EFFECT OF PHOSPHORUS APPLICATION ON GROWTH, CHLOROPHYLL AND PROLINE UNDER WATER DEFICIT IN CLUSTERBEAN (*CYAMOPSIS TETRAGONOLOBA* L. TAUB)

SHUBHRA*, J. DAYAL AND C.L. GOSWAMI

Department of Botany and Plant Physiology, CCS Haryana Agricultural University, Hisar-125004

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SUMMARY

A study was carried out on clusterbean (*Cyamopsis tetragonoloba* L. Taub) cv. HG-365 under pot-culture. Three levels of phosphorus *i.e.*, 15, 30 and 60 mg kg^{-1} soil were supplied in two split doses at week's interval in the form KH_2PO_4 one week after sowing. Water stress was created by withholding irrigation at vegetative, flowering and pod-filling stages. Water deficit decreased the dry weights of leaf, stem and roots in general. The chlorophyll content of the leaf was also decreased by water-deficit but there was accumulation of large amount of proline in the leaf. Treatment with phosphorus proved effective in improving the chlorophyll content as also dry weights of plant parts at all the stages. On the contrary, proline content of the leaf decreased by phosphorus treatment. The present investigation revealed that phosphorus treatment was effective to large extent in alleviating the effect of water deficit in clusterbean.

Key words: **Chlorophyll, clusterbean, growth, phosphorus, proline, water stress.**

INTRODUCTION

Clusterbean (*Cyamopsis tetragonaloba*) commonly called *guar* in India, is an important kharif legume capable of growing under poor fertility and scanty rainfall. Being grown under rainfed condition, its average yield in Haryana is still very low and there is an ample scope for increasing its productivity and quality by nutrient application. Due to its importance for both fodder and seed, the research work in this crop has gained momentum in the last few years. Phosphorus, one of the important macronutrient, plays an important role in plant growth and development. The present investigation was carried out to investigate the role of phosphorus in ameliorating the effects of water deficit on plant growth and development.

MATERIALS AND METHODS

Seeds of clusterbean cv. HG-365 obtained from Department of Plant Breeding of this university, were surface sterilized with 1% sodium hypochlorite solution and then inoculated with mixed rhizobium culture. The seeds were sown in earthen pots filled with 5 kg of dune sand and grown under natural condition in screen house. Five seeds were sown in each pot and after germination two plants were retained. Irrigation was given as and when required. Each pot was supplied with nitrogen free nutrient solution (Wilson and Reisenauer 1963) at fortnightly intervals. Plant protection measures were adopted by spraying 0.02% melathione at regular intervals.

*Corresponding author.

One week after sowing, three levels of phosphorus were supplied (*i.e.*, 15, 30 and 60 mg Kg^{-1} soil) in two split doses at one week interval in the form of KH_2PO_4. Equal concentrations of potassium was maintained in control and phosphorus treated pots by adding K_2SO_4 and CH_3COOK in 1:1 ratio.

Water stress was created by withholding irrigation at different growth stages. For each sampling, three replicates were used. Plants were sampled at permanent wilting point (PWP) with soil moisture content 3.5(±0.5%). Proline and chlorophyll content were estimated using third fully expanded leaf from the top as per methods described by Bates *et al.* 1973 and Hiscox and Israelstam 1979, respectively.

RESULTS AND DISCUSSION

The moisture content of the soil under water deficit condition was around 3.5% (±0.05) at different growth stages. However, under well-watered condition the moisture content was 10±0.05%. The dry weights of leaf, stem and root declined by approximately 20-25% under water deficit condition as compared to control irrespective of the stage (Table 1-3). Similar reduction in dry matter was reported in clusterbean (Venkateshwarlu 1984, Kuhad and Sheoran 1986), sunflower (Hall *et al.* 1985) and pigeonpea (Nandwal *et al.* 1991). Water stress is known to affect root growth (Turner and Begg 1981) and number of lateral roots produced (Brown and Lacate 1961).

Growth is one of the best indices for evaluating plant response to environmental stress. The decrease in weight of leaf, stem and root under water stress in clusterbean (Table 1-3) is due to reduced water supply from the rooting medium leading to the loss of turgor and inhibition of assimilatory process. Decline in the leaf weight may also be due to abscission of leaves induced by stress. Root maintained relatively higher dry weight as compared to stem and leaves under normal as well as stress conditions in clusterbean (Table 1-3).

Phosphorus treatment proved effective in improving the dry weight of leaf, stem and root at different sampling stages in clusterbean (Table 1-3). Favourable effect of phosphorus on growth parameters in sugarcane (Nahatkar *et al.* 1995) wheat (Liang *et al.* 1996, Flavio *et al.* 1998) pearlmillet (Payne *et al.* 1991) pigeonpea (Nandwal *et al.* 1991) and soybean (Israel 1987) have also been reported.

Table 1. Effect of water stress and phosphorus application on leaf dry weight (g $plant^{-1}$) in clusterbean.

		Phosphorus levels (mg kg^{-1} soil)				
		0	**15**	**30**	**60**	**Mean**
Vegetative stage	Control	0.28	0.38	0.60	0.71	0.49
	Stress	0.21	0.28	0.46	0.55	0.37
	Mean	0.24	0.33	0.53	0.63	0.43
CD at 5%		**S=0.03, P=0.10, SxP=0.18**				
Flowering stage	Control	0.35	0.44	0.57	0.70	0.51
	Stress	0.26	0.35	0.43	0.54	0.39
	Mean	0.30	0.39	0.50	0.62	0.45
CD at 5%		**S=0.05, P=0.12, SxP=0.20**				
Pod-filling stage	Control	0.47	0.73	0.84	0.98	0.75
	Stress	0.35	0.59	0.68	0.81	0.60
	Mean	0.41	0.66	0.76	0.89	0.67
CD at 5%		**S=0.08, P=0.16, SxP=0.24**				

Table 2. Effect of water stress and phosphorus application on stem dry weight (g plant^{-1}) in clusterbean.

		Phosphorus levels (mg kg^{-1} soil)				
		0	15	30	60	Mean
Vegetative stage	Control	0.10	0.17	0.21	0.28	0.19
	Stress	0.08	0.13	0.17	0.22	0.15
	Mean	0.19	0.15	0.19	0.25	0.17
CD at 5%		**S=0.05, P=0.10, SxP=0.15**				
Flowering stage	Control	0.18	0.25	0.32	0.36	0.27
	Stress	0.14	0.20	0.26	0.29	0.22
	Mean	0.16	0.22	0.29	0.32	0.24
CD at 5%		**S=0.07, P=0.14, SxP=0.17**				
Pod-filling stage	Control	0.28	0.31	0.42	0.53	0.38
	Stress	0.21	0.24	0.35	0.44	0.31
	Mean	0.24	0.27	0.38	0.48	0.34
CD at 5%		**S=0.10, P=0.14, SxP=0.18**				

Table 3. Effect of water stress and phosphorus application on root dry weight (g plant^{-1}) in clusterbean.

		Phosphorus levels (mg kg^{-1} soil)				
		0	15	30	60	Mean
Vegetative stage	Control	0.37	0.43	0.46	0.50	0.44
	Stress	0.29	0.34	0.38	0.41	0.35
	Mean	0.33	0.38	0.42	0.45	0.39
CD at 5%		**S=0.04, P=0.07, SxP=NS**				
Flowering stage	Control	0.43	0.45	0.48	0.52	0.47
	Stress	0.34	0.36	0.39	0.43	0.38
	Mean	0.38	0.40	0.43	0.47	0.42
CD at 5%		**S=0.06, P=0.09, SxP=NS**				
Pod-filling stage	Control	0.46	0.49	0.58	0.65	0.54
	Stress	0.35	0.38	0.46	0.54	0.43
	Mean	0.40	0.43	0.52	0.59	0.43
CD at 5%		**S=0.07, P=0.15, SxP=NS**				

Total chlorophyll content of the leaf declined under water stress condition at all the three sampling stages in clusterbean (Table 4). Similar results have been reported in *Brassica* (Ashraf and Mahmood 1990). It may be due to decreased synthesis and increased degradation of chlorophyll in leaves under water stress (Dekov *et al.* 2000). Treatment with phosphorus improved chlorophyll content in control as well as stressed plants in clusterbean (Table 4). Chlorophyll content increased upto flowering stage and declined at later growth stages. Similar results have been reported by Singh and Singh (1989) in clusterbean.

Table 4. Effect of water stress and phosphorus application on total chlorophyll content (mg g^{-1} dw) in leaf of clusterbean.

		Phosphorus levels (mg kg^{-1} soil)				
		0	**15**	**30**	**60**	**Mean**
Vegetative stage	Control	4.25	4.36	4.47	4.58	4.42
	Stress	3.49	3.62	3.69	3.73	3.63
	Mean	3.87	3.99	4.08	4.16	4.02
CD at 5%		**S=0.25, P=NS, SxP=NS**				
Flowering stage	Control	4.45	4.61	4.67	4.74	4.62
	Stress	3.58	3.71	3.80	3.86	3.74
	Mean	4.02	4.16	4.24	4.30	4.18
CD at 5%		**S=0.21, P=0.29, SxP=0.40**				
Pod-filling stage	Control	4.21	4.25	4.31	4.39	4.29
	Stress	3.40	3.45	3.49	3.53	3.47
	Mean	3.81	3.85	3.90	3.96	3.88
CD at 5%		**S=0.29, P=0.31, SxP=0.42**				

Table 5. Effect of water stress and phosphorus application on proline content (μg g^{-1} dry wt.) in leaf of clusterbean.

		Phosphorus levels (mg kg^{-1} soil)				
		0	**15**	**30**	**60**	**Mean**
Vegetative stage	Control	590.68	586.60	582.32	567.87	581.87
	Stress	1663.50	1567.20	1556.60	1561.87	1587.29
	Mean	1127.09	1076.90	1069.46	1064.87	1084.58
CD at 5%		**S=7.67, P=10.8, SxP=15.3**				
Flowering stage	Control	716.98	693.50	671.52	665.50	686.86
	Stress	2155.60	2063.80	1959.30	1842.70	2005.35
	Mean	1436.25	1378.65	1315.41	1254.10	1346.10
CD at 5%		**S=32.2, P=45.5, SxP=64.4**				
Pod-filling stage	Control	679.30	667.10	651.30	646.24	660.99
	Stress	2039.36	1926.90	1806.80	1779.20	1888.07
	Mean	1359.33	1297.00	1229.05	1212.72	1274.53
CD at 5%		**S=32.09, P=45.38, SxP=64.18**				

There was many fold increase in proline content of leaf under water stress condition at each of sampling stages both in phosphorus treated as well as untreated plants in clusterbean (Table 5). Proline is known to accumulate in plant under water stress (Hsaio 1973). Similar results were reported in pigeonpea (Scotti *et al.* 1999) and wheat (Hamada 2000). Proline accumulation was maximum at flowering stage and minimum at vegetative stage (Table 5). Increase in proline content is effective in increasing osmotic status of the plant. The accumulation of proline decreased the osmotic potential (Ψs) of leaf and it again increased when water stress was relieved followed by simultaneous increase in leaf water potential in chickpea (Gupta *et al.* 2000). Treatments with different phosphorus concentrations were effective in decreasing the proline content at each sampling stage (Table 5).

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