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Evaluation of Leaf Characteristics of *Cowpea* (*Vigna unguiculata* L.) and Mung Bean (*Vigna radiata* L.) Varieties for Drought Resistance

B.S. Thrikawela and D.C. Bandara[1]

Postgraduate Institute of Agriculture
University of Peradeniya
Peradeniya.

ABSTRACT. *Considering the need for higher production of legumes as a source of protein in the tropics, a field study was conducted to evaluate the response of cowpea and mung bean varieties to water stress. Four varieties of cowpea (MI-35, Arlington, Bombay cowpea and Iita) and four varieties of mung bean (MI-5, Type-77, Type-51 and PBM/74/13/45) were subjected to 3 irrigation regimes in NCB soils at Aralaganwila Research Station. Leaf initiation and expansion, and mid day leaf water potential were recorded at four stages of growth. Leaf initiation and leaf area decreased with increasing moisture stress in all varieties of both crops. Mung bean varieties showed a higher percentage of reduction with increasing moisture stress. In cowpea, the most susceptible variety was Arlington and the resistant was MI-35. In mung bean, the most susceptible variety was PBM/74/13/45.*

INTRODUCTION

Protein malnutrition is one of the major problems affecting the nutritional status of the people in Sri Lanka. Although provision of food containing protein both from plant and animal origins could easily overcome this problem the prohibitive price of animal proteins make it almost impossible, especially for the low income groups to afford. Hence, food from plants containing high levels of proteins such as legumes could provide a significant proportion of the dietary protein in the cereal based diets of people in Sri Lanka.

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[1] Department of Agricultural Biology, Faculty of Agriculture, University of Peradeniya.

Two of the major species of grain legumes grown in Sri Lanka are *cowpea* and mung bean (green gram). They are grown mainly in the dry and intermediate zones of Sri Lanka with 80% being grown under rain fed conditions. One of the major determinants of crop production in these areas is the unavailability of adequate moisture during the crop growth stage. Therefore there is a great need for drought resistant varieties which could withstand limited soil moisture and produce better yields.

Plants response to water stress varies with species and is modified by environmental and physiological factors. The difference in plant response explains why one species or variety survives or yields better under a limited supply of water. Therefore this study sought to compare the response of commonly grown *cowpea* and mung bean varieties in Sri Lanka to water stress. The response in leaf initiation, leaf area and leaf water potential to water stress are discussed in this paper.

MATERIALS AND METHODS

A field trial was conducted in well drained non calcic brown soils at the Regional Agricultural Research Station, Aralaganwila in the Mahaweli System B, during the 1990 Yala season. Four varieties of *cowpea* (MI-35, Arlington, Bombay *cowpea* and Iita) and 4 varieties of mung bean (MI-5, Type-77, T-51 and PBM/74/13/45) were arranged in a RCB design in 4x3 m^2 plots with three irrigation levels and three replicates. The irrigation levels were given upto field capacity once in 2 days, 7 days up to field capacity and 10 days.

The amount of water required for field capacity for each plot was based on the volumetric moisture content of the soil samples taken one day prior to irrigation. Each plot was irrigated separately using sprinkler buckets. Soil water potential values corresponding to the amount of water present at each irrigation were determined according to the moisture characteristic curve obtained by Mapa and Bodinayake (1988).

Prior to seeding, plots were fertilized with NPK at the recommended rates. Plots were seeded in rows of 60 cm apart, and at two weeks of growth plants were thinned out to have within row space of 15 cm before the irrigation treatments were imposed. During the course of plant growth, leaf initiation, leaf area (using a portable leaf area meter) and leaf water potential were recorded. Leaf water potential was measured using the pressure chamber and readings were taken between 10.30 a.m. and 1.30 p.m. Necessary precautions were taken to obtain leaf water potential measurements before any wilting after the detachment of leaf and the ultimate reading was the average of three leaves from each plot. The fifth leaf from the bottom was taken for each leaf water potential reading. For leaf initiation measurements 5 plants were marked from each plot and the average number of leaves was recorded at four different stages of growth. The data were subjected to analysis of variance procedure to test the significance of treatment effects.

RESULTS AND DISCUSSION

Table 1 shows the effect of moisture stress on leaf initiation of *cowpea* at different stages of growth. Leaf initiation was significantly reduced by moisture stress at all growth stages. Varieties were also significantly different at all stages of growth. Arlington showed the highest reduction among the 4 varieties. Interaction effects between variety and irrigation were also significant except at pod filling stage.

Effect of moisture stress on leaf initiation of mung bean is also shown in Table 2. Leaf initiation was significantly reduced by the different irrigation levels applied. The varieties were also significantly different at all stages of growth. However the interaction effect was non significant at flowering and pod filling stages.

The effect of moisture stress on cumulative leaf area of *cowpea* is shown in Figure 1. Leaf area was significantly reduced with increasing moisture stress. The percentage reduction of leaf area when moisture stress increased from 11 to 13 at flowering were 22%, 33%, 28% and 26% in MI−35, Arlington, Bombay *cowpea* and Iita respectively. However at flower initiation the interaction between irrigation and varieties were non significant.

Moisture stress significantly reduced the cumulative leaf area of mung bean at all stages of growth (Figure 2). When moisture stress increased from control to third moisture regime, the percentage reduction of leaf area were 41%, 33%, 35% and 43% for *MI−35*, *Type−77*, *Type−51* and *PBM/74/13/45* respectively. Varieties were also significantly

Table 1. Effect of moisture stress on leaf initiation of *cowpea* at different stages of growth.

Treatment	Number of leaves initiated per plant			
	23 DAP	33 DAP	41 DAP	51 DAP
Irrigation				
I1	5.58b	9.11a	10.97a	9.64a
I2	5.94a	8.33b	9.94b	9.14a
I3	4.92c	6.64c	7.31c	6.36b
Varieties				
V1	6.00a	8.99a	11.22a	10.59a
V2	5.67ab	8.04b	9.11b	7.11b
V3	4.70c	6.78c	8.11c	7.52b
V4	5.55b	8.29b	9.18b	8.29b

P = 0.05

I1 – irrigated once in 2 days up to field capacity
I2 – irrigated once in 7 days up to field capacity
I3 – irrigated once in 10 days up to field capacity

V1 – MI 35
V2 – Arlington
V3 – Bombay *cowpea*
V4 – Iita

Table 2. Effect of moisture stress on leaf initiation of mung bean at different stages of growth.

Treatment	Number of leaves initiated per plant			
	23 DAP	33 DAP	41 DAP	51 DAP
Irrigation				
I1	4.28a	6.17a	7.06a	6.64a
I2	4.06ab	5.47b	6.69a	6.00b
I3	3.89b	5.03c	5.72b	5.03c
Varieties				
V1	3.89b	5.59ab	6.52ab	5.48b
V2	3.92b	5.67a	6.15b	5.56b
V3	3.78b	5.19a	6.33b	6.04ab
V4	4.70a	5.77a	6.96a	6.48a

P = 0.05

I1 – irrigated once in 2 days up to field capacity
I2 – irrigated once in 7 days up to field capacity
I3 – irrigated once in 10 days up to field capacity

V1 – MI 5
V2 – Type 77
V3 – Type 51
V4 – PBM/74/13/45

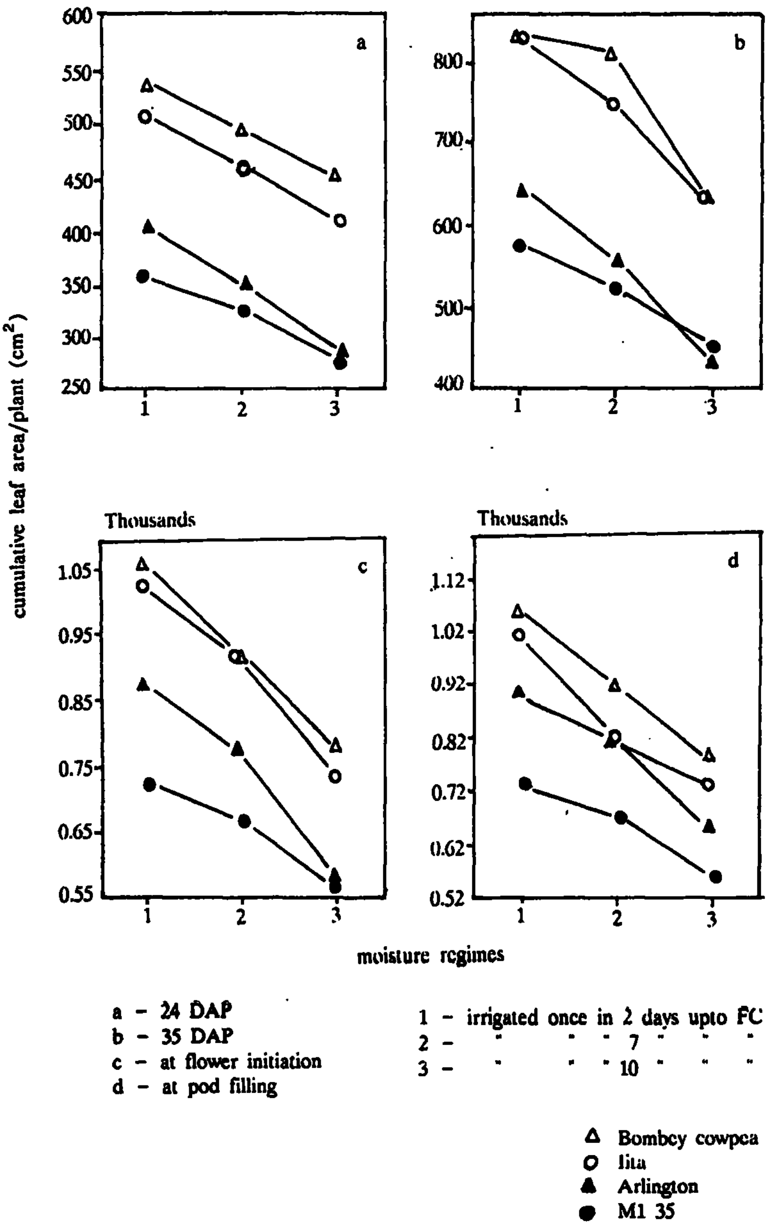

Figure 1. Effect of moisture stress on cumulative leaf area at different stages of growth of *Cowpea*.

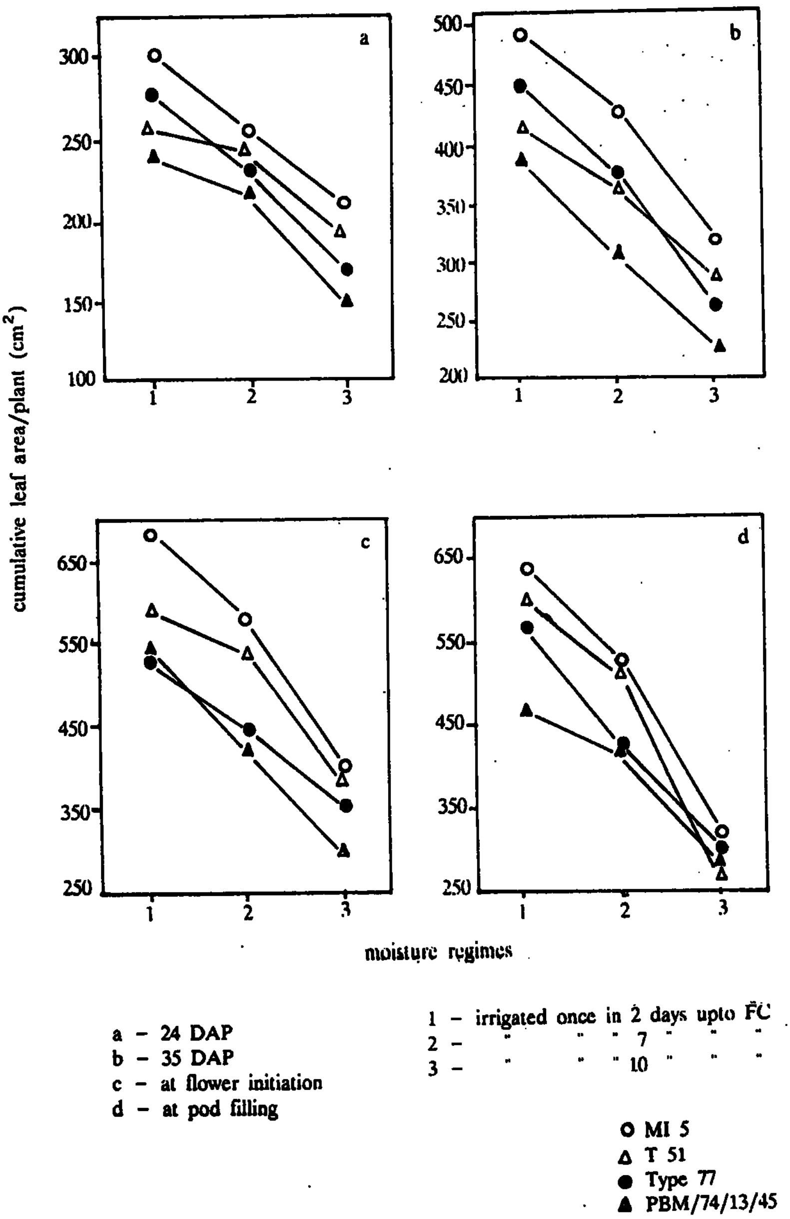

Figure 2. Effect of moisture stress on cumulative leaf area at different stages of growth of Mung bean.

different at all stages of growth and the interaction of irrigation *vs.* variety was also significant at all stages except at 24 DAP.

Decreasing leaf initiation and cumulative leaf area are the major mechanisms of drought avoidance. However, leaf area after the commencement of flowering is responsible for low yield due to the limitation of source of carbohydrates. Therefore large reductions of leaf area as an adaptive mechanism to drought also limits yield. However, all varieties of *cowpea* maintained higher leaf area than mung bean and the reduction due to moisture stress was also less. Therefore it can be deduced from the results that, *cowpea* varieties are more capable of producing carbohydrates under moisture stress conditions, among which Arlington may be the most sensitive variety as the percentage reduction due to water stress was highest at flowering.

All varieties of mung bean showed a higher reduction in percentage number of leaves initiated and cumulative leaf area than *cowpea*, when moisture stress increased. Thus mung bean varieties may be more sensitive to moisture stress than *cowpea*. Among varieties, MI-5, PBM/74/13/45 seemed more susceptible as the reduction in leaf area below the optimum leaf area index will decrease the crop growth rate of the canopy (Donald, 1963).

Mid day leaf water potential values measured at different stages of growth are shown in Table 3. Increase in moisture stress significantly decreased the leaf water potential at all stages of growth. Varieties were also significantly different. Arlington showed the lowest potential values among all varieties. For example, at 34 DAP, average values experienced were -1.45, -1.88, -1.68 and -1.58 MPa for MI-35, Arlington, Bombay *cowpea* and Iita. The corresponding soil water potential values were -0.30, -0.35, -0.35 and -0.30 MPa respectively. Among these varieties Arlington showed the lowest leaf water potential and it also did not show a fair recovery after the rain at 41 DAP. It decreased to a minimum average of -2.05 MPa at pod filling stage. After the rain the best recovery of plant water status was observed in MI-35. It was able to increase the leaf water potential up to -1.12 MPa from -1.45 at the highest moisture regime. Interaction between irrigation and variety was also significant at all stages of growth.

Table 4 shows the effect of moisture stress on mid day leaf water potential of mung bean leaves measured at 4 different stages of growth.

Table 3. Effect of moisture stress on leaf water potential (−MPa) of *cowpea* different stages of growth.

Treatment		Leaf water potential (−MPa)			
		23 DAP	33 DAP	41 DAP	51 DAP
Irrigation levels					
I1	*cowpea*	0.87b	1.26c	1.27b	1.29b
I2	*cowpea*	0.91b	1.41b	1.34ab	1.41b
I3	*cowpea*	1.46a	1.65a	1.44a	1.66a
Varieties					
V1	*cowpea*	1.02b	1.24c	1.12c	1.22c
V2	*cowpea*	1.21a	1.66a	1.53a	1.72a
V3	*cowpea*	1.08b	1.43b	1.34b	1.45b
V4	*cowpea*	1.01b	1.44b	1.40b	1.44b

Means in vertical columns followed by the same letter are not significantly different at 0.05 probability level; LSD test.

I1 – Control (Irrigated once in 2 days up to field capacity)
I2 – Irrigated once in 7 days up to field capacity
I3 – Irrigated once in 10 days up to field capacity

cowpea
V1 – MI−35
V2 – Arlington
V3 – Bombay *cowpea*
V4 – Iita

Table 4. Effect of moisture stress on leaf water potential (−MPa) of mung bean at different stages of growth.

Treatment	Leaf water potential (−MPa)			
	23 DAP	33 DAP	41 DAP	51 DAP
Irrigation levels				
I1	1.03b	1.12c	1.20c	1.23c
I2	1.10b	1.67b	1.39b	1.61b
I3	1.69a	2.33a	1.70a	2.18a
Varieties				
V1	1.27b	1.73ab	1.43b	1.71ab
V2	1.24b	1.82a	1.40b	1.66b
V3	1.37a	1.83a	1.57a	1.78a
V4	1.24b	1.57b	1.34b	1.54c

Means in vertical columns followed by the same letter are not significantly different at 0.05 probability level; LSD test.

I1 – Control (Irrigated once in 2 days up to field capacity)
I2 – Irrigated once in 7 days up to field capacity
I3 – Irrigated once in 10 days up to field capacity

Mung bean
V1 – MI−5
V2 – Type−77
V3 – Type−51
V4 – PBM/74/13/45

Increasing moisture stress significantly reduced the leaf water potential of all varieties. Values experienced at 33 DAP were −2.29, −2.27, −2.06 and −2.40 MPa in MI−5, Type 77, Type 51 and PBM/74/13/45 respectively. The corresponding soil water potential values were −0.25, −0.30, −0.25 and −0.25 MPa respectively. Mung bean varieties also showed comparatively low recovery of leaf water status after rain even though the soil water potential increased to −0.30 MPa. A varietal difference in the recovery of plant water status was also not observed.

All *cowpea* varieties maintained higher mid day leaf water potential values than mung bean varieties. This indicates that *cowpea* varieties are more capable of maintaining plant water status at moisture stress conditions. Higher water status in the plant under moisture stress conditions can be attributed to the reduction of water loss by plant canopy or by maintaining a high water uptake as demonstrated by Turner (1980). Reduction of water loss may be due to increased stomatal and cuticular resistance to transpiration and reduced radiation absorbed. According to Babalola (1980), *cowpea* closed stomates even at high plant water potential when soil moisture was depleting. The shiny appearance of the leaf surface increase the light reflection with increasing moisture stress. The shiny appearance may be due to the increased waxiness as a response to soil water stress as demonstrated by Blum (1975). He pointed out that waxiness also decreased the transpiration. *Cowpea* orientates its leaves to reduce the light interception. Among varieties, MI−35 could maintain higher leaf area for higher assimilation of CO_2 while maintaining a higher leaf water status than other varieties in soil moisture stress conditions. MI−35 is also faster in re−establishing the water status after re−watering.

Leaf water potential values experienced by mung bean were also more negative than *cowpeu* varieties. This indicates that mung bean varieties are less capable of maintaining plant water status under soil moisture stress conditions. Among varieties, PBM/74/13/45 may be the most susceptible variety as it showed the lowest leaf water potential at 35 DAP at the highest moisture regime. Less ability to recover the plant water status after re−watering also indicate that they are less adaptable to water stress. This may be due to the existence of a high resistance to water uptake, caused by stress related root injury (Kramer, 1952). Resistance might also be increased by formation of gas bubbles in stem and leaf xylem by cavitation (Milburn, 1966). The lower leaf water potential can be attributed to the lower capabilities of mung bean varieties to decrease stomatal conductance, closure of stomata at high water potential and to reduce the transpiration loss. Unlike in *cowpea* varieties there is no shiny appearance of the leaf surface of mung bean varieties. However, mung bean leaflets are rather hairy and this will probably reduce the transpiration losses. According to AVRDC (1976) when water potentials were below −2.00 bars there was a drastic reduction in net photosynthetic rate of mung bean.

From the above observations it is apparent that mung bean varieties are more susceptible than *cowpea* varieties to water stress. This was revealed in data on leaf area, leaf water potential and the recovery of the plant water status at re−watering. In *cowpea*, the most susceptible variety was Arlington and the most resistant variety was MI−35. In mung bean, the most susceptible variety was PBM/74/13/45. Thus, in selecting legumes to be grown under rain fed conditions in the dry zone of Sri Lanka, leaf characteristics and their response to moisture stress may be useful parameters to depend on.

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