BRIEF COMMUNICATION

Effect of substrate moisture and potassium on water relations and C, N and K distribution in *Vigna radiata*

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Abstract

The *Vigna radiata* L. plants were grown in greenhouse at moisture content of sand (SMC) of 12.0 ± 0.5 %. At flower bud initiation stage, *i.e.* 45 - 50 d after sowing, the SMC was decreased to 3.5 ± 0.5 %, and the effects of applied potassium (0, 2.56 and 3.84 mmol dm^{-3}) were studied. During water stress, K-fed plants maintained higher leaf water potential and relative water content (RWC) of leaves and nodules and lower osmotic potential as compared to untreated plants. The proline content was higher in nodules than in leaves showing their difference in degree of stress. A partial recovery was found after re-irrigation. When subjected to drought, carbon was accumulated in the leaves and declined in nodules and roots. K-fed plants showed higher C and N content in stem, roots and nodules than untreated plants. The content of K significantly increased in stem and nodules in K-fed plants, irrespective of SMC. Dry masses of different plant parts were also increased in K-fed plants.

Additional key words: drought, mungbean, proline, rehydration.

The major factor limiting crop yield in arid or semiarid region is the amount of soil moisture available to crop during the growing season. Water stress affects almost all aspects of plant growth and development. The importance of potassium in plant nutrition is also well recognised. The effect of K on water relations and stress metabolites has been mainly studied in cereals and little is known about legumes, particularly mungbean which is generally grown under rainfed conditions. The aim of these experiments was to determine, if added K ameliorates the negative effect of drought on water relations and organic and inorganic solute accumulation in different plant parts of mungbean.

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Abbreviations: ψ_s - osmotic potential; ψ_w - water potential; RWC - relative water content; SMC - sand moisture content.

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The plants of mungbean (*Vigna radiata* L. Wilczek) cv. MH-83-30 were raised in earthen pots (30 cm in diameter) filled with 5.0 kg of dune sand in the greenhouse (for detail see Nandwal *et al.* 1996). Before sowing the seeds were surface sterilized with 80 % ethanol, washed with distilled water and then inoculated with *Rhizobium* sp. S-24. After germination, *i.e.*, 10 d after sowing, two healthy and uniform plants per pot were retained. Potassium was added in the form of KCl at concentration 0.00 (K_0), 2.56 (K_1) and 3.84 (K_2) mmol dm^{-3} (in addition to the existing level of 0.65 mmol dm^{-3} potassium in dune sand). At regular intervals, each pot was supplied with equal amount of nitrogen free nutrient solution (Wilson and Reisenauer 1963).

The soil saturation capacity of dune sand was 25 %. The control plants were grown at sand moisture content (SMC) of 12.0 ± 0.5 %. At the flower bud initiation stage, *i.e.*, 45 - 50 d after sowing drought was created by withholding irrigation till SMC decreased to 3.5 ± 0.5 %. The moisture levels of sand were maintained gravimetrically. Half of the stressed plants were reirrigated to control level of SMC and their recovery was seen after two days.

The water potential of third fully expanded leaf from the top was measured between 8.00 to 10.00 with pressure chamber (*Model 3005, Soil Moisture Equipment Corporation*, Santa Barbara, USA). The osmotic potential of corresponding leaf and of nodules was measured with vapour pressure osmometer (*Model 5100-B, Wescor,* Logan, USA), calibrated with a graded series of NaCl solution. For determination of leaf and nodule relative water content the method of Weatherley (1950) was adopted. The content of proline was estimated spectrophotometrically according to Bates *et al.* (1973). The total carbon (C), nitrogen (N) and potassium (K) contents from different plant parts were estimated from 100 mg of oven dried, powdered material. The determination of K was done by flame photometer *CL 26D* (*Elico*, Delhi, India). The C and N contents were estimated by the method of Walkley and Black (1934) and Micro Kjeldahl technique, respectively.

The effects of single factors, *i.e.* potassium and stress levels and their interactions on the parameters tested were evaluated by analysis of variance and by calculating the critical difference (CD) at 5 % level. For each observation three replications per treatment were used for analysis.

Soil moisture stress significantly decreased the water potential (ψ_w) of leaf and osmotic potential (ψ_s) and relative water content (RWC) of leaf and nodules (Table 1). In K-fed plants, the ψ_w of leaf and RWC of leaf and nodules increased, irrespective of soil moisture levels, whereas, ψ_s during the stress become more negative. The ψ_s of nodules was more negative than that of leaf under stress. Upon reirrigation all parameters showed recovery, however, they did not reach the respective controls. These results support the earlier findings in pea (Maribona *et al.* 1992) and pigeonpea (Nandwal *et al.* 1993). Under soil moisture stress, decrease in ψ_w and ψ_s was accompanied by the accumulation of proline (Table 2) and more proline was present in nodules as compared to leaves showing their difference in the degree of stress. The reduction in proline content of nodules in K-fed plants is ascribed to improvement in nodule water status (Table 1).

In control plants the maximum C was found in the leaves (43.5 %) followed by stem, root and minimum in nodules (7.5 %). Under moisture stress the carbon was accumulated in leaves and stem with simultaneous decline of 40 - 45 % in roots and nodules (Table 3). The increase in carbon in leaves was either due to their non-utilization or due to check in translocation of photosynthates to different plant parts (Nandwal *et al.* 1996). On relieving the stress, decline in carbon content of leaves was due to translocation of photosynthates to the developing flowering buds and other plants parts for their regrowth (Nandwal *et al.* 1996). K-fed plants showed higher carbon content in stem, roots and nodules, irrespective of soil moisture content, than untreated plants.

Table 1. Effect of potassium on water and osmotic potentials [-MPa] and relative water content [%] of leaves and nodules in *Vigna radiata* under drought and rehydration.

		Water potential			Osmotic potential			RWC		
		control	stress	recovery	control	stress	recovery	control	stress	recovery
K_0	leaves	0.55	0.84	0.67	1.34	1.55	1.47	80.98	72.31	78.15
	nodules				1.21	2.34	1.72	89.50	65.77	80.04
K_1	leaves	0.47	0.78	0.53	1.30	1.76	1.37	84.22	74.67	82.20
	nodules				1.24	2.66	1.73	92.52	67.46	84.40
K_2	leaves	0.50	0.79	0.54	1.22	1.73	1.26	86.13	76.91	85.69
	nodules				1.25	2.79	1.73	92.40	68.21	86.85

C.D. at 5 % level (K- effect of potassium, S - effect of stress, K×S - interaction):

	K	S	K×S	K	S	K×S	K	S	K×S
Leaves	0.04	0.04	0.07	0.07	0.07	0.13	1.77	1.77	3.07
Nodules				0.06	0.06	0.09	2.02	2.02	3.51

Table 2. Effect of potassium on proline content [μg g^{-1}(d.m.)] of leaves and nodules in *Vigna radiata* under drought and rehydration.

	Leaves			Nodules		
	control	stress	recovery	control	stress	recovery
K_0	129	1989	400	488	6204	1132
K_1	123	2696	546	455	6013	1022
K_2	150	2436	565	432	5368	1041

C.D. at 5 % level

	K	S	K×S		K	S	K×S
Leaves	160	160	278	Nodules	295	295	487

In control plants the lowest N percentage was observed in roots (3.75 %) and the highest in leaves (60 %). K application enhanced the N content in stem, roots and nodules with simultaneous decline in leaves. Under soil moisture stress, stem significantly accumulated nitrogen, whereas reverse was seen in nodules. When

Table 3. Effect of potassium on carbon, nitroger, and potassium content [% of total] and dry matter accumulation [mg(d.m.) $plant^{-1}$] in different parts of *Vigna radiata* unde: drought and rehydration.

		Leaves			Stem			Roots			Nocules		
		control	stress	recovery	control	stress	recovery	control	stress	recovery	control	stress	recovery
K_0	C	43.50	49.50	42.30	39.50	41.50	48.20	9.50	4.75	5.90	7.50	4.25	3.60
	N	60.00	61.00	80.40	24.50	30.10	13.60	3.75	5.50	2.25	11.75	3.50	3.55
	K	32.00	39.25	37.50	55.00	51.50	54.00	9.50	8.00	6.25	3.50	1.25	2.25
	d.m.	310	273	285	279	295	265	81	63	48	49	29	17
K_1	C	40.00	45.80	40.70	41.50	43.20	49.30	10.50	5.75	5.10	8.00	5.25	4.90
	N	56.00	55.00	63.90	26.00	32.50	27.50	4.20	5.25	2.00	13.80	7.25	6.20
	K	30.15	32.25	36.25	57.05	56.50	55.50	8.10	6.00	5.50	4.70	2.25	2.75
	d.m.	343	313	328	324	333	307	98	69	58	62	35	25
K_2	C	40.05	44.90	35.10	42.35	45.10	55.70	9.55	5.25	4.80	8.05	4.75	4.40
	N	57.00	57.80	63.05	26.00	28.25	26.80	4.22	4.50	3.30	12.80	9.45	6.85
	K	30.50	33.50	36.70	58.50	58.25	56.00	6.00	4.75	3.50	5.00	3.50	3.80
	d.m.	374	331	339	332	344	321	109	73	59	59	39	23

C.D. at 5 % level

	K	S	K×S		K	S	K×S
Leaves	27	27	49	Roots	9	9	15
Stems	11	11	18	Nodules	8	8	13

stressed plants were reirrigated, the N content was significantly enhanced in leaves and stem but further declined in root and nodules due to loss in dry mass (Table 3), because of their drying, shedding and decaying. Added K significantly increased the dry mass of different plant parts (Table 3).

In control plants the highest potassium content was noticed in stem (55 %) followed by leaves, root and the lowest in the nodules (3.5 %). In K fed plants, the content of potassium increased in stem and nodules but simultaneously declined in leaves and roots irrespective of soil moisture levels (Table 3). When irrigation was withheld, K content increased in leaves and declined in stem and especially in roots and nodules.

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