Table 1 *Mean values of yield and its components*

	GRU 2 6119	Pink-2	Pink-2 mutant
Maturity (days)	127	117	114
Plant height (cm)	47	54.6	50.4
No. of branches/plant	7	11	13.2
No. of pods plant	24.6	82.4	63
No. of grains pod	1	1	1.1
100 grains weight (g)	14.8	16.2	14.4
Grain type	Desi	Pink (Gulabi)	Desi
Biological yield ($g\ m^{-2}$)	0.30	0.61	0.90
Grain yield ($g\ m^{-2}$)	0.11	0.17	0.37
Harvest index	36	27	42

Figure 2. Leaf mutant along with its parent and another mutant.

some physiological changes resulting in an increase in productivity. Besides, the mutant is of interest in genetical studies as a marker.

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INTERACTIVE EFFECTS OF SOIL FERTILITY AND SALT STRESS ON THE ACTIVITIES OF CERTAIN ENZYMES OF NITROGEN METABOLISM IN MUSTARD

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ALTHOUGH significant interaction between salinity and soil nitrogen has been found in many crops[1], information on the activities of enzymes related to nitrogen metabolism is scanty except for nitrate reductase[2]. However, the effects of salt stress, *per se* have been found to inhibit[3,4] or promote[5] the activities of nitrate reductase (NR), glutamine synthetase (GS) and glutamate dehydrogenase (GDH) depending on the crop, the stage of growth and the salt concentration. In this regard information on glutamate synthase (GOGAT) is meagre. The present study was prompted by the lack of information on mustard and the common practice of cultivation of this crop with substandard ground waters in the semi-arid parts of Rajasthan with soil fertilization.

Plants of *Brassica juncea* (cv. Varuna) were grown in glazed pots (40 kg loamy sand soil) under low (LF-no fertilizer to soil having 0.15% organic carbon, 15 kg/ha available P_2O_5 and 220 kg/ha available K_2O) and improved (IF-60 kg N/ha, 40 kg P_2O_5/ha and 20 kg K_2O/ha) soil fertility conditions. Plants under both the conditions were irrigated at weekly intervals from 20 DAS to 85 DAS with saline waters of 0, 50, 100 and 150 meq/l concentrations having salts in the same proportion as that of local ground waters[2]. At pre-flowering (45 DAS) and flowering (65 DAS) stages, two uppermost fully expanded leaves were homogenized in 0.1 M Tris HCl buffer (pH 7.6) containing 2% polyvinyl pyrrolidone (PVP) and 10^{-4} M ethylenediaminetetraacetic acid (EDTA) at 4°C. After centrifugation, the supernatant was used for the assay of GS (sodium glutamate substrate)[6], GDH (α-keto glutarate substrate)[7] and GOGAT (glutamine and α-keto glutarate substrate)[7]. Activities of these enzymes were ascertained from the change in the absorbance per unit time. TCA (10%) was added to an aliquot of the aforesaid supernatant and the precipitated protein was dissolved in NaOH (0.1 N) for its spectrophotometric estimation[8]. NR was estimated *in vivo* from leaf disks using KNO_3 as

substrate[9]. Observations were based on three replicates.

Results presented in figure 1 indicate that increasing salinity progressively reduced the NRA of plants under both LF and IF conditions but IF plants generally maintained a higher activity compared to LF plants up to 50 and 100 meq/l at pre-flowering and flowering stages respectively. Although NRA is highly sensitive to salt stress[4] but this, as well as, our previous observations on wheat[2] suggested that higher availability of substrate under IF condition possibly induced a greater efficiency of this enzyme despite salt stress at least up to a certain level of salinity.

An increase in salinity also led to decreased activities of GS and GOGAT but the activities, as such, were higher at the flowering stage as compared to the pre-flowering stage (figure 1). Again, fertilized plants displayed markedly higher activities of these enzymes in comparison with the unfertilized plants under control, as well as, saline conditions except at 150 meq/l concentration at the flowering stage. Such induction of a higher activity under salt stress in fertilized plants was also discernible in the case of GDH at both pre-flowering and flowering stages. However, at both these stages, a general decline in the activity was noticed up to 100 meq/l salinity and an increase, more so, in HF-plants was found at 150 meq/l. Increased accumulation of ammonia in the tissue at a high salinity could bring about this increase. However, the inhibitory effects of salt stress as such, on the activities of these enzymes, have also been reported by other workers[3,4].

The above observations logically suggest that an increase in salt concentration may generally reduce the protein level but it should remain higher in fertilized as compared with the unfertilized plants at all levels of salinity. The data presented in table 1 support this contention.

This report reveals a significant salinity–fertility interaction at a biochemical plane, particularly with respect to certain enzymes of nitrogen metabolism.

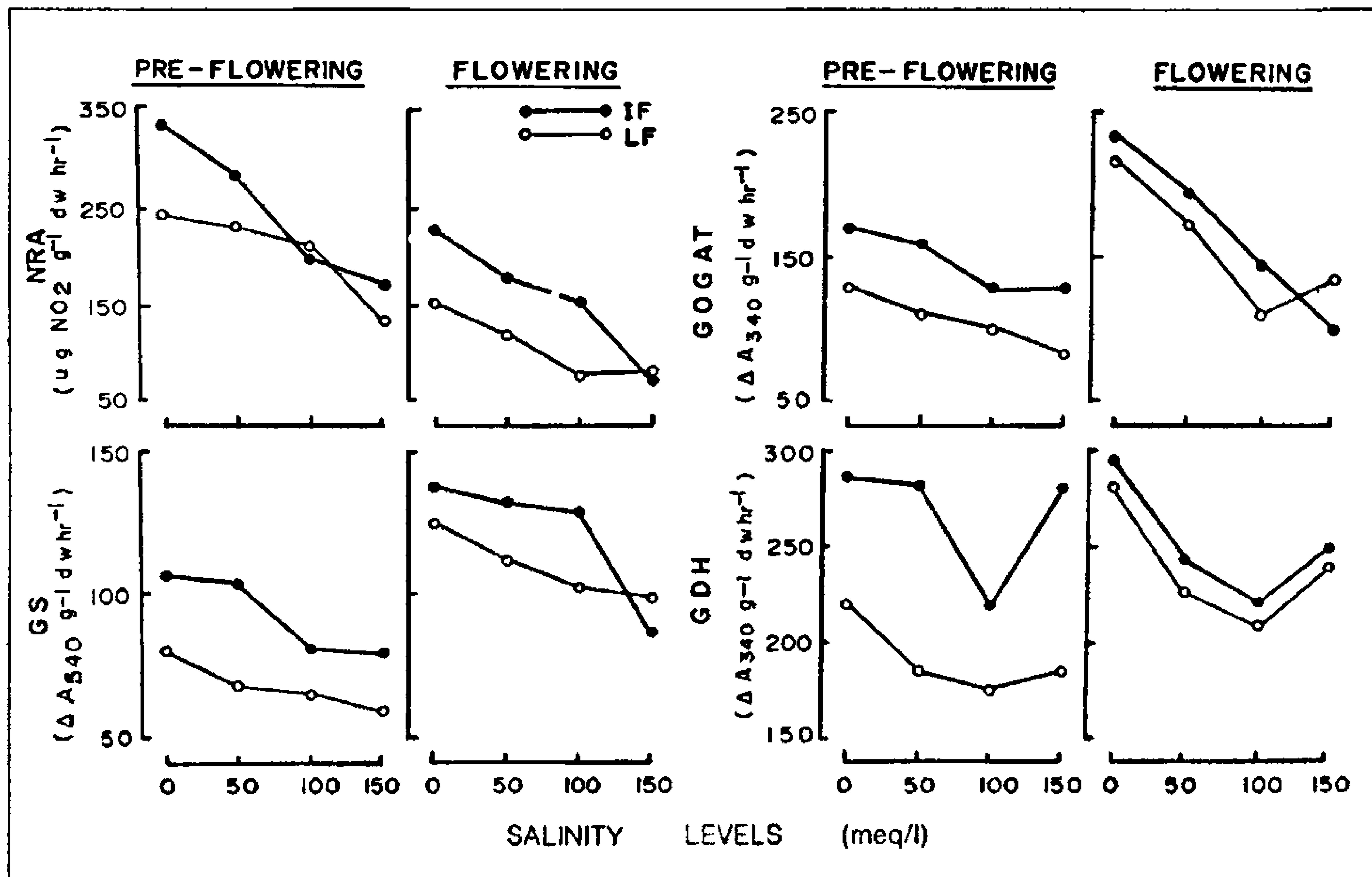

Figure 1. Influence of different levels of salinity on the activities of NR, GS, GOGAT and GDH at the pre-flowering and flowering stages of plants raised under improved and low soil fertility conditions.

Table 1 *Influence of soil fertility on the level of soluble protein in mustard irrigated with saline waters*

Salinity levels (meq l)	Soluble protein (mg/g dry wt) 45 DAS IF	45 DAS LF	45 DAS Mean	65 DAS IF	65 DAS LF	65 DAS Mean
0	285.8	236.8	261.3	217.7	200.5	209.1
50	280.8	221.5	251.2	208.9	186.3	197.6
100	236.9	211.5	224.2	189.8	176.5	183.2
150	250.8	203.5	227.2	193.5	163.3	178.4
Mean	263.6	218.3		202.5	181.7	
LSD at 5%						
Salinity (S)	7.34			4.95		
Fertility (F)	5.19			3.50		
S×F	10.39			7.00		

The merit of this interaction in terms of improvement of plant performance and yield will be reported subsequently.

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SHORT-TERM EFFECT OF UREA ON NITROGENASE ACTIVITY IN *NOSTOC ANTHOCEROS*

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NITROGENASE is found exclusively among prokaryotic organisms. All nitrogenases isolated so far are very similar in their molecular structure[1]. Nitrogenase activity in heterocystous cyanobacteria is located in heterocysts which are the sites of nitrogen-fixation[2]. Nitrogen-fixation is an energy expensive process and therefore, the enzymatic activity of nitrogenase and its biosynthesis is subjected to regulation by ammonia and other nitrogen sources[3,4]. *Nostoc anthoceros* which has stimulated considerable interest owing to their ability to fix N in association with the liverwort *Anthoceros punctatus*. Regulation of cyanobacterial nitrogenase in relation to ammonia metabolism has been reported[5,6], but to date very little data are available on the effect of urea on nitrogenase activity[7]. In this paper we describe the short-term effects of urea on nitrogenase activity of *N. anthoceros*. For this purpose the uptake of urea and the nitrogenase activity have been studied in *N. anthoceros* cultures exposed to urea, methionine sulphoximine (MSX) and adenosine triphosphate disodium salt (ATP).

Axenic batch cultures of *N. anthoceros* were grown in BG-11 medium[8] under continuous light at 50 μmol photons.m^{-2}.s^{-1} at 24±1°C. Exponentially growing culture (7 days) were used for each experiment and the urea concentration was 1 mM. MSX (250 μM) and ATP (50 μM) were added to the cultures 2 h prior to the addition of urea and incubated under normal growth conditions so as to allow the entry of the chemical into the cells. Urea uptake was estimated by measuring its depletion from the external medium as described by Rai and Singh[9]. Nitrogenase activity was measured following the method of acetylene reduction assay[10]. Protein was estimated by the method of Lowry *et al*[11] standardized with bovine serum albumin. Chlorophyll was estimated using the method of Mackinney[12].

Table 1 shows changes in nitrogenase activity levels and urea uptake rates in *N. anthoceros* grown in N-free medium and then transferred to urea-containing medium. Cells grown under N_2-fixing conditions were able to assimilate urea, accompanied by a decrease in nitrogenase activity. Urea decrease in nitrogenase occurred only after a lag period of 1 h. This period was consistent with the necessity for urea to be first hydrolysed to ammonia which may be the active repressor in this case. After 2 and 5 h, cells exhibited an appreciable urea uptake rate (540.50 and 523.87 nmol/mg protein/h, respectively) and nitrogenase activity was about 55 and 10%, respectively of the original value. Our observation also supports the proposition[9] that during short-