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Drought Resistance in Pearl Millet

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Abstract. The influence of wilting on the levels of free proline, soluble proteins, reducing sugars, starch and on the activities of nitrate reductase, invertase, amylase and pyrophosphatases have been studied in the leaf tissue of five cultivars of pearl millet at their vegetative stage under pot culture conditions. The metabolic changes could not be correlated with the yield behaviour of the cultivars under a drought condition in the field.

Metabolic changes caused by water stress are known to be dependent on genotype variations. Despite a fair knowledge of the general trends of stress mediated changes, it has not been possible yet to find a reliable measure of relative drought resistance of crop plants. In this regard, the merit of proline level (Singh *et al.* 1972), deemed promising in the recent past, also seems to be rather equivocal (Stewart and Hanson 1980). Although the pearl millet crop is generally known to be adapted to dry regions, there is meagre information about the magnitudes of metabolic changes caused due to water stress in its different cultivars. Attempts have been made in the present study to obtain information on this subject.

MATERIAL AND METHODS

Plants of five cultivars of pearl millet (*Pennisetum typhoides*, cultivars: BJ 104, RSK, RSJ, Ghana and Chaddi) were grown in 8 kg of loamy-sand soil (having 0.15% organic carbon, 12 kg ha^{-1} of available phosphorus as P_2O_5 and 180 kg ha^{-1} of available potassium as K_2O) in pots enriched with 500 ml of Hoagland solution in a net house. Leaves of control (maintained near field capacity) and wilting plants (water deprived for seven days from the 30th day after sowing *i.e.* at the onset of tillering stage) were analysed for contents of soluble protein (Lowry *et al.* 1951), free proline (Singh *et al.* 1973), reducing sugars and starch (Yemm and Willis 1954), and activities of acid and alkaline pyrophosphatase, amylase and invertase (Kathju and Lahiri 1976) and nitrate reductase (Jaworski 1971).

The yield of these cultivars under field conditions in 1979 were ascertained from 5 m × 4 m plots with six replications adopting a randomized design.

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TABLE 1

Effect of wilting on soluble protein, free proline, reducing sugar and starch contents in leaves of pearl millet cultivars

Cultivar		Soluble protein [mg g^{-1} dry m.]	Free proline [mg g^{-1} dry m.]	Reducing sugars [mg g^{-1} dry m.]	Starch [mg g^{-1} dry m.]
BJ 104	Control	10.37	0.127	10.73	205.20
	Wilted	1.79	2.196	9.22	143.00
RSK	Control	6.66	0.103	7.93	110.00
	Wilted	3.51	1.128	8.76	81.84
Ghana	Control	2.29	0.062	11.12	172.31
	Wilted	1.80	2.325	16.13	111.45
RSJ	Control	9.67	0.098	6.27	—
	Wilted	2.93	6.089	19.40	55.12
Chaddi	Control	3.01	0.157	6.72	151.20
	Wilted	2.07	4.636	15.55	69.48

RESULTS AND DISCUSSION

Water content of leaf of the wilting plants was uniformly 55 to 60% of fresh weight while the soil moisture was just over 2% on dry weight basis. In control plants these were about 75 to 80% and 10%, respectively.

Table 1 indicates that the soluble protein content declined in all the cultivars at wilting. It was maximum in cv. BJ 104 (*ca.* 83 per cent reduction

TABLE 2

Effect of wilting on activities of certain enzymes in leaves of pearl millet cultivars

Cultivar		Acid pyrophosphatase [mg Pi liberated g$^{-1}_{\text{dry m}}$ h^{-1}]	Alkaline pyrophosphatase [mg Pi liberated g$^{-1}_{\text{dry m}}$ h^{-1}]	Amylase [mg starch hydrolysed g$^{-1}_{\text{dry m}}$ h^{-1}]	Invertase [mg glucose formed g$^{-1}_{\text{dry m}}$ h^{-1}]	Nitrate reductase [μg nitrite formed g$^{-1}_{\text{dry m}}$ h^{-1}]
BJ 104	Control	63.4	64.3	788.2	288.0	189.1
	Wilted	31.5	47.0	51.2	56.4	125.6
RSK	Control	237.2	89.3	858.0	358.0	167.3
	Wilted	68.8	73.3	84.6	120.8	148.7
Ghana	Control	38.0	57.0	—	—	239.7
	Wilted	38.6	55.0	—	82.2	89.6
RSJ	Control	44.2	69.2	821.5	191.8	152.9
	Wilted	—	—	64.4	83.6	110.0
Chaddi	Control	58.1	65.8	442.8	219.2	118.5
	Wilted	—	43.9	165.6	16.6	61.5

as compared to control) which was followed by cv. RSJ (70 per cent) and minimum was found in cv. Ghana (21 per cent). Free proline accumulation, however, was maximum in cv. RSJ which was followed by cultivars Ghana and Chaddi and minimum was found in cv. RSK. The foregoing effects of water deprivation could not be correlated with the level of reducing sugars.

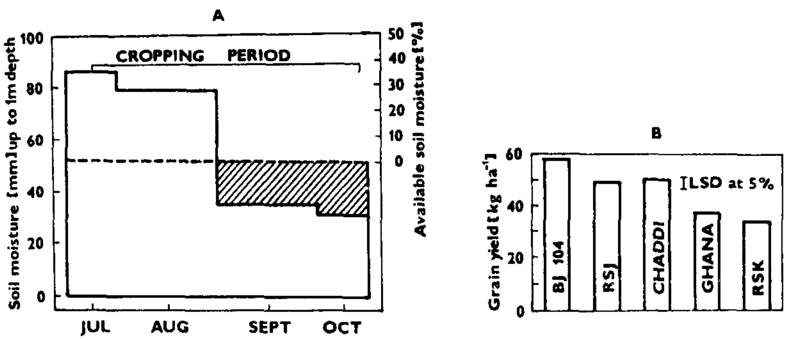

Fig. 1. (A) Moisture [mm] in meter depth of soil from sowing to harvest of pearl millet crop. Shaded part indicates the period when the soil moisture was below the availability limit. (B) Grain yield of different cultivars of pearl millet.

Maximum increase in reducing sugars (*ca.* 209 per cent over control) was found in cv. RSJ and it was followed by cv. Chaddi while in cultivars BJ 104 and RSK there was little change in concentration. Starch content decreased most in cv. Chaddi but the decrease in cultivars BJ 104, RSK and Ghana varied only between about 25 to 35 per cent with respect to their controls.

Table 2 indicates that the reduction of alkaline pyrophosphatase activity at wilting was maximum in cv. Chaddi (*ca.* 33.3 per cent with respect to its control) and it was followed by cultivars BJ 104, RSK and Ghana in decreasing order. However, the activity of acid pyrophosphatase decreased most in cv. RSK (*ca.* 71 per cent with respect to its control) followed by cv. BJ 104. But there was hardly any change in the case of cv. Ghana. Amylase activity, however, was reduced drastically almost in all cultivars (above 90 per cent reduction in cultivars BJ 104, RSK and RSJ) except in cv. Chaddi where the reduction was about 62 per cent. But the reduction in invertase activity due to wilting was maximum in this cultivar (*ca.* 92.5 per cent) and the minimum reduction was found in cv. RSJ. The reduction in nitrate reductase activity, however, was maximum in cv. Ghana (*ca.* 62.7 per cent) and it was followed in a decreasing order by cultivars Chaddi (48.2 per cent), BJ 104 (33.6 per cent), RSJ (28.1 per cent) and RSK (11.2 per cent).

During this year (1979) there was a total rainfall of 785 mm, which was higher than the average rainfall of this area (360 mm). But 56 per cent (470 mm) of it fell just before the sowing within a short period of 5 days. Plants had only 239 mm (30.5 per cent) rainfall between sowing and harvesting (July 21 to October 14) out of which 98 per cent (234 mm) was at the seedling stage (within 25 days from sowing). Only 5 mm precipitation occurred during September and there was no rainfall thereafter. Thus the plants experienced an increasing soil moisture stress with the progress of growth as there was a prolonged dry spell of about 60 days during the reproductive phase (Fig. 1 A). This drought spell brought about a decrease in the yield of all the cultivars but the cv. BJ 104 gave a significantly higher yield as compared to the other cultivars. Again, cultivars RSJ and Chaddi provided significantly higher yields than cultivars Ghana and RSK (Fig. 1 B).

The observations on the enzymes and metabolites of water deprived plants reported here generally conform to the known trends mentioned in the literature. But their levels in the control plants of different cultivars have been found to vary by different extents and this may be linked with the genotype variabilities. However, the magnitude of alterations brought about by moisture stress did not seem to be related to the initial level of metabolites or activities of enzymes in unstressed plants. It appeared again that the moisture stress had a differential influence on different plant processes and this may again vary in different cultivars of the same species. Therefore it was rather difficult to correlate the yield behaviour of different cultivars under drought conditions in the field with the metabolic changes noted under simulated drought under pot culture conditions at the tillering stage of the plants.

The cv. BJ 104 which seems to be relatively more drought resistant than others in field trial, has not been found to have a greater stability of soluble proteins under stress and proline accumulation in this cultivar was also less than in the rest of the cultivars. Nothing remarkable has again emerged as regards its starch and reducing sugar content at wilting. Nor did the stabilities of enzymes of the cultivars studied here under stress provide any specific clue to its higher resistance to drought.

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