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Effect of Waterlogging on Cetain Physiological Parameters of Redgram (*Cajanus cajan (L.) Millsp*)

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ABSTRACT

A pot culture experiment was conducted at Department of Cropphysiology, S.V.Agricultural College,Tirupati during kharif 2013 to know the effect of waterlogging on certain Physiological parameters of Redgram (*Cajanus cajan (L.) Millsp*).The experiment was conducted in a spilt pot design with different time periods of waterlogging as main treatments and genotypes as subplots.LRG 30,Maruti and Asha were the genotypes tested.Waterlogging affected all the physiological and growth parameters *viz*., Plant height,number of primary branches,total dry dry matter,leaf dry matter,root drymatter,leaf area,leaf area index,leaf area duration,specific leaf area, specific leaf weight and crop growth rate . The three different periods of stress imposition were 40 DAS (vegetative stage), 80 DAS(reproductive stage) and 120 DAS(pod formation stage).Sensitive stage for different physiological and growth parameters were recorded. Water logging at 40DAS affected plant height and crop growth rate. When stress was imposed at 80DAS number of primary branches,leaf area,SLA,LAI and SLW were affected.A greater decrease in leaf area,total dry matter, leaf dry weight and dry weight was observed when stress was imposed at 120 DAS. The present study forms a physiological basis to understand the sensitive stage of redgram to waterlogging stress.

Key words : Growth parameters, Redgram, Waterlogging, physiological.

Waterlogging is a serious problem, which effects the crop growth and yield. Waterlogging may occur as a result of high rainfall when evaporative demand is low (Kevin E Trenberth., 2005) and unpredictable rainfall (Ceccarelli et al. 2010). It can also occur when the amount of water added through rainfall or irrigation is more than what can percolate into the soil within one or two days. The situation is further aggravated in clay soils which have characteristically poor internal drainage (Triantafilis et al., 2003).

Pigeon pea is highly sensitive to water logging (Perera et al. 2001). Since it is generally grown under rainfed conditions in the rainy season it is often exposed to drought as well as extended episodes of transient water logging during the peak rainy days, leading to a heavy loss of individuals in the plant stand. In Andhra Pradesh pigeon pea is mainly cultivated in heavy soils of Krishna and Guntur districts. Here the problem of transient waterlogging has cause for a decrease in yield of pulse crops in general and redgram in particular.

Waterlogging is known to inhibit vegetative and flowering stages (Gibbs and Greenway, 2003) and yield of several plant species. This is accompanied by poor uptake of water and minerals from the soil (Sairam *et al*., 2008), epinasty, senescence and abscission of leaves and derangement in the hormonal metabolism of the plant (Phillips, 1964 and Crozier *et al*., 1969). Waterlogging also predisposes pigeon pea plants to Fusarium wilt and Phytopthera blight infections common fungal diseases of rainy season resulting in upto a 100% yield losses.

During recent times a recurrent event of untimely rains and an associated excessive soil moisture situation is causing an impediment to crop production. This is more true in case of khariff pulse crops like red gram.

MATERIAL AND METHODS:

Top 30 cm soil was collected from the field and filled into plastic pots of 25 lit capacity to conduct a pot culture experiment. Before filling in to pots (25 lit) soil was thoroughly mixed with recommended dose of fertilizers leaving a 10 cm depth from the birm. Recommended dose of nitrogen (20 kg ha^{-1}) and phosphorous (50 kg ha^{-1}) was applied in the form of Diammonium phosphate (DAP).

All pots were watered carefully to maintain soil moisture at approximately field capacity up to starting of waterlogging treatment and after the treatment was over. Waterlogging was maintained uniformly in three stages viz., 40 DAS, 80 DAS and 120 DAS for 8 days continuously followed by six days of drainage. Water level of 5 cm depth above the soil was always maintained in all the pots. After waterlogging the pots were kept for drainage of six days and were maintained at field capacity there after (in case of the pots left for harvest data).

The experiment was laid out in a Split plot Design with three main stress imposing stages *viz*., 40 DAS, 80 DAS and 120 DAS were taken as main plots and three genotypes (LRG 30 (Palanadu), ICPL 8863(Maruti) and ICPL 87119(Asha)) were taken as sub plots. Three genotypes were taken to identify the sensitive growth stage and to assess the effect of waterlogging on growth and development. LRG 30 (Palanadu), ICPL 8863(Maruti) and ICPL 87119(Asha) were selected based on the literature as waterlogging resistant, moderately resistant and susceptible cultivars.

Each variety at each main stage of stress (waterlogging) imposition viz., 40 DAS, 80 DAS and 120 DAS was replicated four times in each case of (1)before imposing stress (2) after imposing stress and pots (25 lit capacity) (3) left for harvest data.

Experimental data was collected at the end of each waterlogging condition after 6 days of drainage (T_1 – 40 DAS, T_2 – 80 DAS, T_3 – 120 DAS). At each main stage of stress imposition, for each variety four replications were maintained. Thus in the first stage of stress imposition (40 DAS) altogether there were 36 pots (25 lit capacity).

Twelve pots to get data on growth and development of pigeon pea before imposing stress.In the next 24 pots 12 pots were subjected to waterlogging condition and after completion of the stress period data was collected (through destructive sampling). However the next twelve pots (25 lit capacity) were subjected waterlogging of 8 days followed by a drainage of 6 days. They were maintained for harvest data in order to know the influence of waterlogging at 40 DAS,80DAS and 120DAS respectively on yield parameters.

After separation of leaves from the plant, leaf area was measured by using LI-3100 Leaf area meter (LICOR-Lincoln, Nebraska, USA) and expressed as cm^2 $plant^{-1}$. Dry matter of the plant was recorded at the end of each waterlogging treatment by destructive sampling. Root, stem, leaves and pods were separated and were dried at 80°C temperature in a hot air oven till constant weight was obtained. After complete drying, dry matter was of each plant part was expressed as g $plant^{-1}$. CGR, Leaf Area Index, specific leaf weight were determined by using standard formulae. The SPAD (Soil Plant Analytical Development) meter was used for measuring the chlorophyll content of leaves.

RESULTS AND DISCUSSION

Effect of water logging on physiological and growth parameters was studied in this investigation. Significant differences in plant height were observed only among different stages of waterlogging treatmentWaterlogging at 40 DAS recorded height percentage of loss in plant height (18.31%) followed by 80 DAS (7.35 %) 120 DAS (4.85 %).

Effect of waterlogging stress at 40 DAS, 80 DAS and 120 DAS on plant height at the time of harvest showed significant difference among all stages of waterlogging and genotypes. Mean values pertaining to plant height showed that waterlogging resulted significant difference in the plant height at 40 DAS (126.64) followd by 80 DAS (148.36), 120 DAS (148.16). Among varieties greater decrease in plant height was observed in Maruti (130.67) followed by Asha (132.75) and LRG 30 (159.79).

From the data it is observed waterlogging at 40 DAS is proved detrimental to plant height and LRG 30 was found better to cope up with in waterlogging stress at all the stress imposition stages viz., 40 DAS, 80 DAS and 120 DAS.

Reduction plant height in waterlogging treatment was mainly due to oxygen deficiency, anaerobic condition, less root activity, impaired uptake of nutrients, inhibition of photosynthesis and tranlocation of photo assimilates (Wample and Thorton 1984).

Effect of waterlogging stress in terms of percentage decrease in number of primary branches among treatments and varieties were found to be non significant. However interaction between treatments and varieties there was a significant difference. Highest percentage of loss in number of primary branches was observed in LRG 30 when stress was imposed at 80 DAS (38.62

Table 1. Effect of waterlogging on total dry matter (g plant^{-1}) at different stages.

Treatments	Before Imposing Stress				After Imposing Stress			
	Lrg 30	Maruti	Asha	Mean	Lrg 30	Maruti	Asha	Mean
40 DAS	4.01	3.68	4.66	4.12	2.55	2.08	2.52	2.39
80 DAS	31.83	24.88	35.14	30.62	15.88	15.20	15.92	15.67
120 DAS	63.55	67.94	82.81	71.43	59.54	53.04	56.98	56.52
Mean	33.13	32.16	40.87		25.99	23.44	25.14	
	T	V	T × V		T	V	T × V	
Sem±	3.77	4.97	6.54		1.03	2.89	1.79	
CD (P=0.05)	13.03	N.S.	N.S.		3.56	N.S.	N.S.	

Table 2. Effect of waterlogging on total dry matter (g plant^{-1}) at the time of harvest.

Treatments	LRG 30 (V_1)	MARUTI (V_2)	ASHA(V_3)	Mean
40 DAS (T_1)	55.95	49.35	56.83	54.04
80 DAS (T_2)	55.46	34.68	49.49	46.54
120 DAS (T_3)	42.70	34.62	35.32	37.55
Mean	51.37	39.55	47.21	
	T	V	TXV	
SEm±	0.52	0.40	0.90	
CD (P=0.05)	1.79	1.18	2.19	

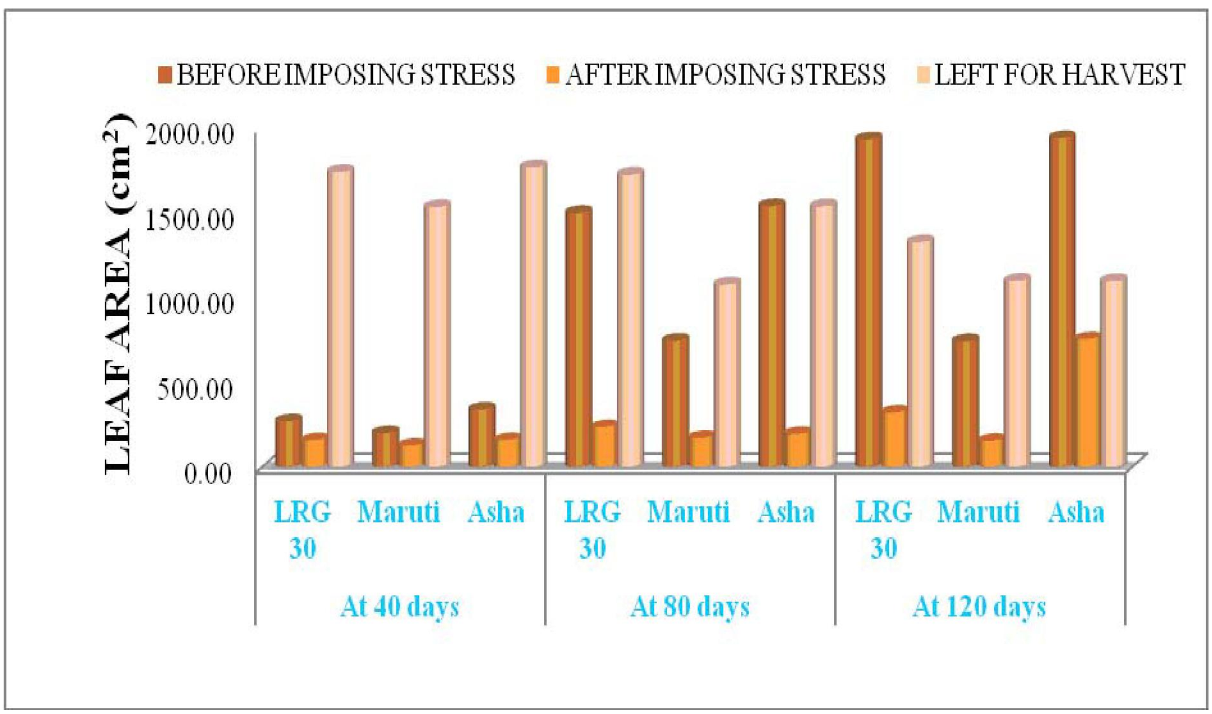


Fig.1. Effect of waterlogging on leaf area at different crop growth stages in redgram genotypes during kharif,2013.

%). Where as in Maruti and Asha the loss of primary branches was higher when the stress of imposed at 40 DAS itself (38.33%, 33.14%).

Significant differences were observed among different stages of waterlogging stress viz 40 DAS, 80 DAS and 120 DAS and also among different genotypes with respect to leaf area development. Waterlogging at 80 DAS recorded highest percentage of loss in leaf area (82.85%) followed by 120DAS (74.54%), 40 DAS (42.80%) which reflects a shoot up in senence and associated loss in leaf number(fig.1).

Leaf area retained at the time of harvest as a result of waterlogging at 40 DAS, 80 DAS and 120 DAS showed significant differences among all stages of waterlogging stress., genotypes and their interaction. Waterlogging at 40 DAS resulted in higher leaf area (1679.92) followed by stress at 80 DAS (1446.81), 120 DAS (1174.91). Whereas among varieties LRG 30 retained higher leaf area (1596.88) followed by Asha(1467.63) and Maruti(1237.13).Loss of turgor, reduction in average leaf sizes, premature senence and abscission of older leaves were the major causes of reduced leaf area in pigeon pea cultivars under waterlogged conditions(Takele and Mc David, 1995).

Among different stress imposition stages viz. 40 DAS, 80 DAS and 120 DAS significant difference was observed in terms of total dry matter content.Total dry matter content at harvest showed significant differences among all stages of waterlogging (40 DAS, 80 DAS and 120 DAS), Genotypes and their interaction. Mean values pertaining to total dry matter showed that waterlogging resulted in significant decrease in the total dry matter at 120 DAS (37.55 g/plant) followed by 80 DAS (46.54 g/plant), 40 DAS (54.04 g/plant). Whereas among varieties higher amount of total dry matter was observed in LRG 30 (51.37) followed by Asha (47.21) and Maruti (39.55) (Table.1&2).

A higher total dry matter content was maintained in the treatment where stress was imposed at 40 DAS. This might be due to the new leaf growth and its associated increase in dry matter production after the stress recovery.

Significantly higher decrease root dry weight was observed at 120 DAS (56.67) followed by 80 DAS (38.03) and 40 DAS (56.67).Effect of waterlogging stress imposed at various stages viz 40 DAS, 80 DAS and 120 DAS recorded significantly differences for root dry weight values at harvest among all stages of waterlogging, genotypes and their interaction . Mean values pertaining to root dry weight were significantly higher at 40 DAS (8.01) followed by 80 DAS (6.16) and 120 DAS (5.55). Among the genotypes LRG 30 recorded a higher root dry weight (8.08) compared to Asha (6.09) and Maruti (5.55). Higher loss of root dry weight was thus observed in Maruti (5.55).

When the stress was imposed a greater reduction in root dry weight is expected as it was the first plant organ affected due to hypoxic conditions. Root dry weight reduction was observed comparatively higher then percentage reduction in root dry weight compared to shoot dry weight was also reported by Chauhan *et al* .(1997) in Redgram.

When stress was imposed at different stages viz., 40 DAS, 80 DAS and 120 DAS leaf dry weight values differed significantly among treatments and genotypes before and after imposition of stress. When stress was imposed at 40 DAS, 80 DAS and 120 DAS and leaf dry weight values were recorded at harvest a significant difference among treatments, genotypes and their interaction was observed . Significant decrease in leaf dry weight was observed at 120 DAS (7.08) followed by 80 DAS (10.45) and 40 DAS (11.83). Whereas among varieties higher loss of leaf dry weight was observed in Maruti (7.4) followed Asha (10.5) and LRG 30 (11.46).(fig.2)

A significant difference among different stages of stress imposition viz., 40 DAS, 80 DAS and 120 DAS, genotypes and their interactions was found in SLA at harvest. Mean values showed that waterlogging resulted in significant decrease in SLA at 80 DAS (140.86) followed by 40 DAS (143.65) and 120 DAS (174.4). Among the varieties a higher decrease in SLA was observed in Asha (139.75) followed by LRG 30 (142.54) and Maruti (176.69).

A comparison of SLA before and after imposition stress through percentage decrease did not follow neither increasing nor decreasing trend. In some genotypes (LRG 30) it is increased and in other genotypes (Maruti and Asha) it is decreased.

A significant difference after imposition of stress in SLW was observed among different treatments (period of stress imposition viz,. 40 DAS, 80 DAS and 120 DAS) and interaction between treatments and varieties. A significant difference in SLW at harvest was observed among different periods of stress imposition (viz,. 40 DAS, 80 DAS and 120 DAS), among genotypes their interaction. Mean values pertaining to specific leaf weight showed that SLW was same at 40 DAS (0.0073) and 80 DAS (0.0073). However significant difference in SLW was observed at 120 DAS (0.0056). Among varieties significantly higher SLW was observed in Maruti (0.006) followed by LRG 30 (0.0073) and Asha (0.0073).

SLW is the ratio between leaf biomass to leaf area. Which shows inverse relation with SLA. The results of SLW showed exactly opposite trend to SLA. Among varieties due to waterlogging effect at harvest SLA was found higher in Asha (139.75) followed by LRG 30 (142.54) and Maruti (176.69) where in SLW it followed the reverse trend.

LAI values at harvest showed significant differences among all stages of waterlogging, among genotypes and their interaction. Waterlogging at 40 DAS, 80 DAS and 120 DAS showed their impact on LAI at 120 DAS (1.29) followed by 80 DAS (1.60) and 40 DAS (1.85). Whereas among varieties higher LAI values were recorded in LRG 30 (1.76) followed by Asha (1.62) and Maruti (1.36).

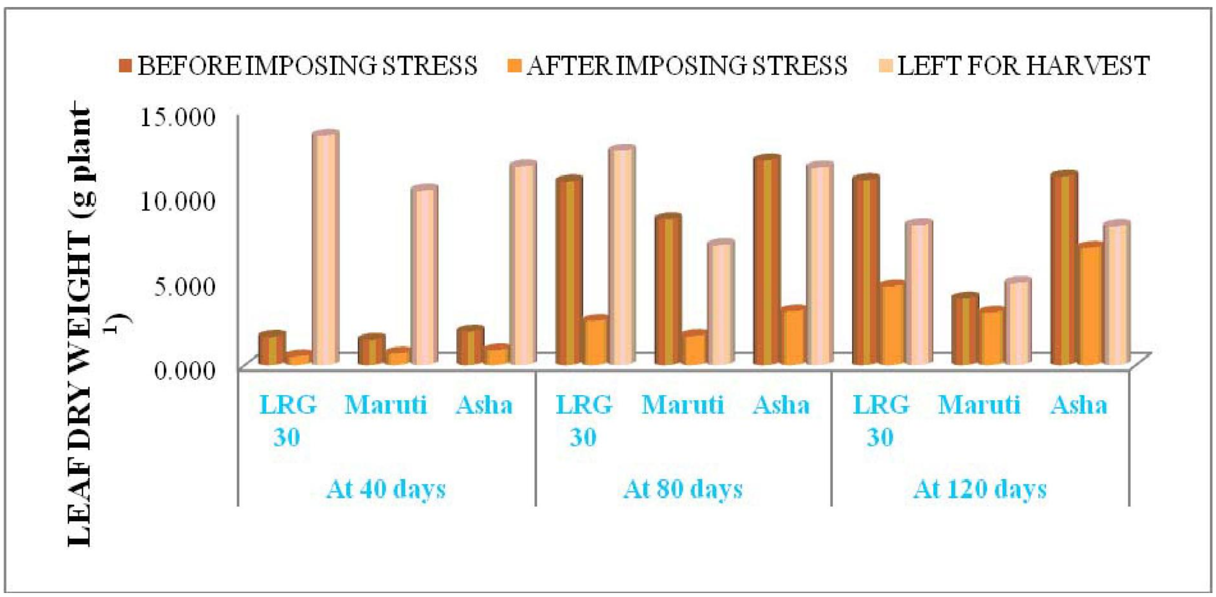
Leaf area index and leaf area followed the same trend among varieties where in LRG 30 should higher values. Like in the case of leaf area, leaf area index values were also increased between 40-80 DAS and then decreased between 80-120 DAS.

CGR showed significant differences among different stages of imposition of stress (viz., 40 DAS, 80 DAS and 120 DAS). However among genotypes and in interaction between treatments and genotypes it was non significant After imposition of stress significant decrease in CGR was observed between 40 to 80 DAS (3.66) compared to 80 to 120 DAS (11.26) .The percentage decrease in CGR was however found non significant at treatments, genotypes and in their interaction

Significant difference among different stages of waterlogging treatment (viz., 40 DAS, 80 DAS and 120 DAS) amd genotypes before and after imposing stress was observed Significantly higher LAD values (2.5) were observed at 80-120 DAS after imposing stress compared to 40-80 DAS. Among genotypes higher LAD after imposition of stress was recorded in Asha (6.91) followed by LRG 30 (4.65) and Maruti (3.09).

In the present study the effect of waterlogging at different crop growth stages was investigated. Compared to vegetative stage the crop seems to be sensitive for waterlogging at flowering stage and pod formation stage.

Fig.2. Effect of waterlogging on leaf dry weight at different crop growth stages in redgram genotypes.



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