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*Original Article*

# Growth responses of *Brassica juncea* to phosphorus application from different sources of fertilizer under salt stress

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**Abstract**

Under salt-stress conditions, available phosphorus may not be in adequate amounts or in accessible forms for timely utilization by plants. This study was carried out to observe the growth and $Na^+/K^+$ ratio in *Brassica juncea* having phosphorus supplied from commercial fertilizers under salt stress. Seeds of *Brassica juncea* (cv. Raya Anmol) were germinated and the seedlings raised in standard nutrient solution under controlled conditions. Phosphorus was applied from three sources of fertilizers i.e. DAP, SSP and TSP @ 2 (as control) and 10 mmol $L^{-1}$. Salt stress was developed with NaCl (150 mmol $L^{-1}$). Under salt stress and elevated P application as SSP and TSP, fresh mass was higher than with DAP source. Dry mass was higher with SSP source than with DAP and TSP. $Na^+/K^+$ ratio was low using SSP. P-uptake by the plants was highest using TSP. For growth parameters and $Na^+/K^+$ ratio, phosphate fertilizers contributed differentially under salt stress.

**Key words:** *B. juncea* growth, P- fertilizer, salt stress, $Na^+/K^+$ ratio

## 1. Introduction

Stress is an unfavorable condition that interrupts, or is presumptively upset, the normal physiological functioning of a living plant. Salinity is an environmental stress that limits growth and development in plants. The response of plants to excess of NaCl, the most important salinity causing substance, is complex and involves changes in their morphology, physiology and metabolism (Hilal *et al*., 1998). The effect of high salinity may be expected to vary with different growth stages of plants (Chartzoulakis and Klapaki, 2000). Salt stress reduces plant growth by affecting the availability, transport, and partitioning of nutrients (Yuncai and Urs, 2005) besides causing nutrient deficiencies or imbalances. Initially salt stress adversely affects germinating seed or root growth of a plant. In this stress, sodium is the main ion that creates different types of harms such as osmotic stress, dehydration, change of normal ratios among cations, reduction in the tissue development using different anions; in addition to water retention an important property of a plant tissue that indicates its health and turgidity (Badr *et al*., 2010). Nutrient interdependence and availability to plants under salt stress is the main focal point of nutrient management under such conditions. Under non-stress conditions all the required nutrients remain in adequate amounts and in accessible forms for timely utilization by plants.

Among the plant nutrients, phosphorus is an essential element for plant growth and its development making up about 0.2 % of plant dry weight (Schachtman *et al*., 1998). Plants acquire phosphorus from the soil solution as phosphate ion. These anions are extremely reactive and may be immobilized through precipitation with cations such as $Ca^{2+}$, $Mg^{2+}$, $Fe^{3+}$ and $Al^{3+}$, depending on the particular properties of a soil (Mahantesh and Patil, 2011). Its amount available to plants is usually a small proportion of the total requirement. Its inconsistent supply/availability disrupts

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metabolic processes in plants. This situation may be variable under different sources of phosphate fertilizer. This assumption is based on the concept that constituents may affect phosphorus availability from a particular fertilizer to the root system of a plant under salt stress. This condition provoked this study to test the hypothesis that phosphorus from different sources of fertilizer has different effects on plant growth under stress conditions. The study was carried out with the objective to observe the growth and $Na^+/K^+$ ratio in *Brassica juncea*, being salt tolerant (Badr-uz-Zaman *et al.* 2006), having phosphorus supply from commercial fertilizers under salt stress.

## 2. Materials and Methods

Seeds of *Brassica juncea* (cv. Raya Anmol) were treated with sodium hypochlorite (1% w/v) for 15 minutes (Britto and Kronzucker, 2002) and then germinated in quartz sand moist with distilled water. After 12 days of sowing, the seedlings were foam-plugged in lids of plastic pots 2.5 L of containing continuously aerated nutrient solution as constituted by Hoagland and Arnon (1950). The nutrient solution was replaced weekly. Light intensity remained at 450 µmol $m^{-2} s^{-1}$. Photoperiod was adjusted to $16hd^{-1}$ photo period and the temperature was maintained at 25±2°C. Phosphorus (2 mmol $L^{-1}$ as control and 10 mmol $L^{-1}$) from three sources of fertilizers i.e. Di ammonium phosphate (DAP), Single super phosphate (SSP) and Triple single phosphate (TSP). Salt stress with 150 mmol $L^{-1}$NaCl was developed after 7 days of transplantation in all pots. The whole plants were unplugged on the 32nd day of transplantation to pots. The plants were rinsed with distilled water, blotted with tissue paper and their fresh mass recorded. The plant samples were dried at 65°C to constant mass. Dry mass of each sample was recorded and samples were digested in 2% nitric acid solution along with a few drops of perchloric acid. Phosphorus in the plant digested material was determined as described by Jackson (1962). The concentrations of Na and K ions were determined by flame photometer. The numerical data were statistically analyzed in triplicates using CRD (Factorial) and the means were separated using LSD test according to Gomez and Gomez (1984).

## 3. Results

The study showed significant ($p \leq 0.01$) interactive effect between salt stress (150 mmol $L^{-1}$ of NaCl) and phosphorus (10 mmol $L^{-1}$) from fertilizers, viz. Diammonium phosphate (DAP), single super phosphate (SSP) and triple single phosphate (TSP) on growth and $Na^+/K^+$ ratio of *Brassica juncea* seedlings.

### 3.1 Effect of P-sources on growth of *B. juncea* under salt stress

Under non-stress and salt stress fresh mass (FM) of the seedlings was improved at the higher level of P-application. Under non-stress, there was an equivalent effect on FM of DAP and TSP; and this was higher than that of SSP. Under salt stress the effect on FM of higher level of SSP and TSP were equivalent and this was higher than that of DAP (Table 1). Under non-stress dry mass (DM) of the seedlings was improved at higher level of P-application. There was an equivalent effect of DAP and TSP; and this was higher than that of SSP. Under salt stress and higher level of P-application, effect of SSP on DM was higher than that of DAP and TSP (Table 2).

### 3.2 Effect of P-sources on Na/K ratio and P-uptake in *B. juncea* under salt stress

Under non-stress and at control and higher level of P-application, $Na^+/K^+$ ratio was affected non-significantly. Under salt stress, at control and higher level of P-applica-

Table 1. Effect of phosphorus from three sources of fertilizer on fresh mass (mg $plant^{-1}$) of *Brassica juncea* (cv. Raya Anmol) under salt stress (Average of 3 repeats).

| P- fertilizer Sources | Na Cl applied (mmol $L^{-1}$) | | | | Means |
|---|---|---|---|---|---|
| | 0 | | 150 | | |
| | P applied (mmol $L^{-1}$) | | | | |
| | Control | 10 | Control | 10 | |
| DAP | 260.5 c | 427.1 a | 252.5 c | 281.2 c | 305.3 A |
| SSP | 148.7 d | 349.5 b | 125.8 d | 445.7 a | 267.4 B |
| TSP | 150.3 d | 419.9 a | 258.5 c | 400.3 a | 307.3 A |
| Means | 186.5 B | 398.8 A | 212.3 B | 375.7 A | |
| Mean of means | 292.7 | | 294.0 | | |

Means sharing similar letter(s) for a parameter do not differ significantly at $p < 0.01$
CV ($p < 0.01$) = 10.27 percent

Table 2. Effect of phosphorus from three sources of fertilizer on dry mass (mg plant$^{-1}$) of *Brassica juncea* (cv. Raya Anmol) under salt tress (Average of 3 repeats).

| P- fertilizer Sources | Na Cl applied (mmol L$^{-1}$) | | | | Means |
|---|---|---|---|---|---|
| | 0 | | 150 | | |
| | P applied (mmol L$^{-1}$) | | | | |
| | Control | 10 | Control | 10 | |
| DAP | 24.7 bc | 26.9 b | 13.2 f | 22.2 cd | 21.8 $^{ns}$ |
| SSP | 17.3 e | 21.3 d | 13.5 f | 35.7 a | 21.9 |
| TSP | 12.8 f | 27.2 b | 22.6 cd | 24.8 bc | 21.9 |
| Means | 18.3 C | 25.1 B | 16.4 C | 27.6 A | |
| Mean of means | 21.7 | | 22.0 | | |

Means sharing similar letter(s) for a parameter do not differ significantly at $p < 0.01$
CV ($p < 0.01$) = 8.98 percent

Table 3. Status of $Na^+/K^+$ ratio from three sources of phosphorus fertilizer in *Brassica juncea* (cv. Raya Anmol) under salt stress (Average of 3 repeats).

| P- fertilizer Sources | Na Cl applied (mmol L$^{-1}$) | | | | Means |
|---|---|---|---|---|---|
| | 0 | | 150 | | |
| | P applied (mmol L$^{-1}$) | | | | |
| | Control | 10 | Control | 10 | |
| DAP | 0.41 $^{ns}$ | 0.22$^{ns}$ | 1.57 bc | 1.56 bc | 0.94$^{ns}$ |
| SSP | 0.41 | 0.25 | 2.19 a | 1.48 c | 1.08 |
| TSP | 0.36 | 0.26 | 1.90 ab | 1.89 ab | 1.10 |
| Means | 0.39 | 0.24 | 1.89 A | 1.64 B | |
| Mean of means | 0.32 | | 1.77 | | |

Means sharing similar letter(s) for a parameter do not differ significantly at $p < 0.01$
CV ($p < 0.01$) = 20.73 percent

tion, effect of DAP and TSP on $Na^+/K^+$ ratio was similar, but this ratio was decreased significantly with P-application (10 mmol L$^{-1}$) from SSP (Table 3).

In *B. juncea* , phosphorus uptake was lowest from the SSP source. P-uptake by SSP was 1.77 and 2.42 times lower than that of DAP and TSP sources respectively (Figure 1)

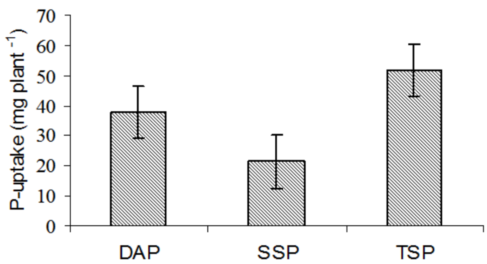


Figure 1. Phosphorus -uptake in *Brassica juncea* (cv Raya Anmol) from the three fertilizers under salt stress.

## 4. Discussion

The fresh mass of the plants is an indicator of fluid material especially water. The high amount of water indicates turgidity of the living tissues of the plant. It also highlights the balanced flow of required nutrients from root to the shoot system. Fresh mass increased two fold in the wheat plant due to simultaneous accumulation of dry mass and water uptake (Dimitrina and Nikolova, 1999). In this study higher dose of application of phosphorus from different fertilizers increased FM of plants under salt stress. In addition, this increase in FM was a function of a differential release of P from fertilizer in response to plants growth. The role of SSP and TSP was prominent over DAP under salt stress. Since SSP contains both mono calcium phosphate and gypsum, its role was prominent under salt stress. Also, in SSP, higher level of sulphur might have been significant to increase succulence. Sulphur has been identified as an important factor in reducing sodium ion toxicity (Badr-uz-Zaman *et al.*, 2002) also calcium and sulphur detoxify glycophytes from Na ion.

Dry mass of plants is the net result of the metabolic processes. Phosphate is utilized in cell synthesis and biochemical linkages. A minute quantity of sodium ion remains beneficial for growth, depending upon the germplasm. A particular amount of sodium ion may be, utilized in place of potassium ion and maybe, sodium and potassium ions cause balance up to a certain level of salt stress conditions to support growth processes. Phosphorus is in synergistic relation with potassium ion under the presence of sodium ion (Badr-uz-Zamant *et al.*, 2006). The coordinated relationship between phosphorus and potassium ion was in harmony under elevated phosphorus application from the three sources of fertilizer for $Na^+/K^+$ ratio.

Under salt stress conditions with TSP application, $Na^+/K^+$ ratio was decreased. In this phosphorus source sulphur and nitrogen were in minute quantity and might have been sufficient to decrease $Na^+/K^+$ ratio. In interactive relations, phosphorus, sulphur, nitrogen and potassium are in coordination in metabolic activities of a plant (Singh *et al.*, 2010). Uptake of phosphorus by plants was higher with DAP and TSP than with SSP. This indicated that the higher uptake of phosphorus is proportional to higher amount from the available source.

From agronomic point of view up-take is a product of dry mass of plant material with a concentration of a particular ion in the respective material. If DM happened to be increased by the presence of another ion in that material or any other factor, then the information on 'uptake' may mislead or confusing. In this study DM and P- concentration were supportive towards the magnitude of the respective fertilizer sources. Medhi *et.al* (2001) found that TSP was a superior source in mildly saline sodic soils. In this study roots of *B. juncea* might have preferred to absorb phosphorus from TSP source as Frank (2002) reported that transfer of phosphorus into the root symplasm occurs through transporter proteins.

## 5. Conclusions

In *B. juncea*, phosphate fertilizers contributed differentially under salt stress. Hence, performance of SSP was prominent for bio mass formation and lowering $Na^+/K^+$ ratio. Fresh mass and P-uptake was increased by TSP application.

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