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Evaluation of crop physiological traits in clusterbean (*Cyamopsis tetragonoloba* L. Taub) and mothbean (*Vigna aconitifolia* Jacq. Marechal)

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Abstract

During kharif 2003, 41 genotypes of clusterbean and 47 genotypes of mothbean were evaluated for crop physiological and yield traits. The detail growth analysis was performed during vegetative, flowering, seed filling and maturity growth stages. Drought tolerance traits like relative water content (RWC) and specific leaf area (SLA) were measured at these stages. The results indicated genotypic variations for yield compo-nents (Biomass, pod yield and seed yield). A significant relationship between SLA and seed yield suggested that low SLA could be an important character for selecting for higher yield. Strong relationship between actual growth rates and derived from thermal time suggested that larger set of germplasm can be evaluated for higher growth rates with ease. Breeders need to record only phenology, biomass & pod weight at maturity to select genotypes with higher crop growth rate and pod growth rate from a larger germplasm instead of tedious sequential growth analysis. Drought tolerance mechanism in clusterbean and moth bean involves keeping stomata open at lower leaf RWC. Genotypes with above average higher crop growth rate and higher partitioning were selected by bi-plotting of biomass and harvest index for further physiological studies.

Key words : Clusterbean, mothbean, crop growth rate, thermal time, specific leaf area

Introduction

Clusterbean and moth bean are important crops of drylands of Rajasthan. In both cluster bean and moth bean there is a need of the development of varieties with high grain yield adapted to poor fertility and marginal and sub-marginal lands with inadequate soil moisture supply. Both Cluster bean and Moth bean suffers from certain inherited traits, which needs improvement through appropriate physiological-breeding programs.

Significant genotypic differences to water stress in clusterbean have bean reported both at the germination (1) as well as other growth stages (2, 3, 4). These studies have indicated that cluster bean has a higher capacity to recover from water stress and thus provide reasonable seed yield and dry matter production, once the stress is relieved. Genotypic variations are reported in the most sensitive growth stage to water stress in Cluster-bean (4). It has been reported that early flowering/maturing genotypes of cluster bean perform better than the late flowering/maturing cultivars under low rainfall conditions. Despite its diverse uses, very little research efforts have so far gone into the plant physiological aspects influencing growth, yield and quality of Clusterbean.

Similarly the cultivars of mothbean are inherently low yielding (5, 6) and the productivity is only 250 kg ha^{-1}. Studies undertaken on growth, yield and various physiological attributes with selective moth bean genotypes under drought and good rainfall conditions indicated that early flowering genotypes (30-31 DAS to 50% flowering) provided significantly higher yield especially in a drought year. A number of investigators have studied genotypic responses under rainfed conditions for selection and development of stable and high yielding varieties of moth bean (5, 7, 8). Henry and Dauley (9,10) reported mutants, which exhibited combination of earliness in maturity, high degree of tolerance to drought condition, and high yield potential can exploit favorable growing condition than other standard varieties. Primitive growth habit and poor yield potential of moth bean warrants its genetic improvement. Kumar et al. (6) emphasized the need for the development of plant type with erect to semi-erect growth habit having early partitioning and maturity and high yield potential in sole, mixed and intercropping system.

To improve these crops, identification of the genetic variability in physiological traits and their association with the yield needs to be established, which require basic information on physiology and biochemistry of the crop. Therefore, this study is aimed to achieve following objective:

1. Use the physiological approaches to select genotypes of Clusterbean and Mothbean with early and higher dry matter partitioning.
2. Identify the drought resistance traits in these two crops and analysis their association with yields.

Material and methods

During kharif 2003, two experiments were conducted by raising cluster bean and moth bean crops at research farm of RRS, CAZRI, Bikaner. The field was harrowed and DAP (20 Kg/hectare) was incorporated. The experiments were laid out in randomized block design with three replications. 47 genotypes of moth bean and 41 genotypes of cluster bean were sown in the respective experiments on July 10, 2003. The required observations on phenology (days to emergence, flowering, pod initiation, maturity) were recorded.

Growth rates: Sequential growth rates (crop growth rate, pod growth rate and partitioning) were determined by performing growth analysis at different growth stages (vegetative, flowering, pod filling, and maturity). Plant sample was collected from the area of 0.5 m x 4 rows from each plot. The plant parts were separated into leaves, stem, pods and roots and were oven dried at 80°C for 48 hours. Total dry weight (TDM) and pod dry weight (PDM) were determined at each growth. Crop growth rate (CGR) was determined by regressing TDM with days after sowing. Similarly, pod growth rate (PGR) was determined by regressing pod growth weight with days after sowing. The partitioning factor was calculated as the ratio of PGR and CGR. Thermal time for different growth stages was calculated as cumulative degree days (Cd°) by the following formulae:

$Cd^{o} = ((Tmax + Tmin)/2)-Tb$, where Tmax, Tmin are the maximum, minimum air temperatures respectively and Tb is the base temperature of crops (8 °C).

The growth rates on thermal basis were calculated as fallow:

$CGR = TDM/ Th - Te)$

$PGR = PDM/(Th -(Te+Tp)$

Where Te, Tp, Th are the thermal time for emergence, pod initiation and maturity respectively.

Drought tolerance traits: Relative water contents (RWC) and Specific leaf area (SLA, leaf thickness), were recorded at different growth stages. 40 leaflets from 10 randomly selected plants were plucked and their fresh weight was recorded immediately (Wf). The leaflets were floated on water in a petridish for 4 hour and saturated weight were recorded after wiping off the free water from the surface of leaflets (Ws). The leaf areas of these leaflets were measured on leaf area meter. The leaflets were enclosed in paper bags and oven dry weights were recoded after drying at 80 °C for 48 hours (Wd). RWC and SLA were calculated as follow:

$RWC = ((Wf-Wd) / (Ws-Wd))*100$

$SLA = leaf area/Wd$

Yield and Yield Components: At maturity, a plant sample of 2 m x 4 rows from each plot of both the experiments were taken and separated into vegetative part and pods. The samples were air-dried and dry weights were recorded to determine TDM, pod weight and harvest index.

Results and discussion

Yield Components: Genotypic variations in yield components were noticed among the genotype of both the crops. Stafford and McMichel (3) reported variations among Guar germplasm for yield components under both dry land and irrigated conditions. The performance of top 10 genotypes in total dry matter (TDM) in each crop are sown in Table 1 & 2. In cluster bean (Table 1), the highest pod yielder was RGM 113, which produced about 27% more pods and 11% more total biomass than the local check RGC 936.

Table 1. Yield components (g m^{-2}) of Clusterbean genotypes during Kharif 2003 (10 top genotypes in Biomass).

Entry	Biomass	Pod weight	Seed Weight
CAZG 50	167.4	85.9	47.2
GAUG 11	182.5	78.8	42.5
GAUG 12	180.3	111.1	45.3
GAUG	175.1	82.2	47.1
HGC 365 C	170.0	105.4	58.1
HGC 870	180.4	88.7	47.5
RGC 936	165.8	92.6	54.3
RGC 1025	169.7	86.3	48.5
RGM 112	184.5	84.3	49.0
RGM 113	193.9	118.1	44.0
Mean	**177.0**	**93.3**	**48.3**
SE±	6.3	4.1	3.3

This indicates that harvesting index increased in this genotype as compared RGC 936. The other promising genotypes were GAUG 12, HGC 870 and RGC 1025 where not only pod yield, but TDM also increased substantially over local check. In moth bean, the genotypes like RMM 225, CGM 79 produced double total dry matter than local check RMO 40.

Table 2. Yield components (g m^{-2}) of Mothbean genotypes during Kharif 2003 (10 top genotypes in Biomass).

Entry	Biomass	Pod weight	Seed Weight
CGM 18	82.9	16.3	9.5
CGM 79	101.7	22.5	16.2
EXP 221	79.5	24.2	15.1
F_4-58	86.7	4.9	1.6
JAWALA	97.0	3.9	1.2
RMB 50	78.8	26.4	19.0
RMM 2	88.5	15.6	9.7
RMM 44	78.8	31.0	21.5
RMM 101	85.5	49.0	36.1
RMM 225	100.4	24.8	10.1
RMM0 40	52.8	30.6	17.6
Mean	**84.8**	**22.6**	**14.3**
SE±	5.8	2.8	1.8

Bi- plotting between crop growth rate (CGR) and partitioning factor (p_f) resulted in the selection of 10 genotypes with above average CGR and p_f in Cluster bean and 5 genotypes on moth bean (Figure 1).

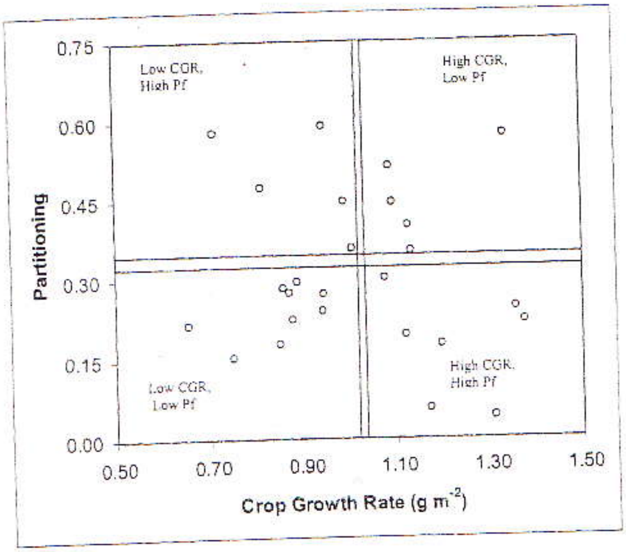

Fig. 1. Bi-plotting between Crop growth rate & partitioning factor in selected set of Mothbean genotypes

Growth Rates: Significant genotypic variations in crop growth rates were recorded among the genotypes in both the crops. A strong relationship between two growth rates based on thermal time and actual growth analysis (Figure 2) suggested that genotypes can be selected for higher growth rates just by measuring dry weight at maturity instead of performing tedious sequential growth analysis at different growth stages.

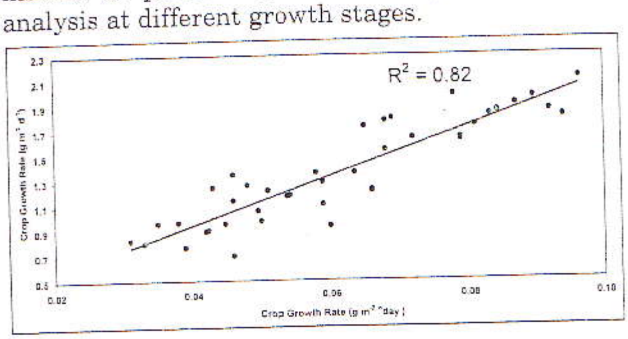

Figure 2. Relationship between two crop growth rates calculated on thermal time (g m^{-2} °day) & sequential growth analysis in mothbean (gm^{-2} d^{-1}).

Relative water contents (RWC) and Specific Leaf area (SLA): Recently the focus in resistance breeding has been shifted to physiological traits associated with drought. Many traits have associated with drought resistance and these include, among others, relative leaf water contents (11), specific leaf area (12), crop growth and partitioning (13). In our study, wide range of specific leaf area was noticed among the genotypes in both the crops (Table 3). The SLA was ranged between 107-167 in Clusterbean and 119-339 in mothbean. This indicates that cluster bean have thicker leaves than mothbean. The relationship between high water use efficiency has been reported with leaf thickness in groundnut (12). On the other hand, differences in photosynthetic rates were positively correlated with leaf thickness in alfalfa (14), soybean (15), oats (16) and Chickpea (17).

Table 3. Variation in SLA and RWC among in clusterbean and mothbean genotypes

Crop	No of Genotypes	SLA (cm ² g-1)		RWC (%)	
		Mean	Range	Mean	Range
Clusterbean	41	129.5	107-167	85.2	79.5-87.8
Mothrbean	47	213.7	119-335	82.7	74.7-87.8

This indicates that variations in SLA (leaf thickness) might be due to the variations in photosynthetic machinery per unit leaf area e.g. Rubisco content in groundnut (18). Although variations in RWC were recorded in genotypes in both the crops but the range in RWC is almost similar in these two crops.

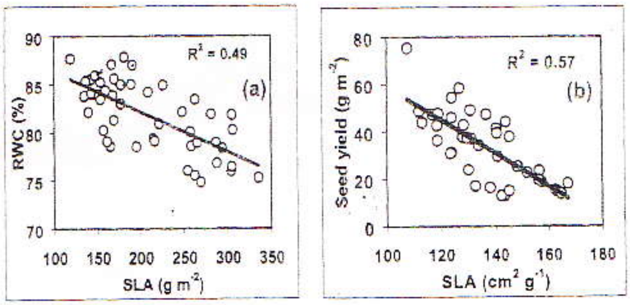

Figure 3. Relationship of Specific leaf area (SLA) with, (a) relative water content (RWC) and (b) seed yield in selected set of mothbean genotypes.

The relationship between SLA and RWC in mothbean indicates that selection for lower SLA may result in the identification of the genotypes with improved drought tolerance (Figure 3). Similarly, a negative relationship between SLA and seed yield indicates that there are significant chances of selected higher seed yield if we select with lower SLA (thicker leaves).

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