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Ameliorative Effects of Nitrogen Application on Vegetative Growth and Productivity in Genotypes of Ragi (*Eleusine coracana* Gaertn.) under Saline Conditions

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ABSTRACT

Background: Salinity and low soil nitrogen availability are important growth limiting factors for most crops. The proper use of N fertilizer is not only important for growth but it may also alter the salinity tolerance of plants depending on the level of salinity.

Methods: The present study was undertaken to determine the interactive effects of N nutrition and saline irrigations (3, 6, 7.2, 10, 12 and 14 dSm^{-1}) on growth and grain productivity in two varieties of finger millet *viz*. VL-315 and Local Hills. Different growth and productivity parameters (like plant height, dry weight of shoot, root and leaves, dry weight of panicle/plant, no. of grains, grain yield/ plant *etc*.) adversely affected by saline irrigations, however, nitrogen nutrition minimized at different levels of salinity.

Result: The positive response of nitrogen was comparatively higher at lower salinity levels (3-7.2 dSm^{-1}) as well as at control than higher salinity (10-14 dSm^{-1}). The effect of salinity was lower in cv. VL- 315 than Local Hills, but the interactive effects of N nutrition and salinity also enhanced the dry weight of shoot, root, leaves, dry weight of panicles and grains/plant. It is probable that N nutrition had enhanced assimilation of NO_3^{-1}-N, through the activity of NRA which further increased total nitrogen and protein content in leaves, hence, enhanced growth, biological and grain yield in both cultivars.

Key words: Assimilation, Finger millet, Nitrogen nutrition, Productivity, Salinity.

INTRODUCTION

Soil salinity is one of the major stresses which severely limit plant growth and productivity (Koca *et al.*, 2007 and Nguyen *et al.*, 2020). In India around 13.3 million hectares of land is affected by salinity. Uttar Pradesh alone has about 1.37 million hectares of saline and sodic soils whereas Rajasthan has 3.75, Punjab 1.5 lakh and Haryana 2.32 hectares of land affected by salt accumulation. Salinity decreases the ability of plants to take up water andthis rapidly causes reductions in the rate of growth, along with a metabolic change same as caused by water stress.

The proper use of N fertilizer in all soils is important, but particularly so in saline soils where N might reduce the adverse effects of salinity on plant growth and yield (Albassam, 2001 and Flores *et al.*, 2001). On the other hand, over fertilization with N may contribute to soil salinization and increase the negative effects of soil salinity on plant performance. Studies of plant growth responses to N and soil salinity during the whole plant life cycle are important to reveal whether the amount of N applied alleviates or aggravates the detrimental effects of salinity during specific growth stages.

Finger millet (*Eleusine coracana* Gaertn.), commonly known as ragi and African millet, is grown under varied agro-climatic conditions, mostly in countries in Africa and Asia. It is important staple millet and cultivated mostly as a rain fed crop in India under diverse production environments. In India the crop is grown in an area of 1.6 million ha with a production of 2.1 million t and productivity of 1.3 t ha^{-1} (Krishnappa *et al.,* 2009). In finger millet grain, total fiber (22.0%) is comparatively higher than other cereal grains (*e.g.* 12.6%, 4.6%, 12.8% and 13.4% in wheat, rice, sorghum and maize, respectively). Excellent grain storage quality attributable to polyphenol content makes finger millet an ideal cereal for famine reserves. The aim of present study to compare the ameliorative effects of nitrogen application on vegetative growth and productivity of *Eleusine coracana* under saline conditions.

MATERIALS AND METHODS

The effect of nitrogen application were observed in two varieties of finger millet *viz*. VL-315 (salt promising) and Local Hills (salt sensitive) under saline water irrigation. The Pure line seeds of both varieties were procured from Govind

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Ballabh Pant University of Agriculture and Technology, Hill Campus, Tehri Garhwal, Uttarakhand. Healthy and uniform sized seeds were surface sterilized with 0.01% $HgCl_2$ for a minute. These seeds were washed repeatedly in tube well water to remove traces of $HgCl_2$ and then sown separately in 1× 1 m size nursery beds. Twenty five days old seedlings, attained the height of 5-6" were uprooted and transplanted into the experimental micro-plots. Each micro-plot was irrigated with saline water of different EC levels *viz.* 3, 6, 7.2, 10, 12 and 14 dSm^{-1} which were prepared by mixing the salts of NaCl, Na_2SO_4, $NaHCO_3$ and $CaCl_2$ in tube well water. The dose of nitrogen nutrition was given in the form of urea at 50 kg/hectare through split manner *i.e*. in two equal halves. One part of this dose was given just before transplanting the seedlings in the soil whereas second dose was given after 15 to 20 days from transplanting the seedlings for high yielding. The data on different growth parameters were recorded at the final harvest (130 days after sowing) and subjected to statistical analyses. F-tests for significance were conducted using Tukey t-tests at $P \leq 0.05$ significance level.

RESULTS AND DISCUSSION

Interactive effects of saline water irrigation and nitrogen nutrition on plant growth and productivity of two cultivars of finger millet *viz*. VL-315 and Local Hills are presented in Fig (a-j). Statistical analysis of the data indicated that nitrogen nutrition had significantly promoted plant height over corresponding non fertilized plants at all salinity levels; however, there is no clear evidence that up to what EC level, the nitrogen application has evoked the plant height.

It is cleared from figures that salinity had evoked adverse responses at different salinity levels, but, nitrogen application has invariably and positively affected plant height. Extension growth of both genotypes was adversely and significantly affected by saline irrigation, however, nitrogen application has minimized this effect at different levels. Plant height was higher not only in cv. VL-315 than Local Hills but also in nitrogen applied plants irrespective of saline irrigation. The reductions ranged 9.6-37.8% and 9.8-38.5% in cv. VL-315 and 13.1-63.3% and 13.8-65.45% in Local Hills in both nitrogen applied and non applied sets respectively.

Dry weight of shoot and root were declined significantly in both cultivars in both fertilized and non-fertilized sets at different salinity levels. Fig (b) revealed that shoot dry weight was higher in cv. VL-315 than Local Hills in both treated and non-treated sets at different salinity levels. The reductions in dry weight of shoot were less in cv. VL-315 (19.8-78.56%) than Local Hills (46.48-94.78%) in nitrogen treated set but, reductions were more pronounced in cv. Local Hills (50.7-96.0%) in non nitrogen treated sets at 3 to 14 dSm^{-1}. It is interesting to note that nitrogen nutrition had expressed positive effect on dry matter production irrespective of the saline irrigation. Cv.VL-315 registered lesser inhibition in root dry weight (27.3-73.6%) than Local Hills (45.6-94.1%) in nitrogen treated sets as compared to non treated sets. Fig (c) also revealed that cv. Local Hills recorded higher root dry weight only in control sets in both fertilized and non-fertilized plants. Therefore, it appears that cv. Local Hills expressed poor performance in both nitrogen treated and non-treated sets under irrigation with saline water (3 to 14 dSm^{-1}). Leaf dry weight of cv. VL-315 also revealed that nitrogen applied sets registered lesser reductions (15.9, 51.2, 55.6, 61.8, 72.4 and 79.42%) than Local Hills (48.4, 70.2, 72.9, 82.3, 87.0 and 91.8%) at different salinity levels (3 to 14 dSm^{-1}) which indicated that nitrogen application could minimize the salt induced effect at lower salinity levels as compared to the higher ones. Leaves dry weight indicates that N_2 treated plants have assimilated more carbon as compared to non treated sets at different saline levels in cv. Local Hills. It is also clear from data that cv. Local Hills registered higher reductions (up to 94%) than VL-315 at different salinity regimes in both nitrogen fertilized and non fertilized plants.

Fig (i) also revealed that nitrogen treatment expressed additive effect on number of panicles/plant in both cultivars over non treated sets but, the reduction was higher in cv. Local Hills than VL-315 in nitrogen applied and non applied sets. The reduction ranged from 14.3-85.7% and 33.0-83.0% in cv. VL-315 and 25.0-75.0% and 50.0-84.3% in Local Hills in nitrogen fertilized and non fertilized sets respectively at 3 to 14 d Sm^{-1}. The length of panicle was declined insignificantly in non treated sets of both cultivars at 3 to 7.2 dSm^{-1} but, declined significantly in nitrogen applied sets. Similar results were recorded at 3 EC and in controls of both cultivars. Fresh and dry weight of panicles/plant progressively and significantly declined in both genotypes at all salinity levels except 3 EC irrigated without nitrogen treatment of VL-315 while nitrogen application enhanced fresh and dry weight as compared to non treated sets of both cultivars. The reduction in fresh weight of panicle/ plant ranged from 20.7-83.7% in cv. VL-315 and 55.4-92.3% in Local Hills in nitrogen treated sets. The reduction in dry weight of panicle/plant ranged from 6.25-78.0% in cv. VL-315 and 54.1-95.4% in Local Hills in nitrogen treated sets.

Similarly Fig (j) also revealed that grain yield/plant was also enhanced in nitrogen applied plants as compared to non treated plants. Cv. VL-315 exhibited 16.0% enhancement while Local Hills registered average 24.3% when treated with nitrogen. The combined effects of saline irrigation and nitrogen application on 1000 grains weight was also observed which indicated a significant increase in both varieties as compared to untreated plants. The enhancement ranged from 3.7-10.7% in cv. VL-315 and 3.4-11.8% in Local Hills in nitrogen applied plants.

The saline water irrigation caused inhibitory effects on the plant growth and grain productivity of finger millet but, N fertilization can reduce or minimize the deleterious effects of salinity. Understanding salinity-fertilizer relationships is of great economic importance and many studies have been conducted to evaluate nitrogen and other nutrients uptake

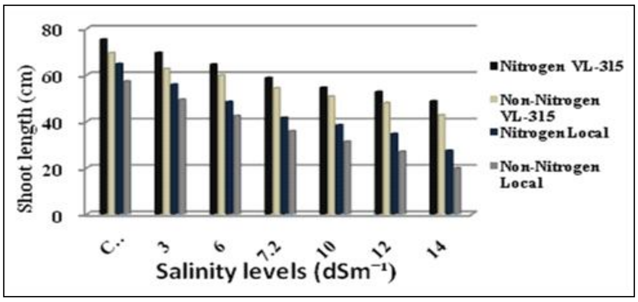

Fig (a): Shoot length.

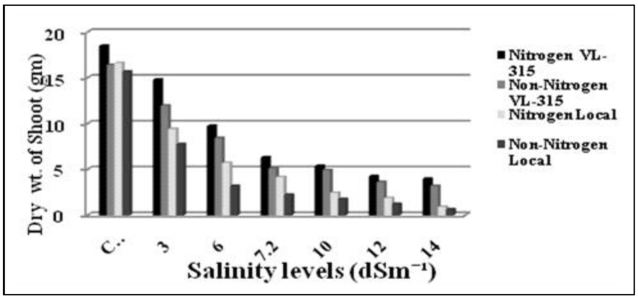

Fig (b): Dry wt. of shoot.

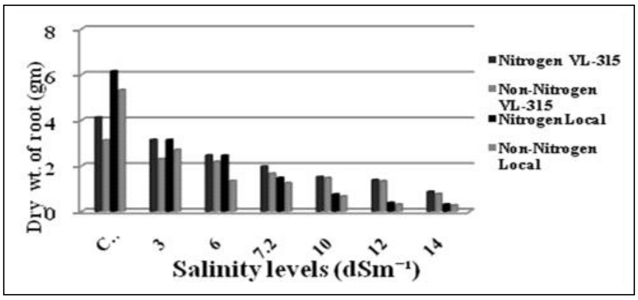

Fig (c): Dry wt. of shoot.

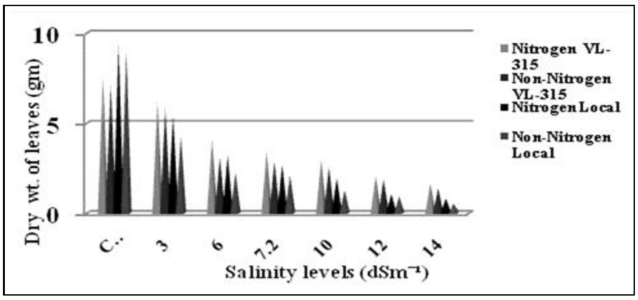

Fig (d): Dry wt. of leaves.

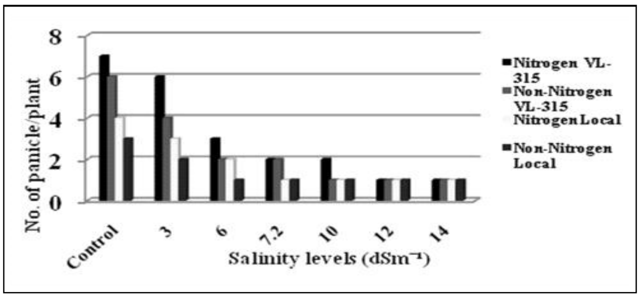

Fig (e): No. of panicle/plant.

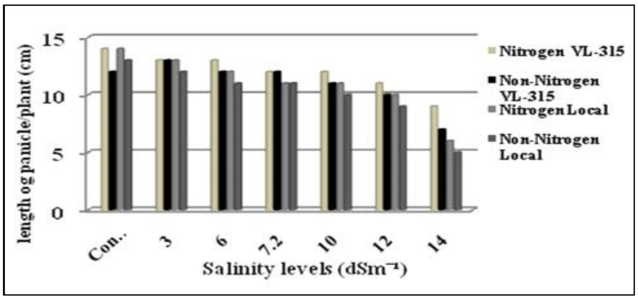

Fig (f): length og panicle/plant.

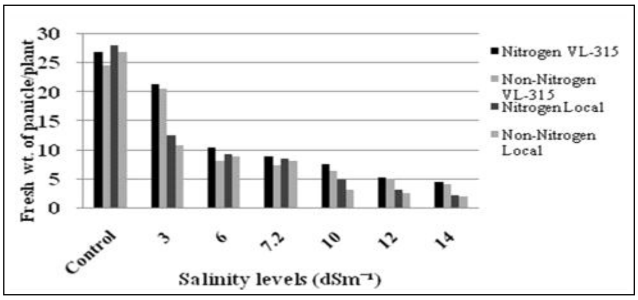

Fig (g): Fresh wt. of panicle/plant.

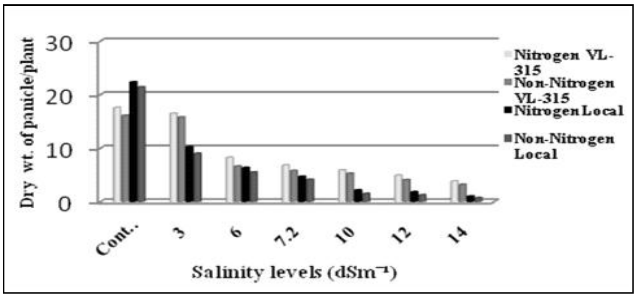

Fig (h): Dry wt. of panicle/plant.

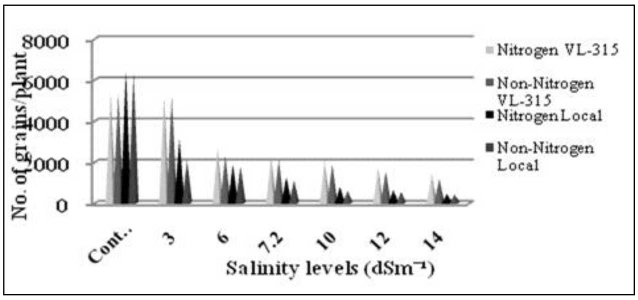

Fig (i): No. of grains/plant.

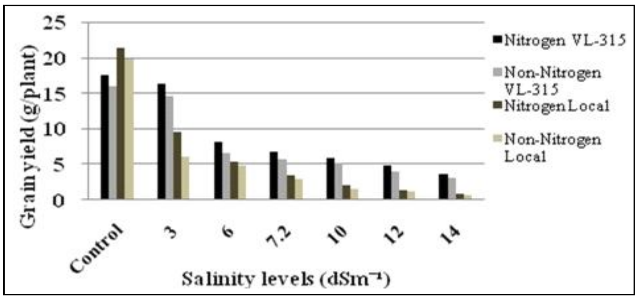

Fig (j): Grain yield.

by plants under saline conditions (Villa-Castorena *et al.*, 2003; Kutuk *et al.*, 2004 and Ahanger *et al.* 2019). Therefore, the interactive effects of nitrogen nutrition and saline water irrigation were observed in two selected cv. VL-315 and Local Hills of finger millet.

Plant height was adversely affected with different saline irrigations, but, nitrogen application enhanced extension growth as compared to non nitrogen applied sets. The enhancement was higher at lower salinity levels (3-7.2 dSm^{-1}). The plant length was higher in cv. VL-315 than Local Hills in nitrogen applied plants. On comparing nitrogen applied and non applied sets, nitrogen application significantly and positively affected the shoot dry weight. These results are supported by the findings of Khan *et al.* (2000) and Achakzai and Kayani (2002) who reported that plant height was increased with an increase in nitrogen doses in soybean. According to Chen *et al.* (2010) and Sikder *et al.* (2020), the adverse effects of soil salinity on cotton growth could be alleviated by N application, but over fertilization with nitrogen might contribute to soil salinization and increase the negative effects of soil salinity on plant performance. Similarly, Kaya and Higgs (2003) reported that supplementary urea could overcome the effects of high salinity in pepper plants.

Dry weight of root was adversely affected by saline irrigations however; it was minimized by nitrogen fertilization. This enhancement was higher in cv. VL-315 than Local Hills. It is observed that in combined effects of nitrogen as well as of salinity, N fertilizer ameliorated the adverse effects of salinity to some extent on leaf growth and there more carbon was assimilated in the nitrogen applied plants as compared to non applied. The grain yield was also positively influenced by nitrogen application as compared to non nitrogen applied sets. Cv. VL-315 expressed higher grain productivity than Local Hills in both nitrogen applied and non applied plants. Our findings are supported by Al-Alawy and Al-Bandawy (2017) in wheat and Krishna *et al.* (2020) in finger millet. Misra *et al.* (1973) also reported significant increase in yield attributes and grain yield in finger millet only up to 60 kg N/ha. Nitrogen application increased dry matter production and grain yield. It is concluded that the increase might be due to increased leaf area index (LAI), green spikes area and an increase in green period of the leaves, which resulted in increased capture of radiation energy and consequently more dry matter production. It is also attributed that increase in grain yield from N application to an increase in the number of kernels per unit area. These findings are also suggested by Latiri-Souki *et al.* (1998); Zayed *et al.* (2013) and Guanglong *et al.* (2020) in rice.

Overall, it is concluded that nitrogen nutrition enhanced plant growth and yield productivity more in cv. VL-315 than Local Hills up to certain (7.2 dSm^{-1}) salinity level and could minimize the deleterious effect of salinity. Hence this cultivar may be recommended for cultivation under saline conditions.

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Conflict of interest

All authors declare that they have no conflict of interest.

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