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Effect of different levels and sources of nitrogen on soil properties, nutrient uptake, and yield of wheat grown on saline soil

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Abstract
The research aimed to study effect of different levels and sources of nitrogen on soil properties, nutrient uptake, and yield of wheat grown on saline soil. The field experiment was carried out at research farm of Department of Soil Science and Agricultural Chemistry, Agricultural Research Station, K. Digraj, Sangli, Maharashtra state, India during post monsoon season during three consecutive years 2014-15, 2015-16 and 2016-17 on different saline soil site. The experimental soil was saline calcareous having Sawargaon series of isohyperthermic family of Vertic Haplustepts. The experiment was laid out in randomized block design with ten treatments and three replications. The treatments were consisting of varying doses of nitrogen *viz*; 100% Recommended dose of nitrogen (RDN), 125% RDN, and 150% RDN kg ha^{-1} with combination of different N sources-urea, ammonium sulphate and calcium nitrate and absolute control. The results revealed that the application of 150% recommended dose of nitrogen through calcium nitrate to wheat recorded higher grain, straw yield of wheat and N, P, K uptake of wheat. However, the application of 150% recommended dose of nitrogen through urea recorded higher net monetary returns (Rs.27,830 ha^{-1}) and B: C ratio (1.74). Hence application of 150% of recommended dose of nitrogen (180 kg ha^{-1}) through urea along with recommended dose of phosphorus (60 kg ha^{-1}) and potassium (40 kg ha^{-1}) + 10 t FYM ha^{-1} to wheat for achieving higher net monetary returns is recommended in saline soils.

Keywords: Nutrient availability, nitrogen fertilizer sources, saline soil, soil properties, uptake, wheat, yield

Introduction
Soil salinity is an enormous problem for agriculture under irrigation. In the hot and dry regions of the world the soils are frequently saline with low agricultural potential. In these areas most crops are grown under irrigation, and to exacerbate the problem, inadequate irrigation management leads to secondary salinization that affects 20% of irrigated land world- wide (Glick *et al.*, 2007) [13]. Irrigated agriculture is a major human activity, which often leads to secondary salinization of land and water resources in arid and semi-arid conditions. Salts in the soil occur as ions (electrically charged forms of atoms or compounds). Ions are released from weathering minerals in the soil. They may also be applied through irrigation water or as fertilizers, or sometimes migrate upward in the soil from shallow groundwater. When precipitation is insufficient to leach ions from the soil profile, salts accumulate in the soil resulting soil salinity (Blaylock *et al.*, 1994) [5]. All soils contain some water-soluble salts. Salinity effects are the results of complex interactions among morphological, physiological and biochemical processes including seed germination, plant growth, and water and nutrient uptake (Akbarimoghaddam *et al.*, 2011; Singh and Chatrath, 2001) [1, 23]. The saline growth medium causes many adverse effects on plant growth, due to a low osmotic potential of soil solution (osmotic stress), specific ion effects (salt stress), nutritional imbalances, or a combination of these factors (Ashraf, 2004) [3].
Nitrogen is an essential element of bio-molecules such as amino acids, proteins, nucleic acids, phytohormones and a number of enzymes and coenzymes. Nitrogen is mainly involved in the initial growth processes, such as replication of chromosomes, synthesis of deoxyribonucleic acids and nuclear protein. Studies showed that N applications can be beneficial in reducing the detrimental effects of salinity by partial substitution of NO_3^{-} with NH_4^{+}. Furthermore N

applications can be beneficial due to the lower energy cost of N assimilation with NH_4^+ as compared to NO_3^- administration. Salinity may affect plant growth and development through high salt concentration in the soil solution cause high osmotic pressure that result in low soil water potential and high concentration of potential toxic ions, such as Na^+ and Cl^{2-}. Soil salinity created by inorganic salts in the growing medium suppress or retard plant growth through osmotic effects of specific ion, inadequate uptake of essential nutrients, or by changing of several process such as nitrogen and carbon dioxide assimilation, protein synthesis and water absorption. In view to above, present study is undertaken to study effect of different levels and sources of nitrogen on soil properties, nutrient uptake, and yield of wheat grown on saline soil.

Material and Methods

Experimental Site and Soils

The field experiment was conducted on saline calcareous soil belonging to Sawargaon series of isohyperthermic family of *Vertic haplustepts* at research farm of Department of Soil Science and Agricultural Chemistry, Agricultural Research Station, K. Digraj, Sangli, Maharashtra, (India) during three consecutive years 2014-15, 2015-16 and 2016-17 on different saline soil site. The initial experimental soil status was given in Table 1.

Collection and Analysis of Soil and Plant Samples

The soil samples were collected from 0-30 cm depth from each plot at the time of sowing and at harvest of wheat. The soil samples were air dried and pulverized to pass through 2 mm sieve for analysis. These soil samples were analysed for various chemical properties. The pH (1:2.5) and EC of soil were determined by pH meter and conductivity meter (Jackson 1973) [15]. The exchangeable Na^+ was estimated by flame photometer (Richards 1968) [21]. The ESP was calculated with exchangeable Na^+ divided by CEC multiplied by 100 (Richards 1968) [21]. The soil samples were analysed for available N by the alkaline permanganate method (Subbiah and Asija, 1956) [24] available P (Olsen- P) by 0.5 M $NaHCO_3$ extraction (Olsen *et al.* 1954) [17] available K (NH_4OAc) by 1N neutral NH_4OAc extraction on flame photometer (Knudsen, Peterson and Pratt 1982) [16]. The soil samples from the 0-30 cm soil depth were analyzed for saturation paste extract. The 200 g of 2 mm soil was taken and saturated by adding distilled water and mixing the soil with a spatula until the surface of the soil glistened. It was then allowed to sit overnight. After the saturation, soil pH was recorded and then extract was drawn with a vacuum pump. The ECe was recorded by potentiometry (Jackson, 1973) [15]. The grain and straw samples were collected separately from each plot at the time of wheat harvest. The samples were oven dried at 60^0C. The plant and grain samples were analyzed for total N by micro kjeldahl method in H_2SO_4:H_2O_2 (1:1) digestion (Parkinson and Allen 1975) [19] total P by vanadomolybdate yellow colour method in nitric acid H_2SO_4:$HClO_4$:HNO_3 (1:4:10) digestion (Jackson, 1973) [15] total K on flame photometer in H_2SO_4:$HClO_4$:HNO_3 (1:4:10) digestion (Chapman and Pratt, 1961) [6].

Experimental Details

The field experiment was laid out in a randomized block design with ten treatments and three replications. The treatments were 100% recommended dose of nitrogen (RDN)through urea (T_1), 100% RDN through ammonium sulphate (T_2), 100% RDN through calcium nitrate (T_3), 125% RDN through urea (T_4), 125% RDN through ammonium sulphate (T_5), 125% RDN through calcium nitrate (T_6), 150% RDN through urea (T_7), 150% RDN through ammonium sulphate (T_8), 150% RDN through calcium nitrate (T_9) and absolute control (T_{10}). The FYM 10 t ha^{-1} was applied one month before sowing of wheat. The recommended dose of fertilizer of wheat was 120:60:40 (N: P_20_5:K_20 kg ha^{-1}) and the half dose of N was applied at the time of sowing and remaining half dose of N at 21 days after sowing in treatments T_1 to T_9. The sources of N were urea, ammonium sulphate and calcium nitrate (Table 2). The recommended dose of phosphorus through single super phosphate and potassium through muriate of potash were applied at the time of sowing to treatments T_1 to T_9. The irrigation water was used for irrigating of wheat with low salinity and low sodium hazard. The five irrigations were given during the crop growth period. The wheat crop was sown in post monsoon (*rabi*) season with 22.5 cm row spacing. The standard agronomic packages of practices were adopted in wheat crop. The statistical analysis was carried out by procedure suggested by Panse and Sukhatme (1985) [18]. Nitrogen use efficiency parameters were calculated for each treatment following equations (Fageria and Baligar, 2005) [11].

1. Agronomic efficiency (kg kg^{-1}) = Gf−Gu / Nq, where *G*f is the grain yield of the fertilized plot (kg), *G*u is the grain yield in the unfertilized plot (kg) and *N*q is the quantity of *N* applied.
2. Agro-physiological efficiency (kg kg^{-1}) = Gf−Gu / Nf−Nu, where *G*f is the grain yield of the fertilized plot (kg), *G*u is the grain yield in the unfertilized plot (kg), *N*f is the *N* accumulation in the fertilized plot (kg) and *N*u is the N accumulation in the unfertilized plot (kg).
3. Apparent recovery N efficiency (%) = (Nf−Nu/Nq) x 100 where *N*f is the N accumulation by straw and grain in the fertilized plot (kg), *N*u is the N accumulation by the straw and grains in the unfertilized plot (kg) and *N*q is the quantity of *N* applied (kg).

Results and Discussion

Effect of Different Levels and Sources of Nitrogen on Chemical Properties of Soil

Soil pH and Electrical Conductivity (1:2.5 Soil:Water ratio)

The soil pH after harvest of wheat was significantly influenced by different levels and sources of N fertilizers (Table 3). The maximum reduction of soil pH was observed in 150% RDN through ammonium sulphate as compared to other rest of the treatments As increased with the dose of N fertilizer there was slightly decrease in soil pH. The more reduction of soil pH was observed in ammonium sulphate sources treatment as compare to urea and calcium nitrate sources treatment. The treatment T_8 was at par with T_2, T_5, T_6 and T_9 treatments. The application of 100%, 125% and 150% RDN through different N sources of fertilizers were found non-significant effect. The highest value of electrical conductivity (2.03 dS m^{-1}) was observed in 150% RDN-ammonium sulphate and it was followed by electrical conductivity (2.01 dS m^{-1}). Slightly higher values of electrical conductivity was recorded in 150% RDN application with different fertilizer sources as compare to 100% RDN application with different fertilizer sources and absolute control treatment. The decrease in soil pH was greater with ammonium sulfate compared to urea. Ammonium sulfate fertilization accounted more variation in soil pH as compare to urea fertilization. Both the N fertilizer sources are acidic and their acid equivalencies [kg calcium carbonate ($CaCO_3$) required to neutralize acidity produced by 100 kg of fertilizers] are 110 for ammonium sulfate and 80 for urea (Fageria, 1989) [10]. Decrease in soil pH has been reported by use of ammonium sulfate and urea (Hetrick and Schwab, 1992) [14]. The ammonium (NH_4^+) ions are oxidized to yield nitrate (NO_3^-) ions or nitrification, which results in the release of H^+ ions, leading to soil acidification.

Effect of Different Levels and Sources of Nitrogen on Available Nutrient Status of Saline Soil

The significantly highest soil available N and P were recorded in application 150% RDN through ammonium sulphate treatment and soil available K in 150% RDN through calcium nitrate treatment over the rest of the treatments (Table 3). The treatment T_8 was at par with treatments T_5, T_6, T_8 for soil available K at harvest of wheat. The increases in doses of N fertilizers in were increased in available N, P and K content in soil. The 100% and 150% RDN was applied to wheat through urea and ammonium sulphates were at par with each other within sources of fertilizers. The increase in nitrogen content may be ascribed to greater availability of nitrogen in soil due to its application. This might be because application of extra N through increased levels increased the concentration of N in the soil. The treatments T_2, T_5, T_6, T_7 and T_9 were at par with each other soil available P. The application N through urea and ammonium sulphate fertilizers gave higher soil available N, P and K as compare to urea in 100%, 125% and 150% levels of RDN. The increase in available soil P might be due to their solubilizing effect on the native insoluble P fraction through release of various organic acids, thus resulting into a significant improvement in available P. The increase of K content might be due to addition of organic matter and microbes reduced K fixation and release of K due to interaction of organic matter with clay, besides the direct K addition to the pool of soil. It may also be due to the decomposition of organic matter accompanied by the release of appreciable quantities of CO_2, which when dissolved in water, forms carbonic acid, which is capable to decomposing certain primary minerals and release of nutrients, which is finally responsible for better absorption resulting in higher K content in plant biomass (Chesti *et al.*, 2015) [7].

Effect of Different Levels and Sources of Nitrogen on Saturation Paste Extract Analysis of Soil at Harvest of Wheat pH, Electrical conductivity of Saturation Paste Extract of Soil, Sodium Adsorption ratio (SAR) and Exchangeable Sodium Percentage (ESP)

The reduction in pH of saturation paste extract of soil (pHs) due to application of increased doses of N (100 to 150% RDN). The highest reduction in pH_s was observed in 150% RDN through ammonium sulphate treatment over the rest of the treatments. The ammonium ions are oxidized to produces nitrate ions, and release of H^+ ions, leading to soil acidification. Decrease in soil pH has been reported by use of ammonium sulfate and urea (Hetrick and Schwab, 1992) [14]. The treatmentsT_2 and T_9 were at par with each other for pHs (Table 4). As regards the sources of N, the greater reduction of pH_s was observed in ammonium sulphate as compare to calcium nitrate and urea. The highest soil pHs was noticed in absolute control. The significantly highest increase in electrical conductivity of saturation paste extract of soil **(**EC_e) 4.77 dS m^{-1} was recorded in the treatment T_8 over the rest of treatments (Table 4). The treatment T_9 was followed by T_5 and T_2. It clearly indicated that source of N through ammonium sulphate increases solubility of salts in soil as compare to calcium nitrate and urea sources of N. There was increase in EC_e with increase in levels of N application indicated that increased doses of N was responsible for higher EC_e due to increase solubility of salts in soil solution. The lowest SAR and ESP were found under treatment with application of 150% RDN- calcium nitrate over rest of the treatments. The application of N through calcium nitrate was recorded lower in SAR and ESP as compare to other sources of N *viz;* ammonium sulphate and urea. The decrease in SAR and ESP of soil with an increase in N application (100% RDN to 150% RDN).

Effect of Different Levels and Sources of Nitrogen on Nutrient Uptake of Wheat

The significantly highest nitrogen uptake by wheat was under treatment with application of 150% RDN- calcium nitrate (98.12 kg ha^{-1}) over rest of the treatment except the treatment 150% RDN- ammonium sulphate (89.15 kg ha^{-1}). The significantly highest phosphorus uptake (23.88 kg ha^{-1}) and potassium uptake (67.89 kg ha^{-1}) were recorded in the treatment with application of 150% N- calcium nitrate over rest of the treatments (Table 5). The chemical fertilizers (100 and 150% NPK) also increased nitrogen content in wheat. This increase in nitrogen content may be ascribed to greater availability of nitrogen in soil due to its application. This might be because application of extra *N* through increased levels increased the concentration of *N* in the soil and led to greater absorption of nutrients, which ultimately resulted in vigorous growth of bread wheat in terms of higher dry matter accumulation and enhanced the total uptake of nitrogen. Higher *N* level (350 kg N ha^{-1}) always increased N content in the grain and nitrogen uptake by wheat crop (Belete *et al.*, 2018) [4]. The increase in available soil P and K might be due to their solubilizing effect on the native insoluble P fraction through release of various organic acids, thus resulting into a significant improvement in available P. The increase of K content might be due to addition of organic matter and microbes reduced K fixation. which is finally responsible for better absorption resulting in higher P and K content in plant biomass (Chesti *et al.*,2015) [7]. Application of N fertilizers significantly enhanced the nutrient (K, P, and N) uptake at N rates (100, 125 and 150 kg N ha^{-1}) under as saline conditions. However, maximum uptake of nutrients was recorded at the highest dose (150 kg N ha^{-1}) but CAN treated plants performed better than that of urea. Similar results were also reported by Asraf *et al.*, (2008). The significantly lowest nitrogen uptake (26.35 kg ha^{-1}), phosphorus uptake (6.00 kg ha^{-1}) and potassium uptake (20.60 kg ha^{-1}) were recorded in absolute control treatment.

Effect of Different Levels and Sources of Nitrogen on Grain and Straw Yield of Wheat

The significantly highest grain yield (32.73 q ha^{-1}) of wheat was recorded in the treatment with application of 150% RDN- calcium nitrate and it was at par with treatment 150% RDN- ammonium sulphate (31.60 q ha^{-1}), 125% RDN- ammonium sulphate (31.13 q ha^{-1}), 125% RDN- calcium nitrate (30.91 q ha^{-1}) and 100% RDN- calcium nitrate (29.57 q ha^{-1}). The significantly highest straw yield (40.28 q ha^{-1}) of wheat was recorded in the treatment with application of 150% RDN- calcium nitrate and it was at par with 150% RDN- ammonium sulphate (39.00 q ha^{-1}) and 125% RDN- calcium nitrate (37.38 q ha^{-1}).However, calcium nitrate as N source was more effective in enhancing grain yield of wheat and yield than ammonium sulphate and urea (Table 6). Nitrogen is considered a master element in plant nutrition and it plays an important role in all physiological growth processes of plant as stimulation of plant growth, yield and chemical constituents in different plants. However, considerable differences existed in the response of various species to different N fertilizer forms (Ghoname *et al.*, 2019) [12]. The dry matter increased significantly with fertilization; however, grain yield differences among the different N sources were seldom significant (Power *et al.*, 1972) [20]. The significantly lowest grain yield (12.70 q ha^{-1}) of wheat was recorded in absolute control treatment Wheat yield reduction at higher salinity levels could be attributed to increased hydrostatic and osmotic pressures (Table 6). Wheat yield increased with increasing N rate from 100 to 150 kg RDN ha^{-1} in case of calcium nitrate, ammonium sulphate and urea. The combined application of NPK also significantly reduced Na^+ uptake in leaves and enhance the sugarcane yield (Ashraf *et al*., 2008) [2].

Nitrogen use efficiency parameters of wheat

Efficiency in uptake and utilization of N in the production of grain requires that those processes associated with absorption, translocation, assimilation, and redistribution of N operate effectively. The significantly highest agronomic efficiency (14.06 kg kg^{-1}) and apparent recovery N efficiency (49.18%) of wheat was recorded in the treatment with application of 100% RDN- calcium nitrate followed by 100% RDN- ammonium sulphate and 100% RDN- urea. As increase in rate of application of N decrease in agronomic efficiency and apparent recovery N efficiency (Table 6). The source of N through calcium nitrate had greater agronomic efficiency and apparent recovery N efficiency over the ammonium sulphate and urea source of N. Roberts reported that increase in N fertilizer rates resulted in a decline in agronomic efficiency. Higher agronomic efficiency could be obtained if the yield increment per unit N applied is high because of reduced losses and increased uptake of N (Craswell and Godwin, 1984) [8]. Nitrogen agronomic efficiency value ranging from 10 to 30 is common (Dobermann, 2005) [9]. The reverse trend was noticed in agro-physiological efficiency. The highest agro-physiological efficiency (45.57kg kg^{-1}) was noticed in 100% RDN- urea as compare to other treatments. The source of N through urea had greater agro-physiological efficiencya over the ammonium sulphate and calcium nitrate source of N.

Effect of Different Levels and Sources of Nitrogen on Economics of Wheat

The pooled mean gross monetary returns, net monetary returns and B: C ratio were computed and presented in Table 7. It was observed that the highest gross monetary return (Rs.73, 660 ha^{-1}) and cost of cultivation (Rs.93, 412 ha^{-1}) was recorded in the treatment with application of 150% RDN- calcium nitrate. However, the application of 150% RDN through urea recorded the higher net monetary returns (Rs.27, 830 ha^{-1}) and B: C ratio (1.74) over the rest of other treatments.

Table 1: Initial experimental soil status before start of experiment

Parameter	2014-15	2015-16	2016-17	Mean
pH (1:2.5)	8.17	8.20	8.12	8.16
EC (dS m^{-1})	2.25	2.15	2.11	2.17
Available N (kg ha^{-1})	185	198	180	188
Available P (kg ha^{-1})	10.25	10.25	8.50	9.67
Available K (kg ha^{-1})	495	550	585	543
Saturation Paste extract				
pHs	8.12	8.02	8.00	8.05
ECe (dS m^{-1})	5.87	5.55	4.92	5.45
HCO_3^- (meq L^{-1})	4.50	4.30	4.38	4.39
Cl^- (meq L^{-1})	35.80	42.50	43.00	40.43
SO_4^{--} (meq L^{-1})	20.50	21.50	14.20	18.73
Ca^{2+} (meq L^{-1})	13.50	15.50	18.38	15.79
Mg^{2+} (meq L^{-1})	5.20	12.00	10.85	9.35
Na^+ (meq L^{-1})	36.29	35.8	37.81	36.63
K^+ (meq L^{-1})	0.09	0.10	0.13	0.11
SAR	11.86	9.65	9.90	10.47
ESP	13.97	11.48	11.77	12.41

Table 2: Quantity of nutrients and fertilizers applied as per treatment

Treatment	Nutrients (kg ha^{-1})			Quantity of fertilizers (kg ha^{-1})				
	N	P	K	Urea	Ammonium Sulphate	Calcium Nitrate	Single Super Phosphate	Muritae of Potash
T_1 -100% N-urea	120	60	40	260	0	0	375	67
T_2-100% N ammonium sulphate	120	60	40	0	586	0	375	67
T_3-100% N- calcium nitrate	120	60	40	0	0	774	375	67
T_4-125% N- urea	150	60	40	326	0	0	375	67
T_5-125% N- ammonium sulphate	150	60	40	0	732	0	375	67
T_6-125% N- calcium nitrate	150	60	40	0	0	968	375	67
T_7-150% N-urea	180	60	40	391	0	0	375	67
T_8-150% N- ammonium sulphate	180	60	40	0	878	0	375	67
T_9-150% N- calcium nitrate	180	60	40	0	0	1161	375	67
T_{10}-Absolute control	0	0	0	0	0	0	0	0

Table 3: Effect of different levels and sources of N fertilizers on soil parameters ant soil nutrient availability at harvest of wheat (Pooled mean of 3 years)

Treatment	pH (1:2.5)	EC (dS m^{-1})	Soil available nutrient (kg ha^{-1})		
			N	P	K
T_1 -100% N-urea	8.10	1.89	186	9.18	542
T_2-100% N- ammonium sulphate	8.04	1.92	196	10.67	582
T_3-100% N- calcium nitrate	8.07	1.90	199	9.86	564
T_4-125% N-urea	8.07	1.91	197	9.93	560
T_5-125% N- ammonium sulphate	8.02	1.95	206	10.86	581
T_6-125% N- calcium nitrate	8.04	1.93	207	10.40	567
T_7-150% N-urea	8.05	1.94	202	10.65	576
T_8-150% N- ammonium sulphate	8.00	2.03	217	11.79	578
T_9-150% N- calcium nitrate	8.04	1.98	208	10.49	586
T_{10}-Absolute control	8.15	2.01	166	8.06	509
S.E.±	0.02	0.01	4.33	0.15	7.13
C.D. at 5%	0.04	NS	12.95	0.46	21.33

Table 4: Effect of different levels and sources of N fertilizers on soil pHs, ECe, SAR and ESP at harvest of wheat (Pooled mean of 3 years)

Treatment	pHs	ECe (dS m^{-1})	SAR	ESP
T_1 -100% N-urea	7.94	4.54	9.85	10.87
T_2-100% N- ammonium sulphate	7.87	4.66	7.66	10.83
T_3-100% N- calcium nitrate	7.90	4.57	7.07	10.48
T_4-125% N-urea	7.87	4.60	8.97	10.63
T_5-125% N- ammonium sulphate	7.84	4.73	7.25	10.84
T_6-125% N- calcium nitrate	7.89	4.63	6.31	10.71
T_7-150% N-urea	7.85	4.64	8.65	10.66
T_8-150% N- ammonium sulphate	7.84	4.77	7.08	10.54
T_9-150% N- calcium nitrate	7.85	4.67	5.93	10.27
T_{10}-Absolute control	8.00	4.66	11.07	11.17
S.E.±	0.02	0.04		0.23
C.D. at 5%	0.07	0.12		0.75

Table 5: Effect of different levels and sources of N fertilizers on nutrient uptake of wheat (Pooled mean of 3 years)

Treatment	Nutrient uptake (kg ha^{-1})		
	N	P	K
T_1 -100% N-urea	56.72	11.29	34.31
T_2-100% N- ammonium sulphate	68.80	14.85	43.36
T_3-100% N- calcium nitrate	85.37	20.09	57.62
T_4-125% N-urea	76.47	16.74	48.05
T_5-125% N- ammonium sulphate	77.21	17.35	49.60
T_6-125% N- calcium nitrate	81.32	18.71	53.61
T_7-150% N-urea	69.63	15.00	43.84
T_8-150% N- ammonium sulphate	89.15	20.43	59.05
T_9-150% N- calcium nitrate	98.12	23.88	67.89
T_{10}-Absolute control	26.35	6.00	20.60
S.E.±	3.51	0.57	1.46
C.D. at 5%	10.52	1.70	4.36

Table 6: Effect of different levels and sources of N fertilizers on yield and nitrogen use efficiency parameters of wheat (Pooled mean of 3 years)

Treatment	Yield (q ha^{-1})		Nitrogen use efficiency parameters		
	Grain	Straw	Agronomic efficiency (kg kg^{-1})	Agro physiological (kg kg^{-1})	Apparent recovery N efficiency (%)
T_1 -100% N-urea	26.54	31.44	11.53	45.57	25.31
T_2-100% N- ammonium sulphate	29.14	34.95	13.70	38.73	35.38
T_3-100% N- calcium nitrate	29.57	35.72	14.06	28.58	49.18
T_4-125% N-urea	27.80	33.41	10.07	30.13	33.41
T_5-125% N- ammonium sulphate	31.13	36.54	12.29	36.24	33.91
T_6-125% N- calcium nitrate	30.91	37.38	12.14	33.13	36.65
T_7-150% N-urea	29.05	34.70	9.08	37.78	24.04
T_8-150% N- ammonium sulphate	31.60	39.00	10.50	30.10	34.89
T_9-150% N- calcium nitrate	32.73	40.28	11.13	27.91	39.87
T_{10}-Absolute control	12.70	22.50	-	-	-
S.E.±	1.12	1.00			
C.D. at 5%	3.34	2.98			

Table 7: Effect of different levels and sources of N fertilizers on economics of wheat (Pooled mean of 3 years)

Treatment	Gross returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B: C Ratio
T_1 -100% N-urea	59743	36814	22929	1.62
T_2-100% N- ammonium sulphate	65724	47710	18014	1.38
T_3-100% N- calcium nitrate	66635	73998	-7363	0.90
T_4-125% N-urea	62564	37226	25338	1.68
T_5-125% N- ammonium sulphate	70194	50846	19348	1.38
T_6-125% N- calcium nitrate	69587	83705	-14118	0.83
T_7-150% N-urea	65468	37638	27830	1.74
T_8-150% N- ammonium sulphate	71235	53981	17254	1.32
T_9-150% N- calcium nitrate	73660	93412	-19752	0.79
T_{10}-Absolute control	28619	16106	12513	1.78
S.E.±	2304			
C.D. at 5%	6900			

Year	Cost of inputs and produce
2014-15	Rate of Urea Rs. 5.60 Kg^{-1}, Ammonium sulphate Rs.25 Kg^{-1}, Calcium nitrate Rs.50 Kg^{-1}, Single super phosphate Rs. 8.0 kg^{-1}, Muriate of potash Rs. 17 kg^{-1}, FYM- Rs. 1,500 t^{-1}, wheat grain Rs. 2250 q^{-1}
2015-16	Rate of Urea Rs. 5.60 Kg^{-1}, Ammonium sulphate Rs.25 Kg^{-1}, Calcium nitrate Rs.50 Kg^{-1}, Single super phosphate Rs. 8.0 kg^{-1}, Muriate of potash Rs. 17 kg^{-1}, FYM- Rs. 1,500 t^{-1}, wheat grain Rs. 2500 q^{-1}
2016-17	Rate of Urea Rs. 5.90 Kg^{-1}, Ammonium sulphate Rs.14 Kg^{-1}, Calcium nitrate Rs.50 Kg^{-1}, Single super phosphate Rs. 7.7 kg^{-1}, Muriate of potash Rs. 12.5 kg^{-1}, FYM- Rs. 1,500 t^{-1}, wheat grain Rs. 2000 q^{-1}

Conclusions

The application of 150% recommended dose of nitrogen through calcium nitrate to wheat recorded higher yield and nutrient uptake. However, the application of 150% recommended dose of nitrogen through urea recorded higher net monetary returns (Rs.27,830 ha^{-1}) and B: C ratio (1.74). Hence application of 150% of recommended dose of nitrogen (180 kg ha^{-1}) through urea along with recommended dose of phosphorus (60 kg ha^{-1}) and potassium (40 kg ha^{-1}) + 10 t FYM ha^{-1} to wheat for achieving higher net monetary returns is recommended in saline soils

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