HortScience 21(1): 131–132. 1986.

Rate of Water Loss from Detached Leaves of Drought Resistant and Susceptible Genotypes of Cowpea

David W. Walker[1] and J. Creighton Miller, Jr.[2]
Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843

Additional index words. southernpea, cuticular resistance, plant breeding, transpiration

Abstract. **Cuticular resistance to water loss was estimated for drought resistant and susceptible cowpea [*vigna unguiculata* (L.) Walp.] genotypes in a series of field and greenhouse experiments. The procedure consisted of harvesting the youngest, fully-expanded middle trifoliate leaf of a well-watered plant. The detached leaf was weighed immediately and then allowed to dry in an air-conditioned laboratory (about 25°C). Leaves again were weighed 24 and 48 hr after detachment and then oven dried at 70° for 24 hr. Oven dry weight was used to determine leaf water content (LWC) at each sampling time. Specific drought resistant and susceptible genotypes consistently expressed increased or reduced LWC, respectively, 48 hr after detachment. Interestingly, named cultivars generally had even higher LWC values after drying than did the selected resistant genotypes. Intraspecific variability for the trait appears to exist and may be related to drought adaptation in cowpea.**

A relatively simple procedure for estimating water retention capacity of detached leaves offers the possibility of identifying genotypes possessing this specific drought adaptation trait. In separate studies, Clarke and McCaig (1) and Dedio (2) found detached leaves of resistant wheat (*Triticum aestivum* L.) cultivars had higher percent LWC after 24 and 48 hr of drying than did leaves of susceptible cultivars. Similar but more sophisticated studies in cotton (*Gossypium hirsutum* L.) have revealed similar findings (4). The objective of these experiments was to detect intraspecific variability for cuticular water loss in cowpea genotypes previously identified as potentially drought resistant or susceptible (5).

A preliminary field-screening experiment was conducted on the upland farm at Texas A&M University, College Station, in a Lufkin fine sandy loam (Vertic albaqualf). Seeds of 6 genotypes, previously identified as potentially drought resistant, 6 drought susceptible genotypes and 2 named cultivars, 'Brown Crowder' and 'California Blackeye No. 5' were planted on 8 June 1982 in 4 replications. The relative drought adaptation potential of the resistant and susceptible genotypes had been determined previously on the basis of shoot biomass production in field experiments conducted during the summer of 1980 (5).

Cuticular resistance, as estimated by rate of water loss, was measured by detaching the middle trifoliate leaflet from the youngest, fully expanded leaf, 72 days after planting (DAP) (1, 2). Three leaflets per plot were detached and placed immediately in a plastic bag, transported to the laboratory and weighed. Leaves were weighed 24 hr later after storage at room temperature (about 25°C) and relative humidity (about 50%) in an air-conditioned laboratory. Air was circulated constantly throughout the room to facilitate uniform drying. Leaves then were oven dried at 70° for 24 hr and weighed to determine dry weight. Dry weight was used to calculate LWC 0 and 24 hr after detachment. Data were analyzed as a split-plot design with genotypes as main plots and drying time, expressed as time after detachment, as subplots. All percentage data were transformed by arcsin prior to statistical analysis.

Significant differences for leaf drying were detected between genotypes and for the interaction between genotypes and time after detachment. Furthermore, a contrast of resistant vs. susceptible genotypes was significant at the .02 level. Named cultivars and resistant genotypes lost less water than did susceptible genotypes after drying for 24 hr (Fig. 1). Three resistant genotypes, TX 2083 (TVu 129), TX 2404 (TVu 5150), and TVu 3192, had a higher resistance to water loss than 'Brown Crowder' or 'California Blackeye No. 5', although these differences were not significant. Three susceptible genotypes, TVu 196, TVu 2738, and TVu 3493 had lower resistances to water loss than most of the other genotypes tested. Based on previous research, it is assumed that the primary source of water loss immediately after leaf detachment was through stomata until a critical leaf water potential was reached, 1.0 to 1.2 MPa (3). After stomatal closure, cuticular resistance and the degree of stomatal closure may have contributed to the differences in water retention capability (1).

After analyzing the results of the field experiments, it was decided to screen a different set of drought resistant and susceptible cowpea genotypes for rate of water loss under controlled conditions in a greenhouse experiment. Seeds were planted in a sand, vermiculite, and peat mix and inoculated with rhizobial strain 32 Hl on 24 Sept. 1983. Plants were watered as needed with a N-free nutrient solution (5).

Ten resistant and 8 susceptible genotypes were screened for rate of water loss 54 and 61 DAP for estimating cuticular resistance. The experimental design was a split-split plot, randomized block design with harvest dates as main plots, genotypes as sub-plots, and drying time as sub-sub plots. The youngest, fully-expanded middle trifoliate leaf was detached and weighed at 0, 24, and 48 hr. Detached leaves were air-dried in an air-conditioned laboratory at room temperature (about 25°C), relative humidity of about 50% and with constant air circulation. Leaves then were oven dried at 70° for 24 hr and weighed to determine LWC.

Although these plants were grown without water stress, significant differences between resistant and susceptible genotypes were found for LWC. Significant differences also were found for the interaction between time after detachment and genotype. The interaction between time after detachment and genotype illustrated that differences between resistant and susceptible genotypes were not notable at the time of detachment but were substantial 24 and 48 hr after harvest (Table 1). Specifically, 4 genotypes, TVu 1489, TVu 2157, TVu 2319, and TVu 2926, had lower rates of water loss than any genotype classified as susceptible. Furthermore, TVu 3766,

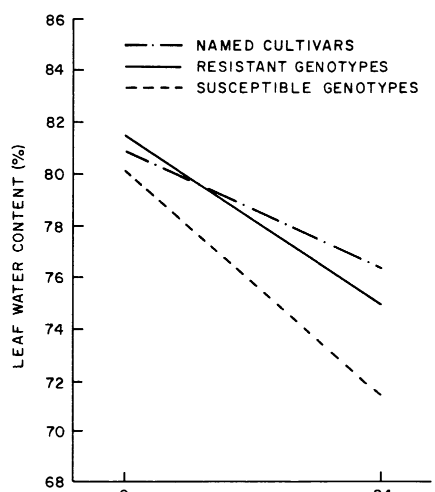

Fig. 1. Mean leaf water content of detached leaves from field-grown plants of 6 drought resistant, 6 susceptible, and 2 named genotypes, measured 0 and 24 hr after detachment. Contrasts of resistant vs. susceptible genotypes and the interaction between genotypes and time after detachment were significant at the 0.02 level.

Received for publication 19 Nov. 1984. Texas Agr. Expt. Sta. Tech. Article 20579. Research supported in part by USAID-CSRS/AID BNF grant 59-2481-0-5-001-0. The authors wish to thank R. Stewart Smith, Director of Research and Development, The Nitragin Company, Milwaukee, Wis., for providing the inoculant used in these studies. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

[1]Research Assistant. Present address: Department of Horticulture, Louisiana State University, Baton Rouge, LA 70803-2120.
[2]Professor.

Table 1. The influence of drought resistant and susceptible genotypes on leaf water content of detached leaves from greenhouse-grown plants, Fall 1982.

Genotype	Time after detachment (hr)		
	0	24	48
	Leaf water content (%)		
Resistant[z]			
TVu 1489[y]	85.0	78.6	71.5
TVu 2157	86.8	79.0	66.4
TVu 2926	87.0	78.1	57.8
TVu 2319	87.5	72.9	57.8
TVu 6480	88.0	75.5	52.5
TVu 2878	88.5	73.8	46.6
TVu 656	90.2	75.0	38.5
TVu 5155	88.8	69.9	36.3
TVu 2886	88.9	72.0	31.3
Mean	87.9	75.0	51.0
Susceptible			
TVu 3716	84.7	70.0	52.9
TVu 2887	87.0	66.6	36.6
TVu 1014	90.5	74.2	34.2
TVu 3444	86.5	65.1	31.7
TVu 6639	87.9	63.8	20.4
TVu 1258	88.0	63.0	15.7
TVu 3165	87.8	59.0	11.8
TVu 3766	88.5	33.8	7.5
Mean	87.6	61.9	26.4

[z]Contrasts of resistant vs. susceptible genotypes and the interaction between genotypes and sampling time were significant at the .0001 level.
[y]TVu numbers as cited in Cowpea Germplasm Catalog. No. 1. 1974. International Institute of Tropical Agriculture, Ibadan, Nigeria.

TVu 3165, TVu 1258, and TVu 6639 had higher rates of water loss than any resistant genotype.

A 2nd greenhouse experiment was conducted to verify the results of the 1st experiment. Seeds of 42 genotypes were planted on 7 Jan. 1983 and inoculated with rhizobial strain 32 Hl. The 42 genotypes screened included 23 genotypes ranging from very drought resistant to moderately resistant, 18 potentially susceptible genotypes, and 3 named cultivars (5), 'Brown Crowder,' 'California Blackeye No. 5,' and 'Bush Purple Hull'.

Most genotypes screened in the previous field and greenhouse experiments were represented. Plants were watered as necessary with a N-free nutrient solution (5). Rate of water loss from detached leaves was measured as previously described, 62 and 81 DAP. The data again were analyzed as a split-split plot design.

Table 2. The influence of selected drought resistant and susceptible genotypes on leaf water content of detached leaves from greenhouse-grown plants, Spring 1983.

Genotype	Time after detachment (hr)		
	0	24	48
	Leaf water content (%)		
Check			
Brown Crowder	82.3	71.1	52.0
Bush Purple Hull	76.7	51.4	24.9
Calif. Blackeye #5	84.3	71.3	45.2
Mean	81.1	64.6	40.7
Resistant[z]			
TVu 2926[y]	81.5	61.6	33.8
TVu 1489	81.3	66.7	33.7
TVu 2319	84.2	55.6	30.3
TVu 2157	84.7	60.3	14.2
Mean	83.4	61.1	28.0
Susceptible			
TVu 3766	85.2	69.6	24.8
TVu 3165	82.0	47.6	20.9
TVu 6639	83.2	36.1	12.7
TVu 1258	82.2	47.1	9.7
Mean	83.2	50.1	17.0

[z]Contrasts of resistant vs. susceptible genotypes and the interaction between genotyes and sampling time were significant at the .0001 level.
[y]TVu numbers as cited in Cowpea Germplasm Catalog. No. 1. 1974. International Institute of Tropical Agriculture, Ibadan, Nigeria.

Although significant differences among genotypes for LWC were detected, a contrast of all genotypes as either resistant or susceptible, excluding named cultivars, was not significant in this experiment. However, a contrast of genotypes that exhibited either greater or lesser resistances to water loss from detached leaves in the previous greenhouse experiment was significant at the .0001 level (Table 2). Therefore, consistent results for these 8 genotypes were obtained from both experiments. Although the genotypes classified as resistant on the basis of leaf drying had higher LWC 48 hr after detachement than susceptible genotypes, LWC of named cultivars, as a group, exceeded that of resistant genotypes. Of the genotypes not previously screened, only TX 2386 (TVu 4534) demonstrated extreme resistance to leaf drying, with a LWC of 58.8% 48 hr after detachment. Of the 42 genotypes screened in this experiment, 23 had mean LWC values less than the mean of selected susceptible genotypes. This finding illustrates that, although genotypes have been identified which possess the ability to resist water loss from leaves, the trait is not common to all exotic cowpea genotypes.

Clarke and McCaig (1) reported that the measurement of water retention capacity of detached leaves was a superior drought screening technique as compared to measuring leaf diffusive resistance or leaf temperature. The possibility certainly exists that this relatively simple and rapid method of screening for drought avoidance may be beneficial to plant breeders attempting to improve drought adaptation in cowpea and perhaps other crops (1, 2, 4). Not only is the technique simple, but our experiments demonstrate that the induction of water stress in living plants is not necessary to screen for this trait. Additional screening studies utilizing other potentially drought resistant cowpea genotypes should identify germplasm possessing the ability to resist water loss at levels exceeding that of named cultivars.

Since cowpea genotypes which previously had been found to have high biomass production potential under drought conditions (5) were shown also to have high water retention capability, it is hoped that this trait can be used to improve seed yield of water stressed plants. Based on these preliminary results, further research is needed to relate biomass production and seed yield in drought environments to genotypic differences in water retention capability. Additional research to test more fully techniques of screening for stomatal and cuticular resistance in cowpea then may be justified.

Literature Cited

1. Clarke, J.M. and T.N. McCaig. 1982. Evaluation of techniques for screening for drought resistance in wheat. Crop Sci. 22:503–506.
2. Dedio, W. 1975. Water relations in wheat leaves as screening tools for drought resistance. Can. J. Plant Sci. 55:369–378.
3. Hiler, E.A., C.H.M. Van Bavel, M.M. Hossain, and W.R. Jordan, 1972. Sensitivity of southern peas to plant water deficit at three growth stages. Agron. J. 64:60–64.
4. Quisenberry, J.E., B. Roark, and B.L. McMichael. 1982. Use of transpiration decline curves to identify drought-tolerant cotton germplasm. Crop Sci. 22:918–922.
5. Walker, D.W. 1983. Influence of genotype on drought resistance and nitrogen fixation in cowpea (*Vigna unguiculata* (L.) Walp.). PhD diss. Texas A&M University, College Station, Texas.