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BRIEF COMMUNICATION

Influence of phosphorus application on water relations, biochemical parameters and gum content in cluster bean under water deficit

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Abstract

Relative water content (RWC), leaf water potential (ψ_w) and osmotic potential (ψ_s), contents of chlorophyll (Chl) *a*, Chl *b*, soluble sugars, and seed quality (gum content) were used to evaluate the role of phosphorus in alleviation of the deleterious effect of water deficit in clusterbean (*Cyamopsis tetragonoloba* L. Taub). Under water stress, ψ_w, ψ_s, and Chl and gum contents decreased and soluble sugar contents increased. Phosphorus application increased Chl and sugar contents in control plants and ameliorated negative effects of water stress.

Additional key words: chlorophyll, *Cyamopsis tetragonoloba*, osmotic and water potentials, relative water content, soluble sugars.

Cluster bean (*Cyamopsis tetragonoloba* L. Taub), locally called guar, is a summer annual legume. It is grown as forage for cattle and as a vegetable for human consumption and thus has great importance. Water relations parameters such as relative water content (RWC), water potential (ψ_w), and osmotic potential (ψ_s) decreased (Kumar and Elston 1993), and total sugar content of leaves increased under water stress in cluster bean (Kuhad and Sheoran 1986), chickpea (Gupta *et al*. 1995), wheat (Hamada 2000) and coconut (Rajgopal and Kasturibai 2000). The accumulation of sugars decreased ψ_s and thus facilitate osmoregulation. Increased reducing sugars/ sucrose ratio has been reported under stress (Pilon *et al*. 1995, Iyer and Caplan 1998). Phosphorus, one of the important macronutrient controlling plant growth and development, is known to play important part in the synthesis of sugars (Pandey 1964). Positive effects of phosphorus application on grain yield and quality as compared to control plants have been reported in cluster-bean (Bhadoria *et al*. 1997, Gora *et al*. 1996). However, very little is known about physiology and biochemistry of cluster bean. Thus, the present investigation was carried out to investigate the role of phosphorus application in amelioration of negative effects of water deficit on growth and development of cluster bean.

A stress tolerant genotype (HG-365) of cluster bean (*Cyamopsis tetragonoloba* L. Taub) was sown under natural conditions in the screenhouse using pots filled with 5 kg dune sand. Irrigation with tap water was provided daily except when nutrient solution was given to the plants. Cluster bean being legume was supplied with nitrogen free nutrient solution (Wilson and Reisenauer 1963) at regular interval of 15 d. Phosphorus in the form of KH_2PO_4 (75, 150 and 300 mg per pot), was supplied in two split doses at weekly intervals. Water stress was created by withholding irrigation until the plant reached permanent wilting point (soil moisture content 3.5 ± 0.5 %). The control plants were kept at field capacity (soil moisture content 10 ± 0.5 %). Sampling was carried out at three growth stages (vegetative, flowering and pod-filling stages). RWC and ψ_w were determined acccording to Weatherley (1950) and Scholander *et al*. (1955), respectivelv. Leaf ψ_s was determined by vapour pressure osmometer *Model 5100-B* (*Wescor*, Logan, USA). These three parameters were measured in third fully expanded leaf from the top. Total content of soluble sugars and contents of chlorophyll (Chl) *a* and Chl *b* were determined by method of Dubois *et al*. (1956) and Hiscox and

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Abbreviations: Chl - chlorophyll; RWC - relative water content; ψ_s - osmotic potential; ψ_w - water potential.
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Israelstam (1979), respectively. Gum content, the most important attribute of seed quality, was determined by methods of Das *et al.* (1977). Various parameters were observed in three replicates and results were statistically analysed by using factorial complete randomized design (CRD). Critical difference (CD) was calculated at 5 % level of significance.

Among different growth stages, highest RWC was observed at vegetative and lowest at pod-filling stage. RWC decreased significantly under water deficit stress from 85.1 % (control) to 69.1 % (water deficit) at vegetative stage (Table 1). Similar decrease in RWC under water stress was seen at other two plant growth stages as compared to control. However, decline in RWC under stress was less with phosphorus treatments (Table 1). RWC increased from approximately 4 - 8 % in control plants, and approximately 10 - 16 % under water stress by phosphorus treatment at successive growth stages (Table 1). Water stress induced decrease in RWC had been reported in cluster bean (Kuhad and Sheoran 1986), pigeon pea (Dayal *et al*. 1993) and chickpea (Singh 1995). Phosphorus increased RWC under stress in wheat (Basak and Dravid 1997) and cherry (Centritto *et al*. 1999).

Under water stress at vegetative stage, ψ_w decreased from -0.29 (control) to -0.86 MPa. Decrease in ψ_w under stress was less under phosphorus treatments (Table 1). P treatment increased ψ_w from -0.29 to -0.23 in plants sufficiently supplied with water. Increased ψ_w due to P treatment was observed also under stress (Table 1). Similarly, P treatment led to improvement of ψ_w in chickpea (Gupta *et al*. 1995). Osmotic potential decreased under water stress in both P treated and untreated plants

Table 1. Effect of water stress and phosphorus application on RWC [%], and water (ψ_w), and osmotic (ψ_s) potentials [-MPa] in cluster bean at different growth stages.

Treatment	P content	Vegetative RWC	ψ_w	ψ_s	Flowering RWC	ψ_w	ψ_s	Pod-filling RWC	ψ_w	ψ_s
Control	P_0	85.10	0.29	1.03	81.86	0.18	0.79	79.45	0.22	0.86
	P_1	86.89	0.27	1.04	83.87	0.16	0.80	81.00	0.21	0.87
	P_2	87.42	0.24	1.06	85.89	0.13	0.82	83.89	0.19	0.89
	P_3	90.05	0.23	1.07	88.44	0.12	0.83	87.00	0.18	0.90
Stress	P_0	69.10	0.86	1.24	61.24	0.57	0.94	55.65	0.64	1.05
	P_1	76.55	0.79	1.25	65.56	0.50	0.95	58.82	0.61	1.06
	P_2	83.82	0.70	1.27	68.37	0.47	0.97	63.60	0.55	1.07
	P_3	87.11	0.67	1.28	71.72	0.45	0.98	67.43	0.53	1.08
CD at 5 %	S	2.06	0.23	0.36	3.78	0.27	0.38	6.50	0.26	0.31
	P	2.91	0.34	0.37	5.35	0.42	0.40	n.s.	0.44	0.46
	S × P	4.12	0.60	0.48	n.s.	0.71	0.56	n.s.	0.50	0.52

Table 2. Effect of water stress and phosphorus application on contents of total soluble sugars [mg g^{-1}(d.m.)], Chl *a* and Chl *b* [μg g^{-1}(d.m.)] in leaf of clusterbean.

Treatment	P content	Vegetative sugars	Chl *a*	Chl *b*	Flowering sugars	Chl *a*	Chl *b*	Pod-filling sugars	Chl *a*	Chl *b*
Control	P_0	25.26	2.82	1.43	36.05	3.03	1.42	20.48	2.72	1.49
	P_1	29.20	2.86	1.50	38.34	3.12	1.49	21.60	2.75	1.50
	P_2	30.82	2.90	1.57	40.45	3.16	1.51	22.70	2.79	1.52
	P_3	32.70	3.03	1.55	43.63	3.24	1.50	24.16	2.90	1.48
Stress	P_0	28.86	2.11	1.38	38.78	2.18	1.40	22.31	1.96	1.44
	P_1	32.06	2.16	1.46	41.20	2.29	1.42	23.80	2.00	1.45
	P_2	33.00	2.21	1.48	42.30	2.36	1.44	25.11	2.03	1.46
	P_3	35.20	2.26	1.47	45.50	2.46	1.41	26.61	2.10	1.43
CD at 5 %	S	2.48	0.41	0.20	n.s.	0.43	0.27	n.s.	0.59	n.s.
	P	3.51	0.63	0.24	n.s.	0.47	0.29	n.s.	0.51	n.s.
	S × P	n.s.	0.61	n.s.	n.s.	0.51	n.s.	n.s.	0.62	n.s.

irrespective of growth stages. Decrease in ψ_s due to P treatment was 2 - 3 %. Higher values of RWC, ψ_w, and ψ_s at vegetative stage indicated more vigorous plants than in following stages.

Soluble sugars accumulated under water stress in both P treated and untreated plants (Table 2). Highest accumulation of soluble sugars was seen at flowering stage and lowest at pod-filling stage under water stress. Content of soluble sugars increased from 25.26 mg g^{-1}(d.m.) in P untreated plants to 32.70 mg g^{-1}(d.m.) in P treated plants under control conditions at vegetative stage (Table 2). Similar increase in total content of soluble sugars was found at other two stages as well. Under water stress, P treatment helped in further accumulation of sugars (Table 2). Such accumulation of sugars can be due to inhibition of their normal utilization and translocation during water stress or due to hydrolysis of starch (Levitt and Clark 1956). Soluble sugar accumulation resulted in decreased ψ_s which facilitated osmoregulation (Table 2). Accumulation of soluble sugars due to P treatment was in agreement with the results of Pandey (1964).

Chl *a* and Chl *b* contents decreased significantly under water stress in both P treated and untreated plants at all the three growth stages. Highest Chl content occurred at flowering stage and minimum at pod-filling stage (Table 2). P treatment increased Chl *a* content only about 4 - 7 %. Decrease in Chl *a* and Chl *b* contents under water stress were less in P treated plants. Reduction in Chl contents might be due to accelerated leaf senescence which is very common under any kind of stress.

One of important seed quality parameters in cluster bean is gum content which decreased under water stress in P treated and untreated plants. Pod-filling stage was most susceptible to water stress, as reduction in gum content was maximum. Gum content increased by P application in control as well as water-stressed plants at different growth stages (data not given). These results are in conformity with those obtained by Garg *et al.* (1998) and Bhadoria and Tomar (1997) in cluster bean. This may be due to the fact that P enhanced the polysaccharide synthesis in seeds.

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