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Short Communication

Leaf Water Relations and Yield of Cowpea Genotypes under Rainfed Conditions

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Cowpea (*Vigna unguiculata* L. Walp.) is an important arid legume cultivated for pulse and forage. The crop grown under rainfed conditions often encounters drought during the pod formation. Breeding to improve genotypes for such regions by selection solely for seed yield is difficult, because of the annual variability in amount and temporal distribution of rainfall. The genotypic variation in yield is low under these conditions. Researchers now believe better adapted and high yielding genotypes could be bred more efficiently and effectively if traits that confer yield under drought conditions could be identified. Morpho-physiological traits have been used to identify drought tolerant genotypes (Sharma *et al.*, 2007; Kumar and Sharma, 2009). However, the usefulness of a trait depends on its correlation with seed yield. The objective of this study was to evaluate the germplasm for leaf water relations during pod formation stage and correlate them with pod setting, number of pods and seed yield, which may help in identifying simple traits to select for drought tolerance.

The experiment was conducted at CCS Haryana Agricultural University, Hisar, India (20 10'N, 75 45'E). The drought plots (30 m long, 6 m wide and 2 m deep) filled with dune sand of 22±2.26% water holding capacity were constructed especially to screen large populations for drought tolerance. Twenty cowpea genotypes namely TPTC-1, PGCP-4, RC-19, TC-601, HG-3-8, HC-1-17, GC-409, GC-410, GC-121, GC-203, CPD-78, CPD-84, PGCP-1, PGCP-2, KBC-IT, TC-701, HCP-519, HCP-475, RC-101 and GC-3 were grown under rainfed conditions in a randomized block design with three replications in 2.80 x 1.80 m plots. The soil contained 14 cm of available water in the 195 cm soil depth at the time of seeding. Seeding was done on 24 July. During the growing season 13.51 cm rainfall was received, however, no rainfall was received after 45 DAS. Soil moisture content was recorded by Neutron Moisture Meter, Troxler, USA, at 60 DAS, i.e., on the day the leaf water relations were measured. Leaf water potential (LWP) was measured by Pressure Chamber Apparatus as described by Scholander *et al.* (1965) and leaf relative water content (RWC) as described by Kumar and Elston (1992) on 60 DAS (pod formation stage) between 730-800 h (referred as "800 h") and 1300-1330 h (referred as "1330 h"). Midday drop in RWC was determined as the ratio of RWC at midday (1330 h) to that in the morning (800 h).

For the determination of pod setting ratio, 25 freshly opened flowers per replication were tagged on the same day, i.e., on the day of measurement of plant water status. Pod setting ratio was calculated as the ratio of the number of flowers tagged to the number of pods formed on the tagged flowers and expressed as per cent. All mature pods in each plot were harvested, and the number of pods plant^{-1}, biomass and seed yield plot^{-1} was recorded. The number of seeds pod^{-1} (from 20 pods in each plot) and 1000-seed weight were recorded.

The soil moisture content on 60 DAS was 5.38± 0.78% (w/w) in 0-15 cm, 6.49±0.43% in 15-45 cm, 7.89±0.46 in 45-75 cm, 9.35±0.26 in 75-105 cm, 12.59±0.58 in 105-135 cm, 13.21±0.24 in 135-165 cm and 16.45±0.68% in 165-195 cm soil depth. It indicated that water deficit developed slowly, which was also evident by narrow differences in LWP and RWC at 800 h (Table 1). However, the differences among the genotypes in LWP and RWC at 1330 h were substantially large and significant. The differences in midday drop of RWC were very large and ranged from 1-13%. The midday drop of RWC was lowest in HC-1-17 (1%) followed by GC-203 (3%), HG-3-8 (3.9%) and the remaining genotypes it ranged from 5.9 to 13%.

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Table 1. Leaf water potential (LWP), relative water content (RWC) and midday drop of RWC measured 60 DAS and yield-attributes and yield of cowpea genotypes

Genotypes	LWP (MPa)		RWC (%)		Midday drop of RWC (%)	Pod setting ratio (%)	Pods plant^{-1}	Seeds pod^{-1}	1000 -seed weight (g)	Biomass (g m^{-2})	Seed yield (g m^{-2})
	800 h	1330 h	800 h	1330 h							
TPTC-1	-0.57	-0.85	89.4	83.7	6.3	66.7	22.8	15.9	109.8	619.1	114.4
PGCP-4	-0.50	-0.73	95.7	86.7	9.4	56.7	15.0	11.2	125.3	311.9	54.1
RC-19	-0.57	-0.90	92.7	84.0	9.4	43.3	11.9	10.3	155.8	519.6	60.5
TC-601	-0.72	-0.75	93.4	86.0	8.0	60.0	17.1	13.1	124.0	415.5	87.4
HG-3-8	-0.63	-0.85	95.0	91.3	3.9	80.0	27.0	11.9	74.5	371.9	134.3
HC-1-17	-0.63	-1.12	95.1	94.2	1.0	73.3	34.2	11.8	110.1	375.6	93.7
GC-409	-0.68	-0.90	94.9	89.3	5.9	60.0	17.9	11.4	138.4	628.7	153.4
GC-410	-0.68	-0.90	93.4	87.8	6.0	53.3	22.1	11.9	126.5	502.6	133.4
GC-121	-0.73	-0.98	94.7	88.1	7.0	60.0	20.8	11.6	152.9	471.0	128.7
GC-203	-0.77	-0.83	94.4	91.3	3.3	66.7	23.2	11.2	103.9	310.8	99.6
CPD-78	-0.68	-0.90	91.9	84.9	7.6	56.7	16.0	8.9	132.2	307.9	76.1
CPD-84	-0.67	-0.90	89.2	78.8	11.6	50.0	14.2	10.0	161.2	254.8	72.8
PGCP-1	-0.67	-0.80	91.8	79.9	13.0	40.0	8.1	10.4	147.1	182.1	43.3
PGCP-2	-0.52	-0.88	91.5	79.7	12.9	43.3	10.7	7.6	170.5	221.6	41.8
KBC-IT	-0.72	-1.00	96.5	83.8	13.1	36.7	11.4	11.4	148.0	679.7	90.4
TC-701	-0.87	-0.78	90.6	79.7	12.0	40.0	11.4	9.1	116.3	232.0	60.6
HCP-519	-0.72	-0.85	92.7	81.4	12.2	43.3	11.0	10.2	126.7	305.4	47.1
HCP-475	-0.77	-0.82	90.8	80.7	11.1	36.7	12.8	9.8	140.3	238.3	51.6
RC-101	-0.75	-1.12	92.2	85.6	7.1	56.7	17.1	11.1	107.1	276.9	63.7
GC-3	-0.87	-1.12	99.2	86.4	12.9	46.7	13.3	11.6	95.9	446.7	106.1
CD (5%)	0.08	0.12	NS	6.48		13.93	11.62	3.01	12.40	116.93	38.88
CV	7.81	8.05	5.29	4.59		15.69	42.04	16.75	5.82	18.37	27.36

The per cent pod set, number of pods plant^{-1}, seeds pod^{-1}, 1000-seed weight, biomass and seed yield showed significant genotypic differences (Table 1). More than 50% pod setting was observed in genotypes HG-3-8, HC-1-17, TPTC-1, GC-203, TC-601, GC-409, GC-121, PGCP-4, RC-101, GC-410 and CPD-84, while it ranged between 36.7 to 46.7% in the remaining genotypes. Genotypes HC-1-17, HG-3-8, GC-203, TPTC-1, GC-410 and GC-121 produced more than 20 pods plant^{-1}. Genotypes PGCP-2, CPD-84, RC-19 and GC-121 displayed the bold seeds (>150 g 1000-seed weight) while genotypes HG-3-8 and GC-3 had the smallest seeds (<100 g 1000-seed weight). The biomass was highest, but statistically similar in genotypes KBC-IT, GC-121 and TPTC-1, which was significantly higher than the remaining genotypes. Genotypes GC-409, HG-3-8, GC-410, TPTC-1 and GC-3 produced seed yield above 100 g m^{-2}, whereas genotypes PGCP-2, PGCP-1 and HCP-519 below 50 g m^{-2} seed yield.

LWP or RWC either at 800 h or 1330 h did not correlate with either of the yield-attributes or the seed yield. However, the midday drop of RWC significantly, but negatively correlated with pod setting ratio ($r=0.89$, $P<0.01$), number of pods plant^{-1} ($r=0.93$, $P<0.01$) and seed yield ($r=0.61$, $P<0.05$) indicating that the genotypes with a smaller midday drop of RWC set higher pods and produced larger number of pods plant^{-1} and consequently had higher seed yield as compared with the plants with a larger midday drop of RWC. The results showed that there was a large genotypic variation in leaf water relations especially midday drop of RWC, which was significantly correlated with yield-attributes and seed yield. Therefore, selection for smaller midday drop of RWC during pod

formation in cowpea may be desirable; however, it needs further research particularly on inheritance.

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