6.00 ^{ab}	18.00 ^{ba}
IT00K-1263	4.00 ^{abcd}	17.00 ^{ba}
IT98K-568-18	8.00 ^{aa}	21.83 ^a
IT07K-318-33	5.00 ^{abcd}	13.50 ^{bac}
IT98K-506-1	2.00 ^{bcd}	6.00 ^{bc}
Lsd	5.54	15.05
Trt		
W	3.27 ^a	11.31 ^a
WS	1.87 ^a	5.97 ^b
Lsd (5%)	1.96	5.32

Trt: treatment, W: well watered, WS: water stress, Lsd: Least significant difference. Mean followed by the same letter (superscripts) are not significantly different at 5% probability level using LSD



Plate I. (A) IT98K-568-18 as affected by *Striga* (B) IT00K-1263 variety as tolerant to *Striga gesnerioides*

The results of pod and seed yield in the stressed treatment indicate a significant reduction compared with the unstressed treatment. The varietal difference in grain yield indicate that variety IT00K-1263 recorded the highest pod weight (370.67g/plant) and seed weight (257.17g/plant). Variety with lower grain yield was recorded in IT98K-1092-2 (pod weight 36.67g/plant and seed weight 21.83g/plant). This agrees with the report by Faisal and Abdel Shakoor (2010) that reduction in the number of harvested pods per plant in water stress may be due to the abscission of reproductive structures.

Table 3: Effect of Water Stress on the Yield (g/plant) of some Cowpea Varieties under Natural *Stiga gesnerioides* Infestations.

S/N	Variety	PDW	SDW	100SW
1	IT98K-1092-1	103.00 ^{ed}	73.33 ^{cde}	4.00 ^f
2	IT98K-506-1	86.50 ^{ed}	60.83 ^{ed}	13.33 ^e
3	IT98K-503-1	118.83 ^{cde}	74.17 ^{cde}	17.66 ^{abcde}
4	IT07K-318-33	132.17 ^{cde}	93.17 ^{cde}	22.00 ^{ab}
5	IT98K-131-2	270.67 ^{ab}	198.00 ^{ab}	19.00 ^{abcd}
6	IT98K-1092-2	36.67 ^{ee}	21.83 ^{ee}	14.66 ^{ed}

7	IT07K-292-10	184.50 ^{bcd}	123.17 ^{bcd}	22.83 ^{aa}
8	IT99K-573-1-1	97.17 ^{ed}	53.50 ^{ed}	15.33 ^{cde}
9	IT98K-568-18	166.33 ^{bcd}	124.50 ^{bcd}	16.00 ^{abcde}
10	IT00K-1263	370.67 ^{aa}	257.17 ^{aa}	20.16 ^{abcd}
11	DAN'ILA	206.17 ^{bcd}	157.50 ^{bc}	12.1 ^{6e}
12	IT97K-499-35	207.00 ^{bcd}	138.50 ^{bcd}	16.50 ^{cde}
13	TVU-7778	192.33 ^{bcd}	133.33 ^{bcd}	13.33 ^e
14	IT98K-205-8	233.50 ^{bc}	159.00 ^{bc}	14.66 ^{ed}
15	IT99K-573-2-1	87.67 ^{ed}	57.33 ^{ed}	17.16 ^{abcde}
16	IT99K-1111-1	151.67 ^{bcd}	106.67 ^{bcd}	20.33 ^{abc}
	LSD	129.65	94.09	5.65
	TRT			
	W	211.25a	148.71a	
	WS	119.35b	80.29b	
	LSD	45.83	33.26	

Trt: treatment, W: well watered, WS: water stress, Lsd: Least significant difference. Mean followed by the same letter (superscripts) are not significantly different at 5% probability level using LSD

CONCLUSION

From the present study, it is concluded that water stress and *Striga* infestation significantly reduced canopy temperature and chlorophyll content in all the stressed varieties. However out of the varieties screened IT07K-292-10, IT98K-205-8, TVU-778 and IT99K-573-2-1 had the highest canopy temperatures. Variety with lower chlorophyll content was found in TVU-778 and IT98K-205-8 recorded the highest. Number of *Striga* and *Striga* growth from the present study indicate that Variety IT98K-568-18 recorded the highest number of *Striga* attached and varieties IT99K-573-2-1, IT98K-205-8, IT97K-499-35, IT99K573-1-1 and IT98K-1092-1 had no *Striga* attachment. The yield component indicate that variety IT00K-1263 recorded the highest pod weight and seed weight. Variety with lower grain yield was recorded in IT98K-1092-2. In conclusion, varieties IT98K-506-1, Danila, IT98K-1092-2 were found to be susceptible to water stress as well as *Striga* infestation, while varieties IT00K-1263, IT98K-131-2, IT98K-205-8, TVU-778 were found to be tolerant to both water stress and *Striga* infestation.

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