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A Review

Effect of saline water on growth, yield, quality and soil properties in barley (*Hordeum vulgare* L.)

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Abstract : The opportunities for salinity research are enormous due to size and diversity of the country, where all kind of soils and waters of varying quality are encountered and require solutions. Salt accumulation leads to two major stresses for the plants: osmotic stress and ionic stress. The osmotic stress firstly comes in plants when salt concentrations increase outside the roots, which leads to reduction in water uptake and subsequently plant development. The ionic stress develops when Na^+ accumulation increases in plants particularly in leaves over threshold level which causes chlorosis in leaves and reduced photosynthesis and other metabolic activities. Several researchers and eminent investigators observed that higher salt concentration takes place near or immediate below the soil surface which significantly impaired the growth parameters of barley. They observed negative effect of salinity on growth and the development of barley in comparison with control treatment. Lower level of salinity upto 3 dS/m did not significantly influence the seed germination, whereas higher salinity level significantly decreased seed germination, plant height and total dry matter production. Irrigation with higher salinity levels significantly decreased tillers plant^{-1}, spikes plant^{-1}, 1000-grain weight, grain yield, straw yield, harvest index and leaf K: Na as compared to control treatment. Higher levels of salinity increased the total soluble sugars but decreased the protein and oil contents as compared to under non-saline conditions. EC and SAR of soil was increased with increasing levels of salinity resulting into decreased, but there was a substantial decrease in soil pH, K: Na ratio, P uptake, K content in the grain and straw as well as available N, P and K in soil.

Key Words : Barley, Growth, Quality, Saline water, Soil properties, Yield

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Introduction

Barley is considered better for malting purposes as compared to all other cereal crops because its glumes and hulls are cemented to kernel, which remain attached to the grain after threshing. During germination process, hull protects the coleoptile from damage as it grows and elongates under the hull. It also acts as a filter and aids in separation of soluble materials. Kernel texture of steeped barley is also firmer and its amylase activity makes it unique for malt recovery. Therefore, barley grains are more suitable for malt purpose and its quality depends on the traits like test weight, grain plumpness, husk content, grain protein content, γ- amylase activity

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and diastatic power. Amongst all these, protein content of grain is key characteristic for malting quality. The annual requirement of barley for malting purposes is on rise in recent years. The current estimates indicate that now about 30% malt is used for energy drinks, pharmaceuticals and confectioneries, 8% for whiskies and the balance (around 60-62 %) is used by breweries. In India, barley is now becoming more and more important as a commercial crop for industrial raw materials particularly with respect to malting and brewing. Thus, barley needs to be promoted as an industrial crop for malting and feed industry to provide better returns to the marginal and sub-marginal farmers.

Soil salinity is a major crop production constraint affecting about 397 million hectares worldwide). India is also occupied with a significant area under salt affected soils and poor quality waters. In India, there is about 6.7 million hectares area under salt affected soils, out of which saline and sodic soils covered 2.9 and 3.7 million hectares, respectively (Mandal *et al*., 2011). In Haryana state, around 0.53 million hectares area and 55 per cent of the ground water used for irrigation is of poor quality. Amongst the poor quality water, the proportion of sodic, saline and saline-sodic water is 18, 11 and 26 per cent, respectively. Relative concentration of salts present in irrigation water plays a vital role in developing salinity in soil. Electrical conductivity (EC) of soil gradually increases with increasing levels of saline water (Kalhoro *et al*., 2016) and hence increasing the salt accumulation and concentrations of different salts (Na^+, K^+, Ca^{2+}, Mg^{2+}, CO_3^{2-}, HCO_3^- and Cl^-) in soils (Ragab *et al*., 2008). Due to uncertainty of rainfall and scarcity of water, farmers of Haryana often irrigate the crops with poor quality water and this situation is likely to become more alarming with the depleting water resources. Thus, there is need to find out the ways to use poor quality water for crop production.

Barley is one of the most salt tolerant crops and can be adopted in a condition where the irrigation quality of the water is saline in nature. In recent years, on one hand, productive agricultural lands are decreasing due to salinity while on the other hand the population increase further enhancing the demand for agricultural products. It has not only threatened the sufficiency of available food resources but also has necessitated bringing marginal land under cultivation. The development of crops with increased salt tolerance and the adoption of new crop and water management strategies will further enhance the use of saline waters for irrigation and crop production. Kumar *et al.* (2012b) observed that lower salinity level (3.0 dS/m) did not significantly affect the yield and yield attributing characters of wheat but higher salinity levels reduced the grain yield over control. The importance of barley derives from its ability to grow under saline conditions and in marginal environments which are often characterized by high temperature and drought (Al-Dakheel *et al.,* 2012). Keeping such emerging problems in view, the present study signifies the importance of using poor quality water in barley production. Its successful cultivation in agriculture will give solution to world's increasing food demands and help in take off the pressure from fresh water use in agriculture sector.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Effect of saline water on growth parameters of barley:

Plant growth and development is adversely affected by salt stress through osmotic effect, nutritional imbalance and specific ion effect (Moradi *et al.,* 2011). Othman *et al.* (2006) reported that salinity level × genotype interaction effects were significant for seed germination percentage, seed viability and ion uptake. Seed germination decreased significantly by increasing salinity level. Germination was significantly diminished at the highest level of salt (300 mM) with significant variation among different genotypes. Bakhat *et al.* (2007) reported that shoot and root fresh weight, shoot length, Na^+, K^+ concentration and K^+/Na^+ ratio was significantly affected by increasing NaCl salinity while a non-significant effect of salinity was observed on root length, shoot dry weight and root dry weight. Salinity caused significant reduction in all parameters of barley except K^+ concentration where a negative correlation was noted with increased salinity.

Rahman *et al.* (2008) carried out field experiments on four wheat cultivars to see the performance of various levels of saline water. They observed that higher salinity (NaCl concentrations) level reduced the shoot length, root length and total dry matter of all the cultivars. There was reduction of 60 to 90 % in root biomass and 68 to 90% in shoot biomass. They also observed that root growth is more affected by salinity stress than above ground parts. Neelam *et al.* (2010) carried out a field study to see impact of different NaCl levels (100, 200 and 500 mM) on growth and yield components of *Brassica juncea* variety PBR 210. They observed reduction in plant height under different salinity levels as compared to control treatment.

Kumar *et al*. (2012a) observed that lower level of salinity upto 3 dS/m did not significantly influence the seed germination and various growth parameters of wheat, whereas higher salinity level significantly decreased seed germination. Plant height increased at lower level of salinity upto 3 dS/m and with increasing level of salinity there was a significant reduction of 33% at 25 DAS, 23% at 75 DAS and 22% at 90 DAS. Similarly higher salinity (> 3 dS/m) level showed a drastic reduction in total dry matter production at different growth stages. Various crop growth indices *viz*., CGR, RGR, NAR, LAI and LAD of wheat crop also decreased at 30, 60, 90, 120 DAS and at maturity with increase in salinity levels.

Al-Busaidi *et al.* (2012) carried out field experiments at Oman to see influence of saline irrigation and leaching fraction on growth of barley. For this purpose highly saline water was diluted to the salinity levels of 3, 6 a nd 9 dS m^{-1}. The results of the experiment showed that both quantity and quality of water regulated salts distribution within the soil. They observed higher salt concentration near or immediate below the soil surface and the salinity of water significantly impaired the growth parameters of barley. The good drainage of sandy soil enhanced the leaching process and minimized the differences between leaching fractions. The increment in saline treatments (3, 6 and 9 dS m^{-1}) added more salts and stressed plant growth. However, the conjunctive use of marginal water at proportional leaching fractions could be effective in enhancing the yield potential of crops in water-scarce areas.

Hamam and Negim (2014) observed that the leaf area $plant^{-1}$ of wheat crop under saline water irrigation was decreased by 8.4, 18.1, 26.4 and 33.9% when treated with 25, 50, 75 and 100 mM NaCl, respectively as compared to the control treatment. Averina *et al.* (2014) reported that when barley seedlings were grown in 150 mM NaCl solution, the plant growth and the root system development were suppressed upto the levels of 63 ± 6% and 61 ± 11%, respectively as compared to control treatment.

Effect of saline water on yield and yield attributes:

The effect of irrigation water at different EC levels in barley was studied by Sharma and Minhas (2005) at Hisar and reported that saline water irrigation significantly decreased the crop productivity. They observed that application of irrigation water wih 2-4 dS m^{-1}, 4-6 dS m^{-1} and 6-8 dS m^{-1} EC gave 100, 89 and 60% grain yield of wheat, respectively, thus, showing a decreasing trend with increasing salinity level. Ragab *et al.* (2008) carried out the pot study in wheat and observed that irrigation with saline water significantly reduced the test weight. In general, higher the salt in irrigation water, the lower was the test weight and vice versa. They also observed significant reduction in grain yield with increase in irrigation water salinity above 0.43 dS m^{-1} and the reduction was highest at salinity level of 8.86 dS m^{-1}.

Asgari *et al.* (2012) conducted a pot experiment using saline water with ECe of 3 dS m^{-1} (control), 8, 12, and 16 dS m^{-1} in wheat crop. They observed that irrigation with higher salinity levels significantly decreased tillers $plant^{-1}$, spikes $plant^{-1}$, 1000-grain weight, grain yield, straw yield, harvest index and leaf K: Na as compared to control treatment. Kumar *et al.* (2012a) reported that yield attributes and yield of wheat was not significantly influenced by lower level of salinity (3.0 dS m^{-1}) but higher salinity levels of 6.0, 9.0 and 12.0 dS m^{-1} significantly reduced the grain yield and straw yield over the control treatment.

Khaled *et al.* (2014) determined the total biomass at harvest, straw yield and yield components of barley associated with different fertilizer doses. They observed negative effect of salinity on growth and the development of barley in comparison with control treatment. The comparison between the different fertilization treatments showed that nitrogen influenced positively on spikes m^{-2}, grains m^{-2} and grain yield m^{-2}. Kumar *et al*. (2014b) observed that the number of grains $spike^{-1}$, 1000-grain weight and straw yield of different barley cultivars were significantly decreased with increase in salinity levels. Similarly, Maamoun (2014) reported that increasing salinity level of irrigation water from TDS 4236 to 7001 ppm significantly decreased the test weight, grain yield and straw yield of wheat.

Yadav *et al.* (2015) carried out a field experiment at Hisar to study the effect of saline water irrigation on the yield and mineral composition of wheat. They reported that irrigation with different salinity levels *viz.,* ECiw of 0.4, 2, 4, 6, 8 and 10 dS m^{-1} showed a significant reduction of 15, 21, 28, 49 and 55% in grain yield and 2, 4, 7, 19 and 28 % in straw yield, respectively.

Effect of saline water on grain and malt quality parmeters:

Nutrients uptake and its transport to the shoot were decreased by soil salinity thus causing nutrient imbalance in the plant (Evelin *et al.* 2009). Singh *et al.* (2002) observed significantly higher protein content in grain with 150 kg N ha^{-1} in comparison to 90 and 120 kg N ha^{-1}. Agarwal *et al.* (2011) carried out field experiments on four *Brassica* genotypes under saline (EC_e=7.5 dSm^{-1} and pH=8.4) and non-saline (EC_e=2.1 dSm^{-1} and pH=7.8) conditions to study the effect of salinity on morpho-physiological parameters, photosynthetic efficiency, water relation parameters, biochemical and seed quality parameters. They observed that salinity (EC_e=7.5 dSm^{-1} and pH=8.4) increased the total soluble sugars but decreased the protein and oil contents as compared to under non-saline conditions.

Kumar *et al.* (2012b) reported that under saline conditions, the protein content in grains of wheat was significantly higher in treatment receiving 150 kg N ha^{-1} in comparison to lower N levels.

Maamoun (2014) observed that increasing salinity level of irrigation water from TDS 4236 to 7001 ppm, caused significant reduction in the protein yield of wheat crop. Kharub and Chander (2012) reported that the agronomic practices that were most beneficial for malt barley production are early seeding and application of nitrogen fertilizer at appropriate rates. In the case of saline soil and barley grown for malting and brewing, the entire doses of all the fertilizers are applied at sowing.

Effect of saline water on plant and soil properties :

Reihan (2002) conducted both laboratory and field studies to determine the effect of salinity and sodicity effect on soil properties. They observed that EC and SAR of soil increased with increasing level of salinity and there was a negative correlation between SAR and infiltration rate. The nitrogen use efficiency of applied fertilizer is adversely influenced by presence of salt in high concentration. The hydrolysis of urea was inhibited by high salinity and high pH. Available nitrogen and organic matter were positively correlated between themselves while they were negatively correlated with pH and ESP, therefore, the efficiency of nitrogenous fertilizer applied in saline soil was reduced, but it was improved by applying nitrogenous inorganic fertilizer along with organic manures. The availability of phosphorus in soil decreased significantly with the increasing level of soil salinity. This may be explained on the basis of the fact that increasing levels of salinity in water increased the EC of soil resulting into decreased availability of N, P and K. Increasing levels of nitrogen increased the nitrogen content in plants. The increase in nitrogen content in different parts of plants may be attributed to reduction in growth and total dry matter accumulation (Sharma, 2013 and Daoud, 2005). Reduction in P uptake may be attributed to the poor root system under the saline soils (Irshad *et al.* 2002). Reduced K content in the grain and straw of different plant parts under saline irrigated water was due to increased sodium concentration in soil solution which in turns suppress the potassium uptake and hence content (Sharma, 2013).

Ragab *et al.* (2008) studied the effect of irrigation water salinity on yield and chemical composition of wheat (*Triticum vulgare* cv. Sakha 8) plants grown in a pot experiment. Irrigation water have salinity levels of 0.43 (control), 4.85, 6.60 and 8.86 dSm^{-1}. The results showed that there was a substantial decrease in K: Na ratio with each increase in irrigation water salinity level. Siddiqui *et al.* (2008) carried out a field study to see influence of NaCl (120 mM) stress on growth parameters and nutrient content of ten genotypes of *Brassica juncea* at 55 and 65 days after sowing. They reported that NaCl treatments decreased shoot length $plant^{-1}$, leaf area, leaf area index, fresh weight and dry weight $plant^{-1}$, leaf nitrogen, potassium and sodium content and leaf K: Na. Salt stress increased Na content while it decreased N and K content and K: Na in all the genotypes.

Khan *et al.* (2008) carried out a field experiment to investigate the physiological responses of different genotypes of *Brassica napus* under salinity and drought stress together by applying irrigation water of 150 mM NaCl solution. They reported that Na^+ ions in each genotype increased significantly in combined stress plants compared to unstressed plants. There were less K^+ and Ca^{2+} ions in the stressed plants as compared to unstressed plants and control treatment. Pak *et al.* (2009) studied the effect of salt stress on sodium and potassium ions content of ten genotypes of rape (*Brassica napus* L.) plants. These genotypes were subjected to salinity levels of control (2.5), 6, 10, 14 and 18 dSm^{-1} for 30 days in hydroponics. They observed that shoot Na^+ content increased with increased salinity levels, but in genotype MHA 4921 this increase was comparatively higher as compared to other genotypes. K^+ content in shoots of MHA 4921 and Hyola 401 were higher than other genotypes at different levels of salinity.

Solhi *et al.* (2012) reported that soil salinity changes along the soil profile and soil salinity was reduced in all soil depths of 0-30 cm, 30-60 and 60-90 cm during the growing season. The reduction in soil salinity was significantly higher in the upper soil depths. This was attributed to the longer growth period of barley that leached more salts in the lower layers. Rameeh (2012) carried out pot study to see influence of salinity stress on yield associated traits and shoot ions composition with eight rapeseed genotypes. These genotypes were evaluated with three salinity levels of irrigation water including 0, 6 and 12 dS m^{-1}. They reported that among shoot ions compositions, K showed significant positive correlation with seed yield, therefore this ion was considered as good indicator for improving seed yield in saline environment.

Singh *et al.* (2014) investigated the effect of salinity on oil content of mustard under normal and saline environments in the field (EC_e 10.7dSm^{-1}) and net-house using saline irrigation levels (EC_{iw} 0, 9, 12, 15, 18 dSm^{-1}). They observed that oil content decreased by 7.27% and 5.78% in net house and field conditions, respectively with highest salinity level. Hama and Negim (2014) evaluated 16 genotypes of spring wheat from different countries for salt stress tolerance in greenhouse under saline water irrigation. The treatments applied for each genotype were tap water (control), 25, 50, 75 and 100 mM NaCl. Results revealed that soil pH decreased significantly from 7.95 to 7.80 in all treatments irrigated with saline water. Soil electrical conductivity (EC) increased from 3.28 to 6.22 dS m^{-1} in all treatments. The irrigation with saline water showed increase in soluble cations and anions in soil. Khan *et al.* (2014) reported that soil salinity increased with the increase in water salinity level. EC_{iw} also significantly affected the soil properties.

Yadav *et al.* (2015) observed increase in N, Na, Mg and Cl contents and decrease in P, K, Ca, and SO_4-S content of wheat grains and straw with increasing level of salinity in irrigation water. The increase in N content of wheat grains and straw was 9, 12, 14, 17 and 19%, and 40, 69, 90, 92 and 101% at 2, 4, 6, 8 and 10 dS m^{-1} EC of irrigation water, respectively as compared to control treatment. Saline water used for irrigation was chlorine dominated and hence 5, 8, 9, 13 and 21% reduction in the P content of grains was observed as compared to control. Similarly a drastic reduction in the K content of grain (5, 13, 15, 21 and 23%) and straw (1, 3, 5, 9 and 9%) was observed at 2, 4, 6, 8 and 10 dS m^{-1} EC of irrigation water, respectively as compared to control. This may be due to the fact that K availability is impaired by the presence of Ca, Mg and Na from the added salt to the soil by using saline water as irrigation have substantial amount of these cations. Su *et al.* (2016) studied the effects of salinity on soil organic carbon and reported that SOC and total nitrogen concentration, cation exchange capacity and labile fractions (microbial biomass carbon, easily oxidizable carbon) decreased significantly with increasing EC_e.

Kumar *et al.* (2018) carried out field experiments at Hisar to evaluate the performance of integrated nutrient management treatments on wheat cultivar WH 711 under saline and non-saline irrigation water. They observed that available N, P and K and organic carbon were significantly higher under canal irrigation treatment as compared to saline water application, while soil pH did not differ significantly after completion of the experiment. Significantly higher values of EC were recorded under saline water treatment than under canal

Table 1: Effect of saline water irrigation on soil pH, EC and organic carbon (OC) after completion of two year of experimentation in relation to barley varieties and nitrogen levels

Treatments	Soil pH	EC (dS m^{-1})	OC (%)
Varieties			
BH 902	8.10	0.81	0.33
BH 946	8.12	0.81	0.34
BH 885	8.11	0.86	0.33
DWRB 101	8.10	0.84	0.33
S.E. ±	0.02	0.04	0.002
C.D. (P=0.05)	NS	NS	NS
Nitrogen levels (kg ha^{-1})			
Control	8.15	0.90	0.32
30	8.13	0.85	0.33
60	8.10	0.81	0.34
90	8.06	0.76	0.35
S.E. ±	0.02	0.01	0.002
C.D. (P=0.05)	0.05	0.03	0.01
Interaction	NS	NS	NS
Initial soil status	8.30	0.33	0.31

Source: Kaur and Satyavan (2021 NS= Non-significant water treatment. Application of 125% recommended dose of fertilizer recorded significantly higher available N, P and organic carbon as compared to 100 and 75% recommended dose of fertilizer.

Kaur and Satyavan (2021) reported that after completion of two years of experimentation, irrigation to barley with saline water decreased the soil pH while soil EC, soil OC and available N status of soil was increased as compared to the initial status of soil. Two-row varieties BH 885 and DWRB 101 exhibited significantly lower values of Na: K at spike initiation stage as compared to 6-row varieties BH 902 and BH 946, thus indicating better salt tolerance in 2-row barley varieties.

So, it may be concluded that salinity has negative effect of on growth and the development of barley in comparison with control treatment. Lower level of salinity up to 3 dS/m did not significantly influence the seed germination, whereas higher salinity level significantly decreased seed germination, plant height and total dry matter production. Irrigation with higher salinity levels significantly decreased tillers plant^{-1}, spikes plant^{-1}, 1000-grain weight, grain yield, straw yield, harvest index and leaf K: Na as compared to control treatment. Higher levels of salinity increased the total soluble sugars but decreased the protein and oil contents as compared to under non-saline conditions. EC and SAR of soil was increased with increasing levels of salinity, but there was a substantial decrease in soil pH and K: Na ratio.

REFERENCES

Agarwal, V. P., Kakralya, B. L. and Gupta, S. (2011). Effect of salinity on morpho-physiological and seed quality attributes of brassicas. *Ann. Arid Zone.*, **50**: 127-130.

Al-Busaidi, A., Rabeea, J., Ahmed, M. and Al-Rawahy, S. (2012). Estimating leaching requirements for barley growth under saline irrigation. *Agric. & Marine Sci*., **17**:1-8.

Al-Dakheel, A. J., Belhaj Fraj, M., Shabbir, G. M. and Al Gailani, A. Q. M. (2012). Evaluation of Batini barley landraces from Oman and breeding lines under various irrigation salinity levels. *Agric. Sci. Res. J.,* **2**: 42-50.

Asgari, H. R., Cornelis, W. and Damme, V. P. (2012). Salt stress effect of wheat growth and leaf ion concentrations. *Inter. J. Plant Prod*., **6**: 195-208.

Averina, N. G, Beyzaei, Z., Shcherbakov, R. A. and Usatov, A. V. (2014). Role of nitrogen metabolism in the development of salt tolerance in barley plants. *Russian J. Plant Physiol.,* **61**: 97-104.

Bakhat, J., Shafi, M., Khan, A. A., Hussain, S., Tariq, M., Akbar, H., Jan, A. U. and Rehman, M. U. (2007). Growth performance of oat and barley at early seedling stage under saline environment. *Sarhad J. Agric.,* **23**: 565-569.

Daoud, A. M. (2005). Yield response and mineral composition of wheat in relation to the applied silicon under saline environment. *Alexandra Sci. Exchange J*., **26**: 385-395.

Evelin, H., Kapoor, R. and Giri, B. (2009). Arbuscular mycorrhizal fungi in alleviation of salt stress: a review. *Ann. Bot*., **104**: 1263-1280.

Hamam, K. A. and Negim, O. (2014). Evaluation of wheat genotypes and some soil properties under saline water irrigation. *Ann. Agric. Sci.,* **59**: 165-176.

Irshad, M., Honna, T., Enej, A. E. and Yamamoto, S. (2002). Wheat response to nitrogen source under saline conditions. *J. Plant Nutr.,* **25**: 2603-2612.

Kalhoro, N.A., Rajpar, I., Kalhoro, S.A., Ali, A., Raza, S., Ahmed, M., Kalhoro, F.A., Ramzan, M. and Wahid, F. (2016). Effect of salts stress on the growth and yield of wheat (*Triticum aestivum* L.). *Am. J. Plant Sci.,* **7:** 2257-2271.

Kaur, A. and Satyavan (2021). Influence of barley varieties and nitrogen levels on chemical properties of soil under saline water irrigation. *J. Soil Salinity & Water Quality,* **13**: 49-54.

Khaled, A. B., Hayek, T., Mansour, E. and Ferchichi, A. (2014). Comparing the interactive effects of NPK fertilization and saline water on two genotypes of barley (*Hordeum vulgare* L.) grown in southern of Tunisia. *Int. J. Curr. Microbiol. Appl. Sci.,* **3**: 711-721.

Khan, A., Mohammad, J., Mohammad, A., Khan, B. M. and Amanullah, J. (2008). Phenology and crop stand of wheat as affected by nitrogen sources and tillage systems. *Pak. J. Bot.,* **40**: 1103-1112.

Kharub, A. S. and Chander, S. (2012). Production technology for malt barley. *A compendium of lectures on "Malting quality improvement in Barley, Sorghum and Corn", January 28-February 6, 2012.* DWR Compendium No. 5: 56-62.

Kumar, D., Narwal, S., Verma, R. P. S., Kharab, A. S., Kumar, V. and Sharma, I. (2012a). Genotypic variability in β-glucan and crude protein contents in barley genotypes. *J. Wheat Res.,* **4**: 61-68.

Kumar, R., Singh, M. P. and Kumar, S. (2012b). Effect of salinity on germination, growth, yield and yield attributes of wheat. *Int. J. Scient. and Technol. Res.,* **1**: 19-23.

Kumar, V., Khippal, A., Singh, J., Selvakumar, R., Malik, R., Kumar, D., Kharub, A. S., Verma, R. P. S. and Sharma, I. (2014b). Barley research in India: Retrospect and Prospects.

J. Wheat Res., **6** : 1-20.

Kumar, V., Naresh, R. K., Kumar, S., Singh, V. K., Singh, S. P. and Mahajan, N. C. (2018). Tillage, crop residue and nitrogen levels on dynamics of soil labile organic carbon fractions, productivity and grain quality of wheat crop in typicustochrept soil. *J. Pharmacognosy & Phytochem*., **7**: 598-609.

Maamoun, H. A. (2014). Effect of silicon and saline irrigation water on productivity of two wheat cultivars at South Sinai, Egypt. *Egypt. J. Soil Sci.,* **54**: 319-336.

Mandal, A. K., Reddy, G. P. and Ravisankar, T. (2011). Digital database of salt affected soils in India using geographical information system. *J. Soil Salinity & Water Quality*., **3**: 16-29.

Moradi, A., Tahmourespour, A., Hoodaji, M. and Khorsandi, F. (2011). Effect of salinity on free-living diazotroph and total bacterial populations of two saline soils. *Afr. J. Microbiol. Res.,* **5**: 144-148.

Neelam, S., Dipti, G. and Kaur, N. (2010). Effect of induced salinity stress on growth and yield of Indian mustard (*Brassica juncea*). *Env. and Ecol.,* **28**: 967-968.

Othman, Y., Al-Karaki, G., Al-Tawaha, A. R. and Al-Horani, A. (2006). Variation in germination and ion uptake in barley genotypes under salinity conditions. *World J. Agric. Sci.,* **2**: 11-15.

Pak, V.A., Nabipour, M. and Meskarbashee, M. (2009). Effect of salt stress on chlorophyll content, fluorescence, Na^+ and K^+ ions content in rape plants (*Brassica napus* L.). *Asian J. Agric. Res.,* **3**: 28-37.

Ragab, A.A.M., Hellal, F.A. and Abd El-Hady, E. (2008). Water salinity impacts on some soil properties and nutrients uptake by wheat plants in sandy and calcareous soil. *Aust. J. Basic Appl. Sci.,* **2**: 225-233.

Rahman, M., Soomro, A. U., Zahoor-ul-Haq, M. and Gul, S. (2008). Effects of NaCl salinity on wheat (*Triticum aestivum* L.) cultivars. *World J. Agric. Sci.,* **4**: 398-403.

Rameeh, V., Cherati, A. and Abbaszadeh, F. (2012). Salinity effects on yield, yield components and nutrient ions in rapeseed genotypes. *J. Agric. Sci.,* **57**: 19-29.

Reihan, K. (2002). Effect of salinity and sodicity on soil physical properties (structure & hydraulic conductivity) in Damghan playa. 17th *World Congress of Soil Sci.* Thailand., **20**: 1-6.

Sharma, B.R. and Minhas, P. S. (2005). Strategies for managing saline/alkali waters for sustainable agricultural production in South Asia. *Agril. Water Manage.,* **78**: 136-151.

Sharma, R. (2013). *Effect of salinity and nitrogen level on yield and nutrient uptake of wheat cultivars.* M.Sc. thesis, Department of Agronomy, CCS HAU, Hisar.

Siddiqui, M. H., Khan, M. N. and Khan, M. M. A. (2008). Cumulative effect of soil and foliar application of nitrogen, phosphorus and sulphur on growth, physico-biochemical parameters, yield attributes and fatty acid composition in oil of erucic acid-free rapeseed-mustard genotypes. *J.Plant Nutr.,* **31**: 1284-1298.

Singh, C. B., Vaish, C. P., Khan, A. A. and Jatav, A. L. (2002). Response of sowing methods and nitrogen levels on the yield and quality of wheat. *Seed Tech. News.,* **32**: 13-19.

Singh, R., Singh, A. K. and Kumar, P. (2014). Performance of Indian mustard (*Brassica juncia* L.) in response to integrated nutrient management. *J. Agri.Search*., **1**: 9-12.

Solhi, S., Mahmoud, S., Abdollah, S, Alireza, A., Sayed, F. M. and Jahangir, A. (2012). Effect of nitrogen fertilizers on nitrate leaching from a saline soil profile under corn and barley cultivation. *Int. Res. J. Appl. Basic. Sci.,* **3**: 563-567.

Su, Y., Liu, T., Wang, X. and Yang, R. (2016). Salinity effects on soil organic carbon and its labile fractions, and nematode communities in irrigated farmlands in an arid region, north-western China. *Sciences in Cold & Arid Regions*., **8**: 46-53.

Yadav, A. K., Yadav, P. K., Phogat, V., Tikkoo, A. and Yadav, S. S. (2015). Effect of saline water irrigation on the yield and mineral composition of crops in rice-wheat cropping system. *J. Indian Soc. Soil Sci.,* **63**: 276-282.

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