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TWO MECHANISMS OF DROUGHT TOLERANCE IN COWPEA

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ABSTRACT

Twelve cowpea [*Vigna unguiculata* (L.) Walp] varieties were planted in wooden boxes of 130 cm length, 65 cm width, and 15 cm depth filled with sand and soil mixture (1:1) at 10 cm row to row and 5 cm plant-to-plant distance. The boxes were watered daily until the unifoliate leaves had fully expanded and the first trifoliates were beginning to emerge. Watering was then stopped to impose moisture stress and effects of drought on the unifoliate and trifoliate leaves as well as growing tips were studied. Two types of drought tolerance mechanisms were observed. Under drought stress 'Type 1', drought tolerant lines TVu 11986 and TVu 11979 stopped growth and conserved moisture in all the plant tissues and stayed alive for over two weeks and gradually the entire plant parts dried together. The 'Type 2' drought tolerant lines like Dan Ila and Kanannado continued slow growth of the trifoliates. However, with continued moisture stress, the unifoliates of these varieties showed early senescence and dropped off but the growing tips remained turgid and alive for even longer time suggesting that the moisture was being mobilized from the unifoliates to the growing tips.

Key Words : Cowpea, *Vigna unguiculata*, drought tolerance mechanisms.

Cowpea [*Vigna unguiculata* (L.) Walp.] is one of the important food legumes widely cultivated in the semi-arid regions of tropical Asia, Africa, and Central and South America. Among many yield reducing factors, drought causes substantial damage to cowpea in the Sudano-Sahelian region of West and Central Africa where rainfall is low and erratic. Therefore, concerted efforts are being made to develop drought tolerant cowpea varieties [1-7]. A simple screening method for drought tolerance in cowpea has been developed [8]. Using this method, a large number of

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cowpea lines have been screened and several sources of drought tolerance have been identified [7, 8]. To use these lines effectively in breeding programme, it would be desirable to study these lines further and elucidate the nature of their response to drought and mechanisms of recovery when moisture stress is removed. This paper describes two different mechanisms of drought tolerance in cowpea.

MATERIALS AND METHODS

This experiment was conducted at the International Institute of Tropical Agriculture, Kano Station, Nigeria, 12°03'N, 8°32'E, and 476m altitude. Twelve cowpea varieties, including the drought tolerant and susceptible lines identified earlier [8], were used for this study and the wooden box method [8] was used to impose drought stress on them. These varieties were planted on Feb. 19, 1994 in wooden boxes of 130 cm length, 65 cm width, and 15 cm depth, filled with soil and sand mixture (1:1) at 10 cm row-to-row and 5 cm plant-to-plant distance (Fig. 1a). Each box contained 1 row of 12 plants each of the 12 cowpea varieties which constituted one replication. The experiment was conducted using randomised complete block design with 4 replications. The boxes were watered once daily until the unifoliates fully expanded and the first trifoliate was just emerging on March 6, 1994. Watering was then stopped to impose moisture stress on all the test plants and the effects of drought on the unifoliate and trifoliate leaves, and the growing tips of each plant were observed. Fifteen days after the termination of watering, when the differences among cowpea varieties were very clear, all the lines were rated for drought tolerance using a 1 to 5 scale. Visual rating was done for unifoliate and trifoliate leaves, including the growing tips separately, as follows :

Score	Appearance
1	normal green turgid leaves
2	green with slight wilting
3	yellowish grey with moderate wilting
4	yellow and light brown leaves with severe wilting
5	completely dried leaves

In order to quantify the visual rating, two plants per replicate of each variety were cut from each 4 replication from the base 10 and 15 days after termination of water, and tissue moisture content was determined. The moisture content of the unifoliates and the remaining plants including trifoliates were determined separately to estimate the differential response of the unifoliates the trifoliates to drought in different varieties. After determining the fresh weight of unifoliates and the remaining

parts of the plants, the materials were oven dried at 80°C for 48 h and dry weight was determined.

RESULTS AND DISCUSSION

The differences among varieties in respect of their response to drought became visible as moisture stress increased with advancing days after termination of watering. The varietal differences were most pronounced 15 days after termination of watering when the most susceptible varieties like TVu 7778 and TVu 8256 were completely dried but the resistant lines showed either of the two types of tolerance reactions. The Type 1 drought tolerant lines like TVu 11986 and TVu 11979 stopped growth after the onset of drought stress and maintained uniform but declining turgidity in all the tissues of the plants, including the unifoliates and the emerging tiny trifoliates for over two weeks, and all plant parts, such as, the growing tip, unifoliates and epicotyl gradually dried almost at the same time. In contrast, the Type 2 drought tolerant lines like Dan Ila, and Kanannado remained green for longer time and continued slow growth of the trifoliates even after sensing the moisture stress. With continued moisture stress, however, the unifoliates of these varieties started wilting and drying keeping the trifoliates and growing tips alive and turgid as if the moisture was being mobilized from the unifoliates to the growing tips (Fig. 1). Thus, 15 days after termination of watering, all the plants of the two susceptible lines, TVu 7778 and TVu 8256, were completely dried, while all plants of the two drought tolerant lines, TVu 11986 and TVu 11979 were partially dried, whereas in Dan Ila and Kanannado the growing tips were alive but their unifoliates had dried (Fig 1b).

The pattern of wilting and drought scores of different varieties in respect of the unifoliate, trifoliate, and moisture contents are presented in Table 1. These data substantiate the visual observations made on the reaction of different cowpea varieties to drought stress. The varietal differences with respect to drought score as well as moisture content were significant. Also, there was significant difference in the loss of moisture content from day 10 to day 15 between the drought tolerant and susceptible varieties. Based on the wilting score of unifoliates, TVu 11986, TVu 11979 and Suvita-2 were more drought tolerant than others. However, based on wilting scores of the trifoliates, Dan Ila and Kanannado remained alive for longer time than others. These differences were also reflected in the moisture contents of different tissues (Table 1). The moisture contents of both unifoliates and total plants were similar up to day 10 but were lower by day 15 in the susceptible varieties like TVu 7778, TVu 8256, IT82D-889 and TVu 13464 compared to the drought tolerant lines such as Kanannado, Dan Ila and Suvita-2.

Table 1. Moisture content and drought tolerance scores in 12 cowpea lines after 15 days of moisture stress*

Cowpea line	Drought tolerance			Moisture content (%)			Moisture loss (%), day 10
	unifoliate leaves	trifoliate leaves	type**	unifoliate	total plant		
				day 15	day 10	day 15	
TVu 11986	2.0	2.5	1	63.8	76	60.9	20.2
TVu 11979	2.6	2.6	1	55.8	74	59.7	19.4
TVu 12349	3.5	3.1	1	51.3	73	56.7	21.7
Kanannado	3.6	1.6	2	45.4	77	65.1	15.5
IT89KD-994	3.4	2.5	1	48.5	75	59.6	20.5
Suvita-2	3.5	2.2	1	71.9	79	73.4	6.9
Dan Ila	4.3	1.1	2	47.1	75	59.1	20.9
Ife Brown	4.6	3.0	S	38.7	69	52.0	24.5
TVu 13464	4.5	3.9	S	16.8	71	42.3	40.7
IT82D-889	4.9	4.1	S	33.4	70	49.2	30.0
TVu 8256	4.5	3.8	S	22.8	66	37.9	42.0
TVu 7778	5.0	5.0	S	14.2	68	36.6	46.5
LSD 5%	0.5	0.6	-	21.4	6.6	12.8	14.8
CV (%)	9.2	14.7	-	35.1	6.4	16.4	38

*Planted on Feb. 19, 1994, watering stopped on March 6, 1994

**Type 1 - total plant tolerance, Type 2 - moisture mobilization from lower leaves to tips, S - drought susceptible

The two types of tolerance responses to drought stress indicate that cowpea has evolved novel mechanisms to cope with prolonged drought which it commonly encounters in the semi-arid regions of Africa where cowpea is believed to have originated. Closure of stoma to check transpiration (drought avoidance) and osmotic adjustment (drought tolerance), have been suggested as the possible mechanisms of drought tolerance in crops [6, 10]. Cowpea is known to be a dehydration avoider with strong stomatal sensitivity and reduced growth rate [10]. This seems to be the case with lines like TVu 11979 and TVu 11986 showing Type 1 reaction to drought. However, cowpea lines, such as, Dan Ila and Kanannado showing Type 2 reaction seem to have a combination of three mechanisms-stomatal regulation, osmotic control, and selective moisture mobilization with distinct visible differences in the dedication

of lower leaves compared to the upper leaves and growing tips. Apparently, Type 2 mechanisms of drought tolerance appears to be more effective in keeping the plants alive for a longer time and ensures better chances of recovery than Type 1 if and when the drought spell ends. Both Dan Ila and Kanannado are local varieties commonly grown in the Sudano- Sahelian border areas of Nigeria and Niger Republic, indicating that farmers have consciously selected cowpea varieties with good adaptation to drought.

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1 b. Different reactions to drought stress

1 a. Box Screening

Fig. 1. Two types of drought tolerance in cowpea; 'Type 1' lines are Suvita-2, TVu 11979, 'Type 2' lines are Kanannado and Dan Ila; drought susceptible are IT82D-889 and TVu 7778

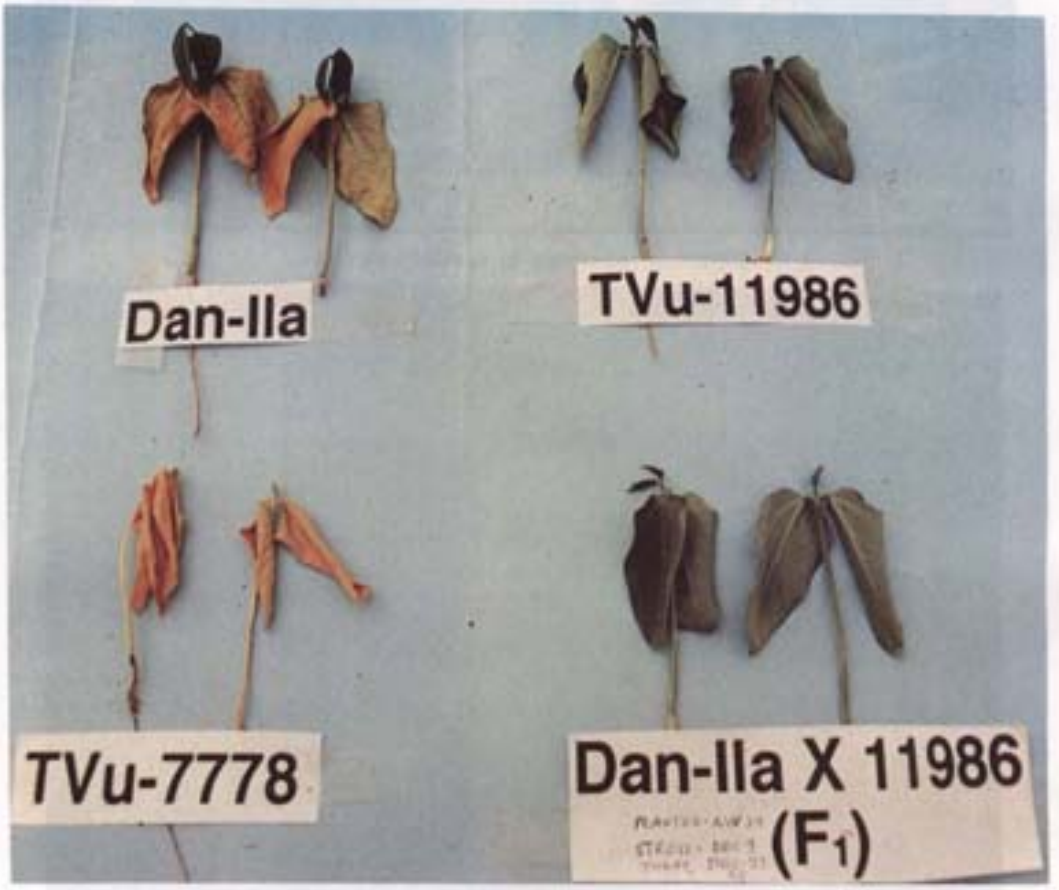

Fig. 1. Two types of drought tolerance in cowpea. 'Type 1' TVu 11986; 'Type 2' Dan Ila, and TVu 7778 = susceptible. The F_1 plant between the two types shows dominance of Type 1.