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Water Relations, Carbon Exchange and Nitrogenase in Chickpea under Soil Water Deprivation

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Chickpea widely grown in the Arid and Semi-Arid Zones of India is characterized as drought tolerant but poor yielder. This crop is usually grown on conserved moisture and experiences drought during reproductive phase, because of decreased soil moisture and rise in temperature. There is also a competition for photosynthates between nodules and reproductive parts at this stage, which results in decline in N_2 fixation (Luthra *et al.* 1983). Since N_2 fixation and CO_2 exchange are importat physiological processes for plant growth and yield, information is required to elucidate the exact mechanism of these processes under water stress. Therefore, it becomes imperative to study the response of these processes in relation to plant water status and under conditions of soil water deprivations.

Seeds of chickpea (*Cicer arietinum* L.) cv H-75-35, inoculated with *Rhizobium* culture (Ca-181) were raised in pots (dia 30 cm) filled with 5 kg of dune sand. Two plants per pot were supplied with N free nutrient solution at weekly interval. At the time of pod formation, *i.e.* 110 days after sowing, the pots were divided into two sets. One set maintained at field capacity, i.e. 50 % of soil saturation% (SSP) and soil moisture content (SMC) of 12±0.5% served as control. In the second set irrigation was withheld and the plants were sampled at two days interval till the plants showed the permanent wilting (SMC = 2.0±0.5%). Half of severe stressed plants were irrigated and sampled after two days to see the recovery. Soil moisture content was determined gravimetrically. Fourth leaf from top was taken for measuring the leaf water potential (ψ w) and osmotic potential (ψ s) with pressure chamber (Model Hr-3005, Soil Moisture Equipment Corporation, USA) and Vapour Osmometer (Model 5100 B, Wescor Inc, USA), respectively. the ψw and ψs of nodulated roots were measured. Photosynthesis and leaf respiration of intact plants were measured as described earlier (Luthra *et al.* 1983). Nitrogenase activity of nodules was determined by acetylene reduction assay (ARA). Leaf area was recorded on leaf area meter (Li-3000, Licor,USA).

Leaf water potential and osmotic potential decreased gradually with decrease in soil moisture (Table 1). Osmotic potential showed more negative value than water potential, thereby lowering the turgor. At -2.2 MPa leaf water potential, plant showed the sign of permanent wilting. Decrease in turgor potential of leaf resulted in marked reduction in leaf area (Table 1) except at SMC of 8 %. Nodulated root maintained higher water potential and osmotic potential than leaf. At permanent wilting nodulated root had more turgor than leaf. After recovery both the components showed better turgor than control. The greater decrease in osmotic potential of nodulated root under water stress seems to be due to accumulation of organic solutes (Nandwal 1989).

Nitrogen fixation is know to be sensitive to water stress (Venkateswarlu *et al.* 1989, Nandwal et al. 1991). Here also, the decrease in nodulated root water potential was accompanied by reduction in nitrogenase activity. Interestingly at leaf and nodulated root water potential of-0.42 MPA and-0.35 MPA respectively, nitrogenase activity was maximum. This might be due to better availability of photosynthates (Table 1) and O_2 diffusion. With further decrease in water potential, fixation declined and no activity was detected at permanent wilting. Chopra et al. (1984) reproted that reduction in N_2 fixation was due to decreased supply of photosynthates, whereas Sprent (1981) held the view that this decrese is mainly due to the direct

Table 1 *Water potential, osmotic potential, photosynthesis, respiration and nitrogenase activity in chickpea experiencing water deprivations.*

Parameters	Days after withholding irrigation					
	Control	2	4	6	8	Recovery
	SMC = 12 ±0.5% at Field capacity (FC)	SMC = 8 ±0.5% 30% Less than FC	SMC = 5.5 ±0.5% 55% Less than FC	SMC = 4 ±0.5% 70% Less than FC	SMC = 2 ±0.5% 85% Less than FC	SMC = 12 ±0.5% at Field capacity
Leaf ψ w (-MPa)	0.12	0.42	1.15	1.60	2.20	0.09
Leaf ψ s "	1.26	1.25	1.40	1.81	2.25	1.27
Leaf ψ p "	1.14	0.83	0.25	0.21	0.05	1.18
Nodulated root ψ w (-MPa)	0.08	0.35	0.70	0.98	1.70	0.08
Nodulated root ψ s (-MPa)	0.95	0.90	1.10	1.36	2.10	1.02
Nodulated root ψ p (-MPa)	0.87	0.55	0.40	0.38	0.40	0.94
Photosynthesis (mg CO_2 Plant^{-1} h^{-1})	30.4	31.2(3)	19.4(-37)	6.7(-78)	0.61(-98)	21.9(-31)
Respiration (mg CO_2 Plant^{-1} h^{-1}	8.2	8.1(-1)	6.1(-27)	5.3(-36)	3.7(-55)	7.7(-6)
Nitrogenase activity (μ mole C_2H_4 g^{-1} h^{-1})	9.5	11.0(10)	3.2(-67)	0.70(-93)	0.0(-100)	4.1(-56)
Leaf area (cm^2 Plant^{-1})	877	892(2)	778(-10)	742(-14)	560(-36)	404(-54)

Values in parentheses are percent increase or decrease over control.

effect on O_2 diffusion in nodules. Durand *et al.* (1987) showed that factors other than photosynthate supply, became limiting to ARA much before a reduction in photosynthesis was observed.

In the present study, the reduction in photosynthesis was less than N fixation and recovery was also better for photosynthesis. This suggests that it is not only the photosynthates which controls the N fixation, but some other critical factors may also be involved, in which water potential of nodulated root is one of them, as reported earlier (Nandwal *et al.* 1991). Decrease in photosynthesis at decreasing leaf water potential was due to decrease in leaf area.

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