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Role of potassium fertilizer on nitrogen fixation in Chickpea (*Cicer arietinum* L.) under quantified water stress

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Two genotypes of chickpea H-82-2 and H-208 were investigated for the role of potassium on nitrogen fixation in alleviating water stress. Crop was raised in earthen pots and potassium was added to the soil as muriate of potash in different concentrations i.e. 60, 90 and 120 ppm in addition to the existing level. Water stress was created by withholding irrigation at different sampling stages i.e. vegetative, 50% flowering and 50% pod formation. Water stress resulted in marked decrease in leghemoglobin, nitrate (NO_3^-) and nitrite (NO_2^-) contents and the activity of enzymes of nitrogen assimilation i.e. nitrate reductase (NRA) and nitrite reductase (NiRA) in both the genotypes. The nitrogen fixation were least affected when crop was stressed at the vegetative stage. Flowering stage proved most sensitive to water stress where reduction in leghemoglobin, NO_3^- and NO_2^- content and NRA and NiRA activity was maximum. The reduction was relatively more in H-208 genotype as compared to H-82-2. There was a corresponding increase in nitrogen fixation and its attributes with the increase in the potassium level. The response of applied potassium was relatively more in H-208 than H-82-2 under water stress conditions.

Key words: Water stress, Cicer arietinum, Potassium, Leghemoglobin,Nitrogenase,Nitrate reductase.

Introduction

Food legumes contribute significantly to dietary protein supply and fixation of atmospheric nitrogen (Ali and Kumar, 2009). Legumes are also important sources of micro and macro-nutrients as well as health promoting secondary metabolites (White and Brown, 2010). Therefore, these crops have become important targets for agricultural, environmental and biotechnological research. Among food legumes, chickpea (*Cicer arietinum* L.) is one of the major annual crops of our country grown onto the extent of twenty percent of the total cultivated area under semi arid conditions. About 85-90% of the pulses

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are grown under rain fed conditions and only 10-15% area under pulses is irrigated. Most of the tropical grain legumes experience frequent drought of varying degree and duration during their growing period. Water is one of the major environmental factors, affecting almost all aspects of plant growth and metabolism (Kramer, 1983). Moisture deficit hampers physiological processes related to yield. The prominent effects of water stress on the crops are reduction in plant growth, nodulation, photosynthesis and water relations (Kuhad and Sheoran, 1987; Schinermann *et al*., 1991; Maribona *et al*., 1992). Under such adverse climatic conditions, potassium has been suggested to play an important role in different physiological and biochemical processes such as plant water relations, stomatal movement, osmoregulation, CO_2-exchange, carbon and nitrogen metabolism, transpiration, protein synthesis, enzyme activation growth and yield of plant (Sinha, 1978; Singh and Kuhad, 2005; Sharma *et al*., 2008).

Potassium influences the water economy and crop growth through its effects on water uptake, root growth, maintenance of turgor, transpiration and stomatal regulation (Nelson, 1980). Although potassium unlike N and P, does not enter into the composition of any product, yet literature on K reveals that it has an important role either direct or indirect, under different environments, in major plant processes such as photosynthesis, respiration, protein synthesis, enzyme activation, water uptake, osmoregulation, growth and yield of plant (Li *et al.,* 1989; Sharma *et al.,* 1992*;* Zaidi *et al.,* 1994, Singh *et al.,* 1997). This shows the importance of potassium in legume nutrition. However, the work done on legumes with potassium application is not well recognized in comparison to cereals and other crops (Tandon, 1992). Therefore, the present study was carried out to investigate the effect of potassium on nodulation and nitrogen fixation in chickpea under water stress condition.

Material and methods

Two promising genotypes of chickpea: H- 82-2 and H-208, selected for the present study, were raised in earthen pots (30 cm diameter) lined with polythene having 5.0 kg of dune sand. These pots were placed in a net house under natural conditions and sowing was carried out at field capacity of soil. Potassium was added to the soil after germination in the form of muriate of potash at 0, 60, 90 and 120 ppm concentration in addition to the existing levels of potassium (50 ppm) in the soil medium.

Water stress was created at 5.5 ± 0.5% of soil moisture content (SMC) by withholding irrigations at three sampling stages i.e. vegetative (30 DAS), 50% flowering (55 DAS) and 50% pod formation (80 DAS) stage . The control plants were maintained at 12 ± 0.5% of SMC which was 50 % of soil saturation

percentage . Half of the stressed plants were re-irrigated and sampled after two days to see the revival of stress. Each pot was supplied with equal quantity of nitrogen free nutrient solution (Wilson and Reisenauer, 1963) at a regular interval at 7-10 days. Two plants in each pot, replicated four times were sampled for various traits under moisture stress and on revival along with control. Nitrogenase activity (Hardy *et al.,* 1968), Leghemoglobin content (Hartree, 1955), Nitrate reductase activity (NRA) (Jaworski, 1971), Nitrite reductase activity (NiRA) (Ferrari and Varner 1971), Nitrate and Nitrite content (Woolley *et al.,* 1960) of nodules were estimated at different sampling stages. Data analysis was done using three factorial complete randomized design.

Results

Leghemoglobin content of nodules decreased under water stress in both the cultivars at all the sampling stages. The reduction was higher at pod formation than the other stages (Table 1). The leghemoglobin content increased when the plants were revived after stress; but the level remained lower than the control. Application of K resulted in a significant increase in the leghemoglobin content. Cultivar H-82-2 exhibited higher leghemoglobin content than cv. H-208.

Nitrogenase activity get inhibited under water stress at all stages in both the cultivars (Table 2). Maximum nitrogenase activity in control and stressed plants was observed at flowering stages and least at pod formation stage. Revived plants showed partial recovery at vegetative and flowering stage whereas, at pod formation stage revived plants showed further decline in the specific nitrogenase activity. Increased level of K resulted in increased nitrogenase activity under control in both the cultivars.

Nitrate reductase activity (NRA) was highest at flowering stage in both the cultivars. Decrease in NRA activity was noted under water deficit condition (Table 3). The decrease was more at pod formation stage compared to other sampling stages. K treatment significantly increased the NRA activity at all the stages. Nitrite reductase activity (NiRA) reduced under water stress in both the cultivars (Table 4). Highest activity of nitrite reductase was observed at flowering stage. Increase in NiRA activity was observed under the treatment of K in both the cultivars. Cultivar H-82-2 exhibited higher nitrogenase, NRA and NiRA activity over cv. H-208 irrespective of sampling stages and potassium treatment.

Nitrate content (NO_3^-) was maximum at pod formation stage in both the cultivars. A significant reduction in the nitrate content was observed under water deficit. However, on revival from stress, NO_3^- content increased but the level remained below that of control. Application of K resulted in a significant

increase in the nitrate content of nodules under control and stress conditions at all stages. Water stress significantly reduced the nitrite content (NO_2^-) of nodules in both the cultivars (Table 6). The magnitude of reduction was highest at pod formation stage. Highest NO_2^- contents were observed at flowering stage. On revival from stress, the NO_2^- content improved at all stages. NO_2^- content increased under the influence of K. Cultivar H-82-2 exhibited higher nitrate content and nitrite content.

Discussion

In most of the legumes, a common pattern of nitrogen fixation has been observed according to which there is an initial increase during vegetative growth, becoming maximum at flowering and then declining as the plants mature (Lawn and Brun, 1974; Herridge and Pale, 1977; Young, 1982). The present findings are also in accordance with these reports. Nitrogenase activity get inhibited under water stress at all stages in both the cultivars (Table 2, 3). Highest nitrogenase activity in control and stressed plants was observed at flowering stage and least at pod formation stage. The decline in total nitrogenase activity (TNA) after flowering might have been either due to non-availability or non-utilization of photosynthates in nodules. This may be due to greater mobilization of current photosynthate for pod formation and seed filling. Moreover, nodules might have also become non-functional due to ageing and senescence (Hooda, 1987). The limitation of nitrogen fixation by inadequate supply of photosynthate to nodules during reproductive period of the plants has been reported in soybean (Ciha and Brun, 1978; Lawn and Brun, 1974), clover (Dejong and Phillips, 1982) and pigeon pea (Luthra *et al*., 1983).

Contrary to these reports, depression of nitrogen-fixation during reproductive period has been attributed to some factors other than photosynthesis (Peat *et al*., 1981; Nelson *et al*., 1984). Total nitrogenase activity as well as specific nitrogenase activity (SNA) were reduced under water stress condition in both the cultivars (Table 2 and 3). The nitrogen fixation was more sensitive to water stress during pod formation and the water stress could actuate the late season decline in nitrogen fixation as has already been reported by Cure *et al*. (1985). Such inhibitory effect of water stress on nitrogen fixation have long been reported (Kuhad and Sheoran, 1982; Bennett *et al*., 1985; Nandwal *et al*., 1991; Mukane *et al*., 1993). Further, the experimental results indicate that effect of decrease in leaf $\square_w$ was reflected on inhibition in nitrogenase activity through photosynthetic rate under soil moisture deficit. Likewise, Durand *et al.* (1987) showed that water stress exerts an influence on nitrogenase activity, which is independent of rate of photosynthesis. It was also suggested that $\square_w$ of nodule is more important than

reduced supply of photosynthesis (Nandwal *et al*., 1991). Both the nodule respiration and nitrogen fixation reduced under water stress condition but decrease in respiration was not to the same extent as the decrease in TNA. This again indicates that it is not the availability of photosynthate which limit nitrogen fixation but some other direct effect may be involved. Nandwal *et al*. (1991) reported that it may be soluble nitrogen content of nodules which influence the nitrogenase activity depending upon its utilization and accumulation in addition photosynthesis which are responsible for decline in nitrogenase activity under water stress condition. During revival, low recovery of TNA and SNA was seen but the cultivars showed differences in between. The SNA decreased on revival at pod formation stage because the nodules might have became non-functional due to ageing and senescence. The major reason for failure to recover the plants from water stress was that at a particular soil depth in the pots, the level of water content was different for nodules which suffered different degree of water deficit depending on their position on the root system. Application of K maintained higher nitrogenase activity under water stress condition in both the cultivars. Response to applied K was higher in H-208 than H- 82-2 under stress conditions.

Leghemoglobin, nitrate (NO_3^-) and nitrite (NO_2^-) contents and the activity of enzymes of nitrogen assimilation i.e. nitrate reducatase and nitrite reductase exhibit the highest value at flowering stage and declined subsequently at later stage of growth (Table 1, 4, 5, 6, 7). Water stress resulted in the marked reducation of leghemoglobin, NO_3^- and NO_2^- content and NRA and NiRA in both the cultivars. The reduction was maximum at pod formation stage under water deficit condition. The extent of reduction under water deficit was relatively higher in NRA followed by NiRA, NO_3^- and NO_2^- content. The leghemoglobin, NO_3^- and NO_2^- content and NRA and NiRA increased when the plants were revived after stress but the level remained below the control. The recovery was less at pod formation stage. This might be due to the decaying and senescence of nodules under water stress at pod formation stage. Similar results were obtained by Swaraj *et al*. (1984), Khanna-Chopra *et al*. (1984), Mukane *et al*. (1993) Singh *et al*. (1993). There was a decrease in leghemoglobin content during water stress in *Medicago sativa* (Becana *et al*., 1986). It was due to a general inhibition of protein synthesis and to an increased proteolytic activity in nodule cytosol rather than to a specific proteolysis of leghemoglobin. The functional enzyme met-hemoglobin reductase was found to be quite sensitive to water stress (Swaraj *et al*., 1984). Srivastava (1980) reported that water stress may decrease the NRA activity either by inhibiting nitrate uptake or protein synthesis. In an intact plant reduced transpiration pull

during water stress may cause a decline in nitrate flux into the tissue which has been confirmed by the present findings.

Application of potassium resulted in the increased leghemoglobin, NO_3^- and NO_2^- contents and NRA and NiRA, TNA and SNA in control as well as under water deficit conditions in both the cultivars (Table 1, 2, 3, 4, 5, 6, 7). The response of applied K under water stress was better in cv. H-208. In *Vicia faba*, potassium application increased the nodule size, biomass, nitrogen fixation and N- turnover due to increase in translocation of photosynthates (labelled-^{14}C- sugars and amino acids) from leaves to the nodules at vegetative stage and enhanced nitrogenase activity (Mengel *et al*., 1974; Sprent, 1979). It was further reported that this improved supply of carbohydrates to nodules resulting in an enhanced turnover of tricarboxylic acid cycle in bacteroides, thus providing higher rate of ATP and reducing electrons to nitrogenase. Similarly, the dry matter yield, nodule parameters and total nitrogen accumulation in the plant increased with increasing K supply (Premaratne and Oertli, 1994). In another study on beans, nitrogenase activity increased in proportion to K fertilization especially during the early stages of growth. Potassium had a significant effect on nodule number and nodule dry weight (Parthipan and Kulasooriya, 1989; Jones *et al.,* 1977). In the present study also, the number and the dry weights of nodules increased with the increase in concentration of potassium (data not given). Tanha (1971) showed that nodules of the plant, with an improved K status, fixed about twice the amount of nitrogen in comparison to nodules of the plant with lower K status. This effect was mainly due to higher nitrogen fixation and to a lesser degree to improved nodulation (Khanna-Chopra *et al*., 1980). Foliar spray of K on stressed plants lead to recovery of turgidity and higher NRA (Sinha, 1978). Also Khanna-Chopra *et al*. (1980) reported that application of K helped in offsetting the decrease in NRA under water stress condition. It may be resumed that K being responsible for water retention in cell may check the dehydration of the enzyme system which subsequently induced the stabilized NRA level (Umar *et al*., 1991). Similarly, Khan (1991) showed that increasing level of K resulted in an increased NRA over control irrespective of stress levels.

As the results indicate that potassium help in improving nodulation and nitrogen fixation in chickpea, there was a possibility that potassium may also help in increasing the functional life span by translocating sufficient amount of photosynthates to the root nodules, particularly after flowering stage, because nitrogen fixation got reduced with simultaneous decrease in leghemoglobin content of nodules. In this way, potassium helped to maintain sufficient rates of nitrogen fixation and N- partitioning to meet the requirement of two active sinks i.e. reproductive parts and the nodules at the same time.

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Table 1. Interaction of drought and applied K on leghemoglobin content (mg g^{-2} FW) of nodules

Varieties	Stress Level	Vegetative Stage K (ppm)					Flowering Stage K (ppm)					50% pod fomation K (ppm)				
		0	60	90	120	Mean	0	60	90	120	Mean	0	60	90	120	Mean
H-82-2	Control	2.12	2.18	2.48	2.54	2.33	3.08	3.23	3.69	3.85	3.46	1.49	1.56	1.77	1.84	1.66
	Stress	1.63	1.67	1.95	2.10	1.83	2.25	2.43	2.81	2.97	2.61	0.47	0.66	0.80	0.98	0.72
	Revival	1.84	1.89	2.15	2.18	2.01	2.67	2.75	3.15	3.20	2.94	0.56	0.75	0.88	0.96	0.78
	Mean	1.86	1.91	2.19	2.27		2.66	2.80	3.21	3.34		0.84	0.99	1.15	1.26	
H-208	Control	2.01	2.08	2.23	2.35	2.16	2.93	3.04	3.26	3.39	3.15	1.25	1.28	1.42	1.49	1.36
	Stress	1.42	1.46	1.53	1.60	1.50	1.94	1.98	2.16	2.23	2.07	0.37	0.40	0.49	0.56	0.45
	Revival	1.58	2.62	1.75	1.83	1.69	2.57	2.62	2.81	2.89	2.72	0.43	0.48	0.56	0.61	0.52
	Mean	1.67	1.72	1.83	1.92		2.48	2.54	2.74	2.83		0.68	0.72	0.82	0.88	
	C.D. at 5% level															
		V =	0.19	V x S= 0.33			V =	0.14	V x S = 0.25			V =	0.02	V x S =0.03		
		S =	0.23	V x K = 0.38			S =	0.17	V x K = 0.28			S =	0.28	V x K=0.03		
		K =	0.27	S xK = NS			K =	0.20	S x K = 0.35			K =	0.03	S x K =0.04		
			V x S x K = NS					V x S x K = 0.50					V x S x K = NS			

V = Variety ; S = Stress Levels ; K = Potassium Conc.

Table 2. Interaction of drought and applied K on total nitrogenase activity (μ mol C_2H_4 evolved $plant^{-1}h^{-1}$)

Varieties	Stress Level	Vegetative Stage K (ppm)					Flowering Stage K (ppm)					50% pod formation K (ppm)				
		0	60	90	120	Mean	0	60	90	120	Mean	0	60	90	120	Mean
H-82-2	Control	5.74	5.91	6.71	6.88	6.31	13.51	14.18	16.21	16.88	15.19	3.15	3.27	3.71	3.81	3.48
	Stress	1.36	1.44	1.63	1.75	1.54	2.25	2.43	2.81	2.97	2.61	0.96	1.00	1.16	1.22	1.08
	Revival	3.08	3.17	3.60	3.66	3.37	6.94	7.14	8.18	8.32	7.64	1.89	1.92	2.19	2.23	2.05
	Mean	3.39	3.51	3.98	4.06		7.56	7.91	9.06	9.39		2.00	2.06	2.35	2.42	
H-208	Control	5.13	5.38	6.25	6.41	5.79	12.10	13.06	15.12	15.73		2.97	3.14	3.56	3.65	3.33
	Stress	1.02	1.11	1.28	1.34	1.18	1.98	2.21	2.67	2.81		0.81	0.89	1.05	1.07	0.95
	Revival	2.86	3.00	3.40	3.48	3.18	6.17	6.54	7.52	7.71		1.63	1.71	1.95	2.00	1.82
	Mean	3.00	3.16	3.64	3.74		6.75	7.27	8.43	8.75		1.80	1.91	2.18	2.24	
	C.D. at 5% level															
		V =	0.16	V x S=0.28			V =	0.12	V x S = 0.21			V =	0.02	V x S =0.03		
		S =	0.19	V xK=0.32			S =	0.15	V x K = NS			S =	0.03	V x K = NS		
		K =	0.23	S xK =0.39			K =	0.17	S x K = 0.30			K =	0.02	S x K =0.04		
			V x S x K = 0.56					V x S x K = NS					V x S x K = NS			
	V = Variety ; S = Stress Levels ; K = Potassium Conc.															

Table 3. Interaction of drought and applied K on specific nitrogenase activity (μ mol C_2H_4 g^{-1} nodule dry wt h^{-1})

Varieties	Stress Level	Vegetative Stage K (ppm)					Flowering Stage K (ppm)					50% pod formation K (ppm)				
		0	60	90	120	Mean	0	60	90	120	Mean	0	60	90	120	Mean
H-82-2	Control	48.33	49.59	56.31	57.75	53.12	57.25	59.99	68.56	71.42	64.30	16.52	12.18	19.49	19.98	18.29
	Stress	5.91	6.26	7.09	7.62	6.72	7.23	7.80	9.03	9.54	8.40	1.89	1.98	2.28	2.41	2.14
	Revival	20.08	20.68	23.49	23.89	22.03	24.19	24.91	28.54	29.02	26.66	1.04	1.06	1.20	1.22	1.13
	Mean	24.94	25.51	28.96	29.75		29.55	30.90	35.37	36.66		6.49	6.74	7.65	7.87	
H-208	Control	40.55	42.57	49.06	50.68	45.71	47.25	51.03	59.06	61.42	54.69	14.43	15.29	17.31	17.74	16.19
	Stress	4.11	4.47	5.17	5.42	4.79	5.84	6.54	7.88	8.29	7.13	1.61	1.77	2.04	2.14	1.89
	Revival	17.62	18.50	20.96	21.49	19.64	19.16	20.30	23.37	23.95	21.69	0.95	0.99	1.14	1.16	1.06
	Mean	20.76	21.84	25.06	25.86		24.08	25.95	30.10	31.22		5.66	6.01	6.83	7.01	
C.D. at 5% level																
		V = 0.26	V x S = 0.45				V = 0.34	V x S = 0.60				V = 0.72	V x S = 1.24			
		S = 0.32	V x K = 0.NS				S = 0.43	V x K = NS				S = 0.87	V x K = 1.43			
		K = 0.37	S xK = 0.64				K = 0.49	S x K = 0.85				K = 1.01	S x K = 1.76			
		V x S x K = NS					V x S x K = NS					V x S x K = 2.48				

V = Variety ; S = Stress Levels ; K = Potassium Conc.

Table 4. Interaction of drought and applied K on nitrate reductase activity (µg NO_2 produced g^{-1} fresh wt h^{-1}) of nodules of chickpea

Varieties	Stress Level	Vegetative Stage K (ppm)					Flowering Stage K (ppm)					50% pod formation K (ppm)				
		0	60	90	120	Mean	0	60	90	120	Mean	0	60	90	120	Mean
H-82-2	Control	67.5	82.9	101.1	104.7	88.9	86.1	113.0	138.2	140.5	119.5	82.0	105.0	129.5	130.4	111.7
	Stress	37.1	46.3	59.1	62.0	51.1	40.1	53.3	67.8	69.6	57.7	33.7	43.6	55.1	55.7	47.0
	Revival	60.1	75.5	93.6	97.1	81.6	76.3	101.8	126.2	129.0	108.3	61.9	80.1	100.4	101.1	85.9
	Mean	55.0	68.2	84.6	88.0		67.5	89.4	110.7	113.0		59.2	76.2	95.0	95.7	
H-208	Control	61.1	73.4	88.7	91.7	79.7	77.3	99.5	122.0	123.7	105.6	74.7	93.3	115.7	116.5	100.0
	Stress	31.8	38.8	49.0	51.2	42.7	34.4	45.0	57.1	58.5	48.7	29.3	37.2	47.6	48.1	40.5
	Revival	54.2	66.1	82.1	94.9	71.8	68.2	89.5	111.2	113.3	95.5	55.5	70.4	88.0	88.6	75.6
	Mean	49.0	59.4	73.2	76.2		60.0	78.0	96.8	98.5		53.1	67.0	83.8	84.4	
	C.D. at 5% level															
		V = 4.37	V x S = 5.21				V = 3.59	V x S = 4.71				V = 4.27	V x S = 6.24			
		S = 3.54	V x K = 3.68				S = 6.28	V x K = 3.94				S = 5.62	V x K = 4.35			
		K = 2.10	S xK = 1.71				K = 5.33	S x K = 5.10				K = 7.13	S x K = 5.13			
		V x S x K = NS					V x S x K = 2.69					V x S x K = 4.11				

Table 5. Interaction of drought and applied K on nitrite reductase activity (µg NO_2 produced g^{-1} fresh wt h^{-1}) of nodules

Varieties	Stress Level	Vegetative Stage K (ppm)					Flowering Stage K (ppm)					50% pod formation K (ppm)				
		0	60	90	120	Mean	0	60	90	120	Mean	0	60	90	120	Mean
H-82-2	Control	21.80	24.41	30.52	31.61	27.08	27.61	33.40	41.41	42.24	36.16	26.09	30.78	38.61	38.87	33.58
	Stress	13.05	14.88	19.56	20.52	17.00	14.15	17.39	22.50	23.20	19.31	11.69	13.92	17.95	18.16	15.43
	Revival	19.46	22.09	27.85	29.00	24.60	24.54	30.00	37.67	38.57	32.69	19.91	23.76	30.40	30.48	26.13
	Mean	18.10	20.46	25.97	27.04		22.10	26.93	33.86	34.67		19.23	22.82	28.98	29.17	
H-208	Control	19.76	21.73	26.77	27.66	23.95	24.82	29.46	36.98	37.23	32.04	23.50	27.02	34.07	34.31	29.72
	Stress	11.16	12.48	16.06	16.86	14.14	12.10	14.62	19.00	19.49	16.30	10.03	11.69	15.27	15.45	13.11
	Revival	17.56	19.61	24.26	25.28	21.67	21.96	26.42	33.19	33.84	28.85	17.66	20.62	26.20	26.39	22.71
	Mean	16.16	17.94	22.33	23.26		19.62	23.50	29.62	30.18		17.06	19.77	25.18	25.38	
	C.D. at 5% level															
		V =	0.96	V x S =	1.78		V =	1.11	V x S =	1.27		V =	1.34	V x S =	0.86	
		S =	2.15	V x K =	0.77		S =	1.86	V x K =	0.98		S =	2.21	V x K =	1.20	
		K =	0.85	S xK =	NS		K =	1.05	S x K =	1.08		K =	2.06	S x K =	NS	
			V x S x K =		0.54			V x S x K =		0.71			V x S x K =		0.83	

V = Variety ; S = Stress Levels ; K = Potassium Conc.

Table 6. Interaction of drought and applied K on nitrate (NO_3) content ($\mu g\ g^{-1}$ DW) of nodules.

Varieties	Stress Level	Vegetative Stage K (ppm)					Flowering Stage K (ppm)					50% pod formation K (ppm)				
		0	60	90	120	Mean	0	60	90	120	Mean	0	60	90	120	Mean
H-82-2	Control	51.33	56.46	64.16	66.72	59.66	72.40	83.26	94.12	97.74	86.88	69.19	77.44	87.22	91.26	81.41
	Stress	30.19	33.60	38.87	40.68	35.83	36.20	42.05	48.26	50.64	44.28	30.32	34.41	39.38	41.10	36.30
	Revival	45.83	50.63	57.80	60.10	53.89	64.35	74.67	84.79	88.05	77.96	52.78	59.56	67.81	70.47	62.25
	Mean	42.45	46.89	53.61	55.83		57.65	66.66	75.72	78.81		50.75	57.13	65.00	67.61	
H-208	Control	49.15	54.06	58.97	61.43	55.90	68.27	77.82	85.33	88.75	80.04	65.43	73.28	79.82	82.44	75.24
	Stress	27.30	30.21	33.69	35.71	31.72	32.50	35.59	41.81	43.50	38.35	27.26	31.05	34.40	35.84	32.13
	Revival	43.68	48.26	52.88	55.09	49.97	60.41	69.48	76.52	79.59	71.50	49.19	55.51	60.69	62.93	57.08
	Mean	40.04	44.17	48.51	50.74		53.72	60.96	67.88	70.61		47.29	53.28	58.30	60.40	
	C.D. at 5% level															
		V =	1.24	V x S = 2.17			V =	2.05	V x S =1.74			V =	1.38	V x S = 2.65		
		S =	0.98	V x K = 1.64			S =	1.39	V x K = 0.92			S =	2.54	V x K = 1.54		
		K =	1.35	S xK = 0.83			K =	2.14	S x K = 1.65			K =	3.16	S x K = 1.49		
			V x S x K = NS					V x S x K = 0.99					V x S x K = 1.87			

V = Variety ; S = Stress Levels ; K = Potassium Conc.

Table 7. Interaction of drought and applied K on nitrite (NO_2) content ($\mu g\ g^{-1}$ DW) of nodules of chickpea

Varieties	Stress Level	Vegetative Stage K (ppm)					Flowering Stage K (ppm)					50% pod fomation K (ppm)				
		0	60	90	120	Mean	0	60	90	120	Mean	0	60	90	120	Mean
H-82-2	Control	0.673	0.720	0.821	0.854	0.767	0.841	0.933	1.059	1.101	0.983	0.805	0.877	0.998	1.038	0.929
	Stress	0.420	0.455	0.529	0.554	0.489	0.442	0.496	0.572	0.601	0.527	0.369	0.407	0.468	0.489	0.433
	Revival	0.598	0.642	0.736	0.765	0.685	0.744	0.833	0.920	0.987	0.871	0.612	0.672	0.767	0.798	0.712
	Mean	0.563	0.605	0.695	0.724		0.675	0.754	0.850	0.896		0.595	0.652	0.744	0.775	
H-208	Control	0.594	0.635	0.694	0.724	0.661	0.750	0.825	0.907	0.945	0.856	0.709	0.772	0.843	0.872	0.799
	Stress	0.349	0.375	0.420	0.446	0.397	0.375	0.418	0.467	0.486	0.436	0.308	0.341	0.379	0.396	0.356
	Revival	0.525	0.564	0.619	0.646	0.588	0.660	0.733	0.809	0.843	0.761	0.531	0.582	0.638	0.663	0.603
	Mean	0.489	0.524	0.577	0.605		0.595	0.658	0.727	0.758		0.516	0.565	0.620	0.643	
	C.D. at 5% level															
		V =	0.12	V x S = 0.34			V =	0.10	V x S = 0.28			V =	0.09	V x S = 0.36		
		S =	0.53	V x K = 0.26			S =	0.35	V x K = 0.18			S =	0.18	V x K = 0.14		
		K =	0.08	K xS = 0.07			K =	0.11	K x S = 0.10			K =	0.10	K x S = 0.13		
			V x S x K = NS					V x S x K = 0.05					V x S x K = NS			

V = Variety ; S = Stress Levels ; K = Potassium Conc.