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Studies on drought tolerance in dolichos bean (*Lablab purpureus* L. Sweet)

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Abstract
In the present investigation four extensively cultivated genotypes of dolichos bean were subjected to drought stress to know their performance. In present study different levels have been imposed (T_1: 100% of field capacity- Control; T_2: 80% of field capacity-Mild stress; T_3: 60% field capacity-Moderate stress; T_4: 40% of field capacity-Severe stress). Results indicated that, under different regimes of stress a decrease in the growth, yield and physiological changes were noticed. The physiological traits such as stomatal frequency, relative water content, chlorophyll content and moisture retention capacity were showed deceased trend with increased level of drought stress. This revealed that dolichos bean is drought tolerant crop it can tolerate up to moderate stress level without compromising in yield traits. Hence more importance can be given to genotypes which are high performing under water stress regimes where genotype Arka Sambhram performed better under growth and yield attributing traits and Hebbal Avare-4 performed better in physiological traits.

Keywords: Dolichos bean, field capacity, stomatal frequency, relative water content, chlorophyll content, moisture retention capacity

1. Introduction

Dolichos bean (*Lablab purpureus* L. Sweet) is also known as Indian bean, Field bean, Hyacinth bean, Egyptian bean and Lablab bean and it is grown across the tropical regions of Asia, Africa and America. It is also known as "poor man's bean" (Ismunandji and Arsyad, 1990) [7]. It belongs to the family Fabaceae and its chromosome number is 2n=2x=22. It is a crop of ancient origin which has both food and fodder value. Dolichos bean is said to have originated in South East Asia or India and it was then spread to China, Western Asia and Egypt (Choudhary, 1972) [4]. Dolichos bean is an herbaceous perennial crop, but it is cultivated as an annual one for vegetable purpose. It contains anti-diabetic properties and given as a natural remedy for bladder burns and heart disorders. Among all legumes, dolichos beans are a significant source of therapeutic agents in both contemporary and traditional medicine (Morris, 2009) [12]. Dolichos bean is regarded as a versatile crop because it is used for feed, soil development, soil protection and weed control (Shivashankar and Kulkarni, 1989) [18]. It is a key source of dietary fiber and proteins, particularly in the southern part of India (Murphy, 1998) [13]. The lablab bean is a drought-resistant crop but prone to waterlogging. It grows well in arid climate with little rainfall. Dolichos bean is locally consumed as a grain legume and vegetable. It is having adaptability to wide range of climatic conditions such as arid, semi-arid, sub-tropical and humid region (Kimani *et al.*, 2012) [8]. Generally diverse germplasm is expected to give high hybrid vigour hence, the present investigation is necessary to study the growth, quality and yield parameters of genotypes under water stress. Droughts are expected to becoming more prevalent and effective as result of climate change, hence a better understanding of drought response patterns and associated traits are essential for achieving yield stability in water-limiting regions. In Southeast Asia as well as Eastern Africa, *Lablab purpureus* is traditionally farmed as a pulse crop for human use (Maas, 2006) [9].

When established, lablab species are known to be drought tolerant and this involved a complex multi- dimensional approach which requires an understanding of physiology, biochemistry to deal with the interaction of morpho-physiological responses with soil and climatic variations. The study was undertaken with the following objectives to reveal the best genotype responsible for sustaining yield level in water deficit condition with the support of morphological and physiological observations.

2. Materials and Methods

The experiment was conducted in Department of Vegetable Science, College of Horticulture, Bengaluru, UHS, Bagalkot, Karnataka during winter *i.e.*, from November 2021 to February, 2021. The pot experiment under polyhouse condition consisted of 4 dolichos bean genotypes. Out of four, 3 genotypes were collected from IIHR, Bengaluru, 1 genotype from VC Farm, Mandya. The experiment was laid out in Factorial Randomized Block Design (FCRD) in three replications with four different water stress levels at field capacity as treatments. The genotype Hebbal Avare-4 as a check variety. A potting mixture containing soil and farmyard manure was filled in the pots. The lateritic sandy clay loam (55% clay, 30% silt and 15% sand) was taken from the top fifteen centimeter of the regularly tilled field and utilized in the mixture. Drought stress was created by inducing different water stress regimes at forty-five days after planting based on field capacity such as control, mild stress, moderate stress and severe stress. The crop water requirements for 4 water regimes (100%, 80%, 60% and 40%) was calculated according to the field capacity of soil. Various growth and yield factors such as plant height, number of branches per plant, pod length, pod width and pod yield per plant were noted each genotype. At 45 days after planting, the various physiological parameters including stomatal frequency using thermocol-xylene method (Wolf, 1979) [20], relative water content suggested by Barr and Weatherley (1962) [21], chlorophyll content using SPAD value and epicuticular wax content according to Ebercon *et al*., (1977) [6] using Spectrophotometric method were assessed and mean was worked out for further statistical analysis. The correlation co-efficient among all possible character combinations were estimated employing formula of Pearson's correlation coefficient. (Al-Jibouri *et al.*, 1958) [1].

3. Results and Discussion

The analysis of variance was done for 6 parameters at 45 days after sowing at various levels of water stress and the interactions effects of genotypes with water stress levels (genotype × water stress levels). Highly significant variations were seen for all characters studied due to different water stress levels. Further the interaction effects due to genotype × water stress levels were also found to be highly significant for seven the characters (p<0.01) were presented in Table 1. The Table 2 depicts the average of plant height at different field capacity (55.09-40.34 cm) The decrease in plant height is due to lack of moisture for cell elongation Mahala and Jadav (1982) [11] and Satyavathi *et al.* (2014) [16]. Table 3 Number of branches per plant (5.49-3.45) increased rate of transpiration, lack of hydration of protein and protoplasm might be the reason for poor vegetative growth under moisture stress conditions Arora *et al*. (2011) [3]. Table 4 Pod length (7.52-5.57 cm), Table 5 Pod width (1.74-1.38 cm), Table 6 Pod yield per plant (109.09-40.80 g) The decrease in pod length under moisture stress condition might be due to reduced level of cell elongation as cell elongation requires moisture Reddy *et al.* (2017) [15], Rai *et al*. (2012) [14], Thakur *et al.* (2016) [19]. Table 7 Stomatal frequency (34.70-25.27 number/mm^2) under water stress reduced, decrease in leaf area due to water stress results in the decreased transpiring area which results in lower stomatal frequency as one of the drought postponement or avoidance strategies to conserve the moisture. Stomatal closure is the first reaction to drought stress in most plants Anosheh *et al*. (2016) [2]. Table 8 Chlorophyll SPAD value (72.64-59.35) under severe moisture stress condition, there will be producing of reactive oxygen species as a result of oxidative burst as the chloroplast is the active site of ROS production (Mafakheri *et al*. 2010) [10]. Table 9 Relative water content (76.47-64.12%) under water stress, water stress depends on variety and to a greater extent on the length of its exposure, plus that of temperature in growing conditions and may also due to differences in the tested varieties to accumulate and adjust osmotically to maintain tissue turgor and hence physiological activity. Choudhry *et al*. (2014) [5]. All these parameters showed decreased trend with increasing water stress level. Table 10 Epicuticular wax content (0.31-0.58 mg/cm^2) showed increased trend. Presence of epicuticular wax on leaf surface is having prominent role in keeping transpiration rate low mainly by reflecting visible and infrared radiations and reducing the leaf temperature.

Correlation study was identified for numerous traits, indicating that the environment has a reduced influence on the expression of these traits and there is a significant inherent relationship among the characters. The correlation for pod yield per plant had positively and significantly (at $p\leq0.05$) associated with days to first flowering (0.535) and positively and highly significant ($p\leq0.01$) association with days to fifty per cent flowering (0.682), pod length (0.648), pod width (0.712), 100 seed weight (0.774) and number of pods per plant (0.891). It is well understood that yield depends on so many factors the variation in yield components such as pod length and pod width also cause severe variation in yield of the plant. In the present study these traits were associated positively with yield, pod length (0.648), pod width (0.712). Similar type of association was also noticed by Rai *et al*. (2012) [14]. Pod yield is positively and significantly ($p\leq0.05$) associated with number of pods (0.515), as noticed by Shah *et al*. (1986) [17]. The significantly positive associations suggest that selection should be oriented towards higher content of pod yield/plot and thus ultimately resulting in higher pod yield content (Table 11).

Table 1: Analysis of variance (ANOVA) of Dolichos bean for Morpho-physiological parameters

		Source of variation					
Components	**d.f**	**X_1**	**X_2**	**X_3**	**X_4**	**X_5**	**X_6**
Treatment (T)	3	469.72**	9.294**	506.8**	398.04*	0.18**	359.9*
Treatment (G)	3	29.04	3.002	22.59	20.70	0.07	74.85
T × G	9	7.40**	0.462**	33.78**	3.72**	0.00**	37.93**
Error	32	5.76	0.344	1.59	0.83	0.00	15.74
CD @ 5%							
T		2.00	0.49	1.05	0.76	0.03	3.30
G		2.00	0.49	1.05	0.76	0.03	3.30
T × G		3.99	0.98	2.10	1.52	0.06	6.60
CV (%)		4.96	12.84	2.62	1.40	7.00	5.79

**Significant at 1% *Significant at 5% d.f- degrees of freedom
X_1: Plant height X_2: Number of branches X_3: Stomatal frequency X_4: Chlorophyll SPAD X_5: Epicuticular wax X_6: Relative water content

Table 2: Variability for plant height (cm) among dolichos bean genotypes under different levels of water stress.

Factors	**T_1 (100% FC)**	**T_2 (80% FC)**	**T_3 (60% FC)**	**T_4 (40% FC)**	**Average**
Hebbal Avare-4	52.10	47.56	44.08	40.75	46.12
Arka Amogh	56.65	52.35	47.69	40.24	49.23
Arka Sambhram	54.18	52.99	49.16	40.43	49.04
Shivalli local	57.44	51.01	48.55	39.00	49.39
Average	55.09	50.98	47.37	40.34	
	S.E m ±	CD (5%)	CV (%)		
T	0.69	2.00	4.96		
G	0.69	2.00			
TG	1.39	3.99			

Table 3: Variability for number of branches among dolichos bean genotypes under different levels of water stress.

Factors	**T_1 (100% FC)**	**T_2 (80% FC)**	**T_3 (60% FC)**	**T_4 (40% FC)**	**Average**
Hebbal Avare-4	5.36	5.28	4.57	4.45	4.90
Arka Amogh	5.55	4.92	4.11	3.00	4.37
Arka Sambhram	6.17	5.67	4.88	3.44	5.04
Shivalli local	4.91	4.07	3.83	2.89	3.95
Average	5.49	4.99	4.35	3.45	
	S.E m ±	CD (5%)	CV (%)		
T	0.17	0.49	12.84		
G	0.17	0.49			
TG	0.34	0.98			

Table 4: Variability for pod length (cm) among dolichos bean genotypes under different levels of water stress.

Factors	**T_1 (100% FC)**	**T_2 (80% FC)**	**T_3 (60% FC)**	**T_4 (40% FC)**	**Average**
Hebbal Avare-4	5.82	4.86	4.04	4.03	4.69
Arka Amogh	8.93	8.77	7.78	7.42	8.24
Arka Sambhram	10.08	9.59	8.52	7.50	8.91
Shivalli local	5.27	4.73	3.79	3.34	4.28
Average	7.52	6.99	6.03	5.57	
	S.E m ±	CD (5%)	CV (%)		
T	0.10	0.29	5.31		
G	0.10	0.29			
TG	0.20	0.58			

Table 5: Variability for pod width (cm) among dolichos bean genotypes under different levels of water stress.

Factors	**T_1 (100% FC)**	**T_2 (80% FC)**	**T_3 (60% FC)**	**T_4 (40% FC)**	**Average**
Hebbal Avare-4	1.54	1.50	1.41	1.33	1.44
Arka Amogh	1.94	1.81	1.68	1.46	1.72
Arka Sambhram	2.03	1.83	1.67	1.45	1.74
Shivalli local	1.45	1.41	1.34	1.30	1.38
Average	1.74	1.64	1.52	1.38	
	S.E m ±	CD (5%)	CV (%)		
T	0.02	0.05	3.60		
G	0.02	0.05			
TG	0.03	0.09			

Table 6: Variability for pod yield per plant (g) among dolichos bean genotypes under different levels of water stress.

Factors	T_1 (100% FC)	T_2 (80% FC)	T_3 (60% FC)	T_4 (40% FC)	Average
Hebbal Avare-4	90.66	77.91	48.88	43.83	65.32
Arka Amogh	122.12	97.73	67.41	44.17	86.83
Arka Sambhram	146.36	107.13	76.63	50.84	91.27
Shivalli local	77.19	59.55	43.90	24.35	51.25
Average	109.09	85.58	59.21	40.80	
	S.E m ±	CD (5%)	CV (%)		
T	1.72	4.96	8.10		
G	1.72	4.96			
TG	3.45	9.93			

Table 7: Variability for stomatal frequency (number/mm^2) among dolichos bean genotypes under different levels of water stress.

Factors	T_1 (100% FC)	T_2 (80% FC)	T_3 (60% FC)	T_4 (40% FC)	Average
Hebbal Avare-4	37.00	34.20	30.11	28.65	32.49
Arka Amogh	34.12	31.56	29.34	25.81	30.20
Arka Sambhram	34.35	35.44	33.89	30.33	33.50
Shivalli local	33.33	29.78	25.56	24.22	28.22
Average	34.70	32.74	29.72	27.25	
	S.E m ±	CD (5%)	CV (%)		
T	0.26	0.74	1.84		
G	0.26	0.74			
TG	0.51	1.48			

Table 8: Variability for chlorophyll SPAD values among dolichos bean genotypes under different levels of water stress.

Factors	T_1 (100% FC)	T_2 (80% FC)	T_3 (60% FC)	T_4 (40% FC)	Average
Hebbal Avare-4	75.94	68.21	63.04	60.20	66.85
Arka Amogh	73.12	65.94	62.53	59.32	65.23
Arka Sambhram	71.92	65.27	61.77	59.75	64.68
Shivalli local	69.60	64.82	61.34	58.11	63.47
Average	72.64	66.06	62.17	59.35	
	S.E m ±	CD (5%)	CV (%)		
T	0.26	0.76	1.40		
G	0.26	0.76			
TG	0.53	1.52			

Table 9: Variability for relative water content (%) among dolichos bean genotypes under different levels of water stress.

Factors	T_1 (100% FC)	T_2 (80% FC)	T_3 (60% FC)	T_4 (40% FC)	Average
Hebbal Avare-4	86.81	69.65	67.63	65.12	72.30
Arka Amogh	72.55	66.92	64.05	61.83	66.34
Arka Sambhram	74.78	69.19	68.83	65.64	69.60
Shivalli local	71.73	65.64	62.08	63.03	66.63
Average	76.47	67.85	65.25	64.12	
	S.E m ±	CD (5%)	CV (%)		
T	1.15	3.30	5.79		
G	1.15	3.30			
TG	2.29	6.60			

Table 10: Variability for epicuticular wax content (mg/cm^2) among dolichos bean genotypes under different levels of water stress.

Factors	T_1 (100% FC)	T_2 (80% FC)	T_3 (60% FC)	T_4 (40% FC)	Average
Hebbal Avare-4	0.41	0.49	0.57	0.61	0.52
Arka Amogh	0.25	0.32	0.45	0.53	0.39
Arka Sambhram	0.36	0.50	0.59	0.63	0.52
Shivalli local	0.21	0.32	0.46	0.56	0.39
Average	0.31	0.41	0.52	0.58	
	S.E m ±	CD (5%)	CV (%)		
T	0.01	0.03	7.00		
G	0.01	0.03			
TG	0.02	0.05			

Table 11: Correlation studies for growth and yield parameters of dolichos bean genotypes.

	Plant height	No. of branches	Pod length	Pod width	Pod yield
Plant height	1	0.668**	0.622*	0.560*	0.183
No. of branches		1	0.932**	0.900**	0.458
Pod length			1	0.937**	0.648**
Pod width				1	0.712**
Pod yield					1

4. Conclusion

India consumes large amounts of legumes, particularly, vegetable beans in their diet. Dolichos bean is one of the legumes that is a significant source of medicinal compounds utilised in both conventional and modern medical practises. A proper understanding of drought response patterns and associated features is essential for establishing yield stability in water-limiting environments since droughts are anticipated to increase in both frequency and intensity as a result of climate change. The principle objective of this study was to study identification of dolichos bean genotype with better tolerance, growth and yield under different drought stress regimes. The morpho-physiological traits and yield attributing traits provides information underlying conclusions on the better understanding of drought response patterns and associated traits to obtain yield stability in water limiting area. The more importance can be given to genotypes which are high performing under water stress regimes where genotype Arka Sambhram performed better under growth and yield attributing traits and Hebbal Avare-4 performed better in physiological traits. The genotype Shivalli local was least performing under all the applied water stress levels in present study which indicates, it is showing intolerance to drought stress.

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