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Fertilizer Requirement of Wheat in Recently Reclaimed Soils

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Abstract: The fertility of salted soils after reclamation become low, therefore, the fertilizer requirements is more than normal soils. Therefore a field experiment was conducted at four different locations in farmer fields i.e. Thatta Langar, District Hafizabad (S_1), Bhattal, District Sheikhupura (S_2), Kot Hara, District Gujranwala (S_3) and Jamke Cheema, District Sialkot (S_4) to determine the fertilizer requirement of wheat in recently reclaimed soils. At all the four sites soils were saline sodic and recently reclaimed by applying gypsum @ 100% gypsum requirement. Wheat variety Inqilab 91 was sown after rice. Different rates of N (85, 130, 175 kg ha^{-1}), P (0, 70, 105, 140 kg ha^{-1}) and K (0, 40, 60, 80 kg ha^{-1}) were applied in 10 combinations. The randomized complete block design with three replications was employed. Soil analysis after harvest of rice showed that it was still slightly saline sodic (EC_e 4.16-4.83, pH_s 8.63-9.00 and SAR 29.46-37.71) in nature, deficient in total nitrogen (N) and available Phosphorus (P) but medium in extractable potassium (K). The results showed that increasing fertilizer over control increased grain and straw yields significantly. There was increase in grain (9.76-44.72 %) and straw (11.30-56.76 %) yield by the application of each increment of N fertilizer, where as P and K had non-significant effect except P at higher rate (10.28-16.48 % in grain and 11.15-18.15 % in straw yield) and K at lower rate (2.97-15.73 % grain and 5.91-14.35 % straw yield). The optimum dose determined was 175-105-60 kg ha^{-1}as N, P_2O_5 and K_2O respectively. The NPK contents both in grain and straw were significantly increased over control. Nitrogen concentration was increased both in grain and straw with its increasing levels of application. Soil analysis after harvest of wheat showed that the extent of salinity/sodicity was further decreased (EC_e 3.96-4.89, pH 8.44-8.70 and SAR 21.42-31.33) while fertility status of the soils was further improved.

Key words: Recently reclaimed soils · fertility · wheat grain and straw yield

INTRODUCTION

Wheat yield on slightly and moderately salt affected soils is reduced by 36 and 68 % respectively, as compared to those obtained on non-saline-sodic soils. Under extreme saline conditions growth and yield of rice and wheat crops are greatly reduced [1] and partly it can be attributed to the imbalanced and inadequate fertilizer use. Amelioration of saline-sodic/sodic soils require the application of amendments preferably gypsum and adoption of rice-wheat cropping is recommended [2]. Recently reclaimed soils are low in plant nutrients because of leaching of nutrients during reclamation process [3]. Pakistani soils are mostly alkaline and calcareous in nature, low in organic matter, N, P and micronutrients particularly in rice growing area [4].

Studies on different crops had shown large increases in yield in soils deficient in organic matter and available phosphorus under increasing levels of N and P [5]. Singh [6] reported the response of P and K applied to rice and wheat. The results showed that grain yield of wheat increased significantly due to application of N over control. The grain and straw yield of wheat increased significantly with application of phosphorus @ 22 kg ha^{-1} to either or both the crops in sequence as compared to application of N alone in both the crops. Potash application had non significant effect on yields. The available P status of the soil was higher as a result of application of P in soil in P treated plots as compared to no application of P in the soil. Among the fertilized plots, K status of the soil was highest in the plots where K was applied as compared to the treatment where no K was applied. The present study was therefore conducted, at different four locations, with the objective to determine the fertilizer requirements of wheat in recently reclaimed soils.

MATERIALS AND METHODS

Field experiments were conducted at four sites i.e. Thatta Langar, Distt. Hafizabad (S_1), Bhattal, Distt. Sheikhupura (S_2), Kot Hara, Distt. Gujranwala (S_3) and

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Table A: Treatments applied

Treatment	kg ha^{-1} N	P_2O_5	K_2O
T_1	0	0	0
T_2	85	105	60
T_3	130	105	60
T_4	175	105	60
T_5	130	0	60
T_6	130	70	60
T_7	130	140	60
T_8	130	105	0
T_9	130	105	40
T_{10}	130	105	80

Jamke Cheema, Distt. Sialkot (S_4). Saline-sodic soils were selected at all the sites and soil samples were collected before the transplantation of rice and analyzed for various physical and chemical characteristics (EC_e, pH_s, SAR, Gypsum Requirement (G.R.), total nitrogen, available phosphorus and Extractable Potassium). These sites were reclaimed by applying gypsum @100 gypsum requirement (G.R.) (Table 1). After reclamation, rice cv. Shaheen Basmati was transplanted and different combinations of NPK fertilizers were applied.

The randomized complete block design with three replications was employed. Plot size was 6 m x 4 m. After harvest of rice crop wheat crop was sown in the same layout and ten different combinations of NPK fertilizers were applied as experimental treatments (Table A). Wheat variety Inqilab 91 was sown using seed rate 60 kg acre^{-1}. All the PK and 1/3 N fertilizer were applied at the time of sowing while 1/3 N at first irrigation and remaining 1/3 N at 2nd irrigation was applied. Chemical herbicide (Quartro 500 ml acre^{-1}) was used for the control of weeds. All cultural practices when required were performed. Crop was harvested at maturity. Grain and straw yield data was recorded by harvesting 3m × 5 m. Grain and straw samples were analysed for NPK contents.

Total nitrogen in soil and plant was estimated by the method of Jackson [7] and available P in soil as suggested by Watanabe and Olsen [8]. All the analyses were done according to the methods given in Hand Book No.60 [9]. All the data were statistically analysed using RCBD and means were compared by least significance difference test [10].

RESULTS AND DISCUSSION

The chemical analysis of all the sites is given in Table 1. The data showed that all the sites were saline-sodic in nature having EC_e 6.54 to 6.90 dS m^{-1}, pH_s 8.95 to 9.28, SAR 45.28 to 58.26 (mmol L^{-1})$^{1/2}$ and gypsum requirement of 3.91 to 5.45 tones acre^{-1}. All the soils were reclaimed by applying gypsum at the rate of 100% G.R. These sites were deficient in total nitrogen (0.016-0.023 %), available phosphorus (3.20-4.60 mg kg^{-1}) and medium in extractable potassium (99.0-129.0).

Grain and straw yield: The grain and straw yield data are presented in Table 2 and 3. The results showed that both grain and straw yield was increased (9.76-44.72 % grain and11.30-56.76 % straw) with each increment of N fertilizer application at all the sites. While with P application yield was increased only at higher rate i.e. 140 kg P_2O_5 ha^{-1} (10.28-16.48 % grain and 11.15-18.15% straw yield). In case of K application the yield was significantly improved only at 40 kg K_2O ha^{-1} at Thatta Langar (15.73 % grain and 14.35 % straw) and Bhattal (4.83 % grain and 6.74 % straw) as compared to control. Yield remained non significant at Kot Hara (2.97 % grain and 11.78 % straw) and Jamke Cheema (3.66 % grain and 5.91 % straw) sites. The results showed that maximum grain yield was recorded in T_4 (140-85-60) treatment and minimum in T_1 (control) at all the four sites. Similar results were reported by Singh [6]. As for as straw yield is concerned it was increased with each increment of N fertilizer application while in case of P and

Table 1: Original soil analyses of sites

Sites	EC_e (dS m^{-1})	pH_s	SAR (mmol L^{-1})$^{1/2}$	G.R. (t. acre^{-1})	Total N (%)	Avail. P (mg kg^{-1})	Ext. K (mg kg^{-1})
Thatta Langar (S_1)	6.90	9.28	58.26	5.45	(0.016	3.20	129.0
Bhattal (S_2)	6.82	9.05	47.68	4.26	0.019	4.60	104.0
Kot Hara (S_3)	6.90	9.10	50.64	4.38	0.021	4.30	99.0
Jamke Cheema (S_4)	6.54	8.95	45.28	3.91	0.023	3.60	106.0

Table 2: Grain yield in different soil series

Treatments N-P_2O_5-K_2O (kg ha^{-1})	(t ha^{-1}) S1	S2	S3	S4
0-0-0	1.27 F	1.27 F	1.51 E	1.69 F
85-105-60	1.76 DE	1.76 DE	2.16 C	2.12 D
130-105-60	1.99 BCD	1.99 BCD	2.47 B	2.56 BC
175-105-60	2.27 A	2.27 A	2.81 A	2.81 A
130-0-60	1.69 E	1.69 E	1.72 D	1.93 E
130-70-60	1.89 BCDE	1.89 BCDE	2.36 B	2.41 C
130-140-60	2.12 AB	2.12 AB	2.71 A	2.80 A
130-105-0	1.81 CDE	1.81 CDE	2.73 A	2.48 BC
130-105-40	2.03 ABC	2.03 ABC	2.83 A	2.60 B
130-105-80	2.08 AB	2.08 AB	2.86 A	2.52 BC
LSD	0.2237	0.2237	0.1627	0.1627

Figures having same letter are nonsignificant at 5% level of probability

Table 3: Straw yield in different soil series

Treatments N-P_2O_5-K_2O (kg ha^{-1})	(t ha^{-1}) S1	S2	S3	S4
0-0-0	1.40 F	1.40 F	1.68 G	1.84 F
85-105-60	1.96 E	1.96 E	2.63 E	2.35 D
130-105-60	2.26 BCD	2.26BCD	3.02 D	2.92 B
175-105-60	2.63 A	2.63 A	3.51 ABC	3.25 A
130-0-60	1.88 E	1.88 E	2.08 F	2.12 E
130-70-60	2.15 CDE	2.15 CDE	2.88 D	2.70 C
130-140-60	2.45 AB	2.45 AB	3.31 C	3.23 A
130-105-0	2.02 DE	2.02 DE	3.38 BC	2.82 BC
130-105-40	2.31 BCD	2.31 BCD	3.58 AB	3.01 B
130-105-80	2.32BC	2.32BC	3.63 A	2.86 BC
LSD	0.2712	0.2712	0.2237	0.1956

Figures having same letter are nonsignificant at 5% level of probability

Table 4: Nitrogen concentration in grain of wheat in different soil series

Treatments N-P_2O_5-K_2O (kg ha^{-1})	(%) S1	S2	S3	S4
0-0-0	1.51 d	1.41 b	1.33 c	1.65 e
85-105-60	2.23 abc	2.20a	2.23 ab	2.26 bcd
130-105-60	2.26 ab	2.28 a	2.29 a	2.30 ab
175-105-60	2.27 a	2.28 a	2.30 a	2.32 a
130-0-60	2.20 bc	2.20 a	2.20 b	2.23 cd
130-70-60	2.18 c	2.17 a	2.19 b	2.22 d
130-140-60	2.18 c	2.17 a	2.19 b	2.21 d
130-105-0	2.26 ab	2.24 a	2.27 ab	2.29 ab
130-105-40	2.25 ab	2.24 a	2.27 ab	2.28 abc
130-105-80	2.24 ab	2.22 a	2.26 ab	2.26 bcd
LSD	0.05425	0.2170	0.07671	0.05425

Figures having same letter are nonsignificant at 5% level of probability

Table 5: Nitrogen concentration in straw of wheat in different soil series

Treatments N-P_2O_5-K_2O (kg ha^{-1})	(%) S1	S2	S3	S4
0-0-0	0.51 b	0.52 e	0.53 b	0.56 c
85-105-60	0.74 a	0.70 d	0.73 a	0.74 b
130-105-60	0.77 a	0.74 abc	0.76 a	0.78 ab
175-105-60	0.79 a	0.75 ab	0.78 a	0.81 a
130-0-60	0.76 a	0.74 abc	0.76 a	0.78 ab
130-70-60	0.74 a	0.73 bc	0.74 a	0.77 ab
130-140-60	0.73 a	0.72 cd	0.74 a	0.76 ab
130-105-0	0.77 a	0.76 a	0.77 a	0.80 ab
130-105-40	0.75 a	0.74 abc	0.76 a	0.79 ab
130-105-80	0.74 a	0.73 bc	0.74 a	0.76 ab
LSD 0.05425	0.02663	0.05425	0.05425	

Figures having same letter are nonsignificant at 5% level of probability

Table 6: Phosphorus concentration in grain of wheat in different soil series

Treatments N-P_2O_5-K_2O (kg ha^{-1})	(%) S1	S2	S3	S4
0-0-0	0.18 c	0.20 d	0.20 c	0.21 c
85-105-60	0.35 a	0.33 ab	0.35 a	0.38 abc
130-105-60	0.35 a	0.33 ab	0.35 a	0.37 ab
175-105-60	0.32 ab	0.32 abc	0.34 ab	0.35 a
130-0-60	0.32 ab	0.31 bc	0.33 ab	0.35 bc
130-70-60	0.30 b	0.30 c	0.31 b	0.33 a
130-140-60	0.29 b	0.30 c	0.31 b	0.32 a
130-105-0	0.35 a	0.34 a	0.34 ab	0.37 a
130-105-40	0.32 ab	0.31 bc	0.32 ab	0.35 ab
130-105-80	0.31 b	0.31 bc	0.31 b	0.34 abc
LSD 0.03344	0.2538	0.03116	0.02455	

Figures having same letter are nonsignificant at 5% level of probability

K applications, yield was increased only at higher rate i.e. 140 kg P_2O_5 ha^{-1}. In case of K application the yield was improved only at 40 kg K_2O ha^{-1} at all the four sites in comparison to control and remained non significant at higher application rate. The results showed that maximum grain yield was recorded in T_4 (140-85-60) treatment and minimum in T_1 (control) at all the four sites except Kot Hara where it was maximum in T_{10}(130-105-80) treatment. Both Singh [6] and Hayee *et al.* [11] also reported similar effects of N, P and K fertilizer on grain yield of wheat.

Nitrogen concentration: The data regarding nitrogen concentration in grain and straw of wheat are shown in Table 4 and 5. Maximum N concentrations were recorded in T_4 (175-105-60) treatment and minimum in control

treatment. Each increment of N increased N concentration in grain while P and K had non-significant effect at all the four sites. Nitrogen concentration in grain was significantly higher in T_4 (175-105-60 kg ha^{-1}) treatment at all the four sites and it differed significantly with T_5, T_6, T_7 and T_1 treatments. All other treatments were however statistically at par in N concentration with the treatment except at Bhattal where it was significantly different with control. These results correlate the findings of Singh [6] and Imtiaz *et al.* [12] who also reported similar effects.

In case of wheat straw maximum N concentration was recorded in T_4(175-105-60) treatment and minimum in control treatment. Each increment of N increased N concentration in straw while P and K showed non-significant effect at all the four sites. Significantly higher nitrogen concentration was observed in T_4 (175-105-60 kg ha^{-1}) treatment at all the four sites like N in grain. At Thatta Langer, Kot Hara and Jamke Cheema sites, it differed significantly with T_1 (control) treatment and non-significantly with remaining treatments while at Bhattal it differed significantly with T_7, T_8, T_2 and T_1 (control) treatments and non-significantly with remaining treatments. Singh [6] also reported similar effects of N, P and K on N concentration in straw.

Phosphorus concentration: Phosphorus concentration in wheat grain and straw is depicted in Table 6 and 7. The data indicated that the effect of nitrogen on P concentration in grain remained significant over control while P and K had non-significant effect, which might be due to dilution effect. Phosphorus concentration was found maximum in T_2 (85-105-60) treatment at all the four sites. At Thatta Langar it was non-significant with T_3 (130-105-60) and T_8(130-150-0) and significantly different with all other treatments. At Bhattal site it was non-significant with T_8 (130-150-0) treatment and at Kot Hara site, it was non-significant with T_3, T_4, T_2, T_1, T_8, T_9 and at Jamke Cheema site, it differed non-significantly with all the remaining treatments except control.

As for as Phosphorus concentration in wheat straw is concerned, the effect of nitrogen on P concentration in straw was also significant over control, while N, P and K had non-significant effect at Thatta Langar and Jamke Cheema. At Thatta Langar site, it was maximum in T_4 treatment and minimum in T_1 (control), at Bhattal and Kot Hara sites it remained non-significant. Maximum P concentration at Jamke Cheema site was noted in T_4 treatment that differed with T_5 and T_1 and

Table 7: Phosphorus concentration in straw of wheat in different soil series

Treatments N-P_2O_5-K_2O (kg ha^{-1})	(%) S1	S2	S3	S4
0-0-0	0.08 b	0.09 NS	0.10 NS	0.09 c
85-105-60	0.11 a	0.12	0.13	0.12 abc
130-105-60	0.12 a	0.11	0.11	0.13 ab
175-105-60	0.13 a	0.10	0.12	0.14 a
130-0-60	0.13 a	0.08	0.09	0.10 bc
130-70-60	0.10 ab	0.11	0.11	0.14 a
130-140-60	0.12 a	0.12	0.13	0.15 a
130-105-0	0.13 a	0.09	0.11	0.13 a
130-105-40	0.12 a	0.09	0.10	0.13 ab
130-105-80	0.11 a	0.08	0.10	0.12 abc
LSD 0.02780	NS	NS	0.02938	

Figures having same letter are nonsignificant at 5% level of probability
NS = Nonsignificant

Table 8: Potassium concentration in grain of wheat in different soil series

Treatments N-P_2O_5-K_2O (kg ha^{-1})	(%) S1	S2	S3	S4
0-0-0	0.29 c	0.21 e	0.30 e	0.32 d
85-105-60	0.58 a	0.46 a	0.48 a	0.51 a
130-105-60	0.55 ab	0.44 ab	0.45 b	0.48 b
175-105-60	0.55 ab	0.41 bcd	0.44 bc	0.47 b
130-0-60	0.55ab	0.43 abc	0.45 b	0.48 b
130-70-60	0.53 ab	0.39 d	0.43 bcd	0.46 b
130-140-60	0.51 b	0.40 cd	0.41 d	0.43 c
130-105-0	0.54 ab	0.42 bcd	0.44 bc	0.47 b
130-105-40	0.52 ab	0.41 bcd	0.42 cd	0.46 b
130-105-80	0.52 ab	0.41 bcd	0.41 d	0.46 b
LSD 0.05425	0.03199	0.2633	0.02664	

Figures having same letter are nonsignificant at 5% level of probability

Table 9: Potassium concentration in straw of wheat in different soil series

Treatments N-P_2O_5-K_2O (kg ha^{-1})	(%) S1	S2	S3	S4
0-0-0	1.53 c	1.38 b	1.40 b	1.60 b
85-105-60	2.44 ab	2.25 a	2.30 a	2.33 a
130-105-60	2.42 ab	2.26 a	2.30 a	2.34 a
175-105-60	2.35 b	2.24 a	2.25 a	2.27 a
130-0-60	2.42 ab	2.26 a	2.28 a	2.31 a
130-70-60	2.37 ab	2.24 a	2.28 a	2.29 a
130-140-60	2.35 b	2.25 a	2.26 a	2.28 a
130-105-0	2.46 a	2.28 a	2.30 a	2.35 a
130-105-40	2.43 ab	2.29 a	2.31 a	2.34 a
130-105-80	2.42 ab	2.27 a	2.30 a	2.34a
LSD	0.09396	0.09396	0.3162	0.09393

Figures having same letter are nonsignificant at 5% level of probability

non-significantly with all the remaining treatments. The results are in line with findings of Singh [6] who also reported similar effects of N on P concentration both in grain and straw of wheat.

Potassium concentration: The data regarding K concentration in wheat grain and straw at all the four sites are shown in Table 8 and 9. The data showed that K concentration in wheat grain significantly increased by N fertilizer over control. The effect of increasing levels of N, P and K was however non-significant at all the four sites. Maximum K concentration was noted in T_2 treatment and minimum in T_1 (control) treatment at all the four sites. At Thatta Langar, it was maximum in T_2 treatment that was statistically at par with all other treatments, except T_7 and T_1 treatments, which were significantly different. At Bhattal and Kot Hara sites, K concentration was maximum in T_2 treatment and minimum in T_1 (control), while at Jamke Cheema, it was maximum in T_2 treatment, which differed significantly with all the remaining treatments applied. The results are in line with findings of Singh (11) who found similar effects of N, P and K on K concentration in grain.

In wheat straw K concentration was affected by the application of different combinations of N-P-K at all the four sites. The results showed that K concentration in wheat straw increased by N fertilizer significantly over control. But the effect of increasing levels of N, P and K remained non-significant at all the four sites. The K concentration in wheat straw at Thatta Langar and Jamke Cheema sites was maximum in T_8 treatment and minimum in T_1 (control). At Bhattal and Kot Harra sites, it was maximum in T_9 treatment, which remained statistically at par with the applied treatments except T_1 (control). Singh [6] also reported similar effects of N, P and K on K concentration in straw.

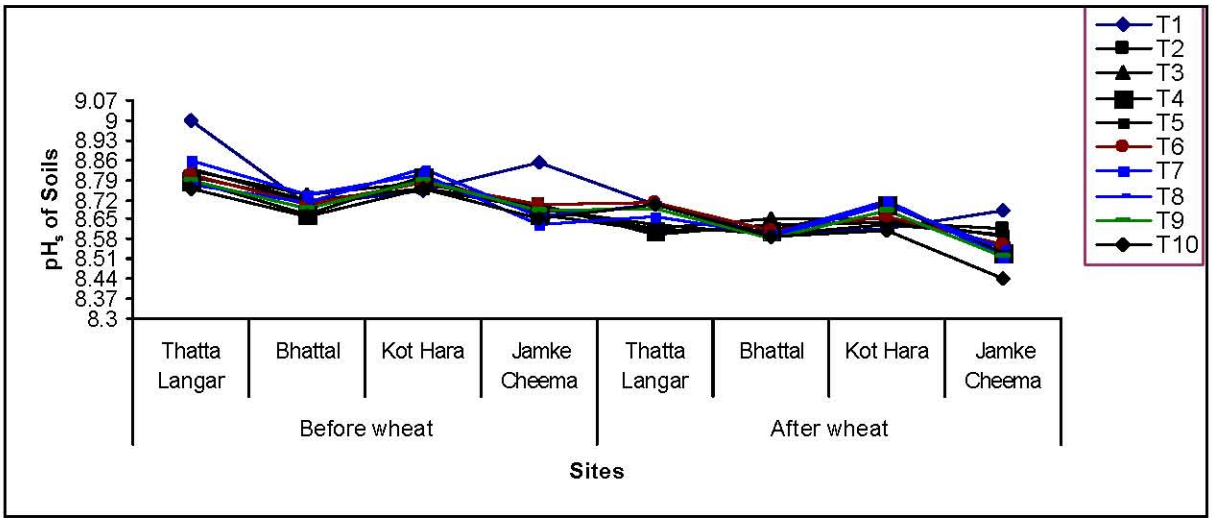
Soil analysis: Soil samples after the harvest of rice crop (for pre-sowing analysis of wheat) and after harvest of wheat (for post harvest analysis) were collected from all the sites and analyzed for electrical conductivity (EC_e dS m^{-1}), pH_s, sodium adsorption ratio [SAR $(mmol\ L^{-1})^{1/2}$], total nitrogen (N %), available phosphorus (P mg kg^{-1}) and extractable potassium (K mg kg^{-1}). The chemical characteristics of the soils are presented in Fig. 1-3, which showed that there was an erratic (haphazard) effect of fertilizer rates on these characteristics (EC_e, pH_s and SAR). The EC_e after rice harvest was decreased in comparison to original, which was further, reduced after wheat harvest in all the treatments at all the sites. Similarly pH_s and SAR were also decreased like EC_e after rice and further decreased after wheat harvest. The effect of various rates of NPK on these soil characteristics (EC_e, pH_s and SAR) was erratic (haphazard), indicating that increasing rates of NPK fertilizers did not affect the chemical characteristics of the soils.

The EC_e after wheat at Thatta Langar site ranged from 3.96 to 4.29 dS m^{-1}. Maximum reduction in EC_e was observed in T_2, which differed significantly from all other treatments. The EC_e at Bhattal site ranged from 4.10 to 4.32 dS m^{-1}. The minimum EC_e was observed in T_2, which remained at par with T_1, T_3, T_4, T_5, T_8 and T_9 statistically and differed significantly with remaining treatments. The EC_e at Kot Hara site remained non-significant at all the treatments. The EC_e at Jamke Cheema site ranged from 4.55 to 4.89 dS m^{-1}being minimum in T_9 and maximum in T_6. The pH_s after wheat at Thatta Langar site ranged from 8.60 to 8.71. The minimum pH_s was recorded in T_2 which differed significantly with T_6, T_7, T_8, T_9 and T_{10} and non-significantly with T_3, T_4 and T_5. The pH_s at Bhattal site ranged from 8.58 to 8.65. The minimum pH_s was recorded in T_9 which differed significantly with T_3 and remained at par with all the remaining treatments. The pH_s at Kot Hara site ranged from 8.61 to 8.72. The minimum pH_s was recorded in T_{10} which remained at par with T_1, T_2, T_3, T_5 and T_6 and differed significantly with all the remaining treatments. The pH_s at Jamke Cheema site ranged from 8.44 to 8.68 being minimum in T_{10} and maximum in T_1. The sodium adsorption ratio $(mmol\ L^{-1})^{1/2}$ (SAR) after wheat at Thatta Langar site ranged from 25.72 to 31.33 being minimum in T_8 and maximum in T_7. The SAR value at Bhattal site ranged from 21.42 to 28.56 being maximum in T_{10}, which remained statistically at par with T_3, T_5, T_6 and T_7 while minimum SAR was noted in T_8 that differed significantly with all the remaining treatments. The SAR value at Kot Hara site ranged from 21.99 to 26.25 being maximum in T_2 and minimum in T_9.The minimum SAR value in T_9 remained statistically at par with T_4 and differed significantly with all the remaining treatments. The SAR value at Jamke Cheema site remained non-significant with all the treatments.

The reason for decrease of these parameters i.e. EC_e, pH_s and SAR after rice harvest might be that, under sub-merged conditions, soluble salts are leached down resulting in lowering of EC_e and SAR. Under sub-merged conditions, alkaline and acids soils tend to become neutral i.e. their pH decreases in alkaline soil and increases in acidic soils, so it may be very close to pH 7.0 [13] Hence, pH of this soil was decreased. The reason for decrease in these parameters after wheat might be that decaying of

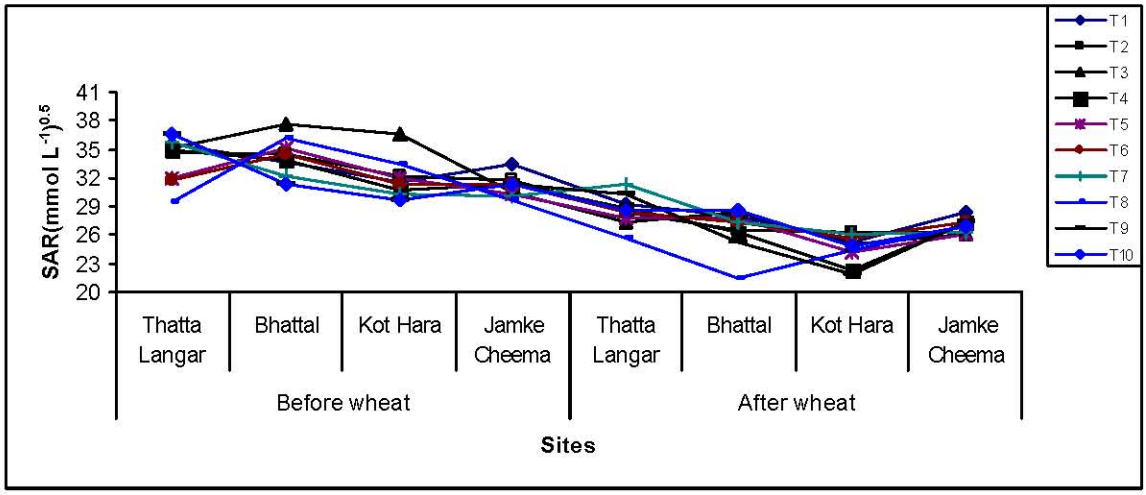
LSD value	Before wheat				After wheat			
	Thatta Langar	Bhattal	Kot Hara	Jamke Cheema	Thatta Langar	Bhattal	Kot Hara	Jamke Cheema
	0.1534	0.1085	0.1213	0.07671	0.1329	0.9396	NS	0.1085

Fig. 1: Changes in EC_e of soils



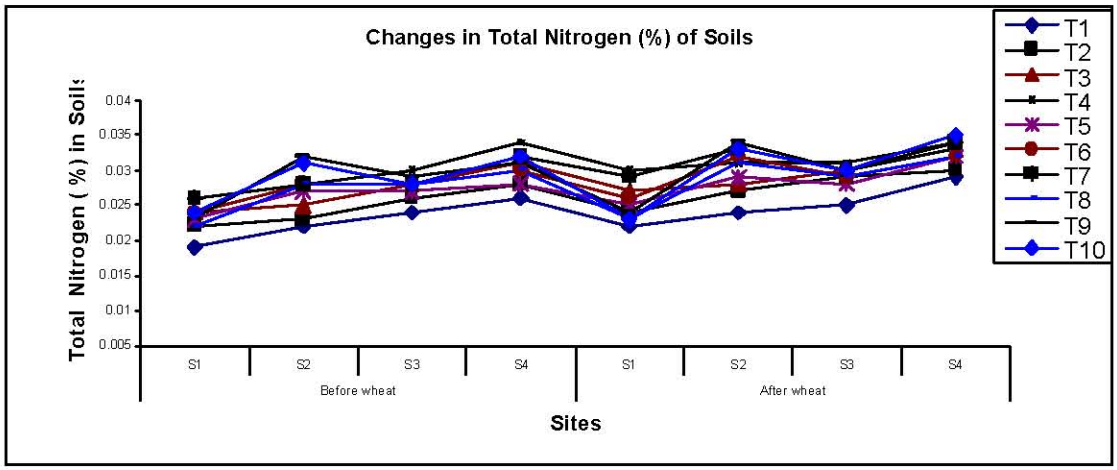
LSD value	Before wheat				After wheat			
	Thatta Langar	Bhattal	Kot Hara	Jamke Cheema	Thatta Langar	Bhattal	Kot Hara	Jamke Cheema
	0.1085	NS	NS	0.05425	0.05425	0.05425	0.05425	0.05425

Fig. 2: Changes in pH_s of soils



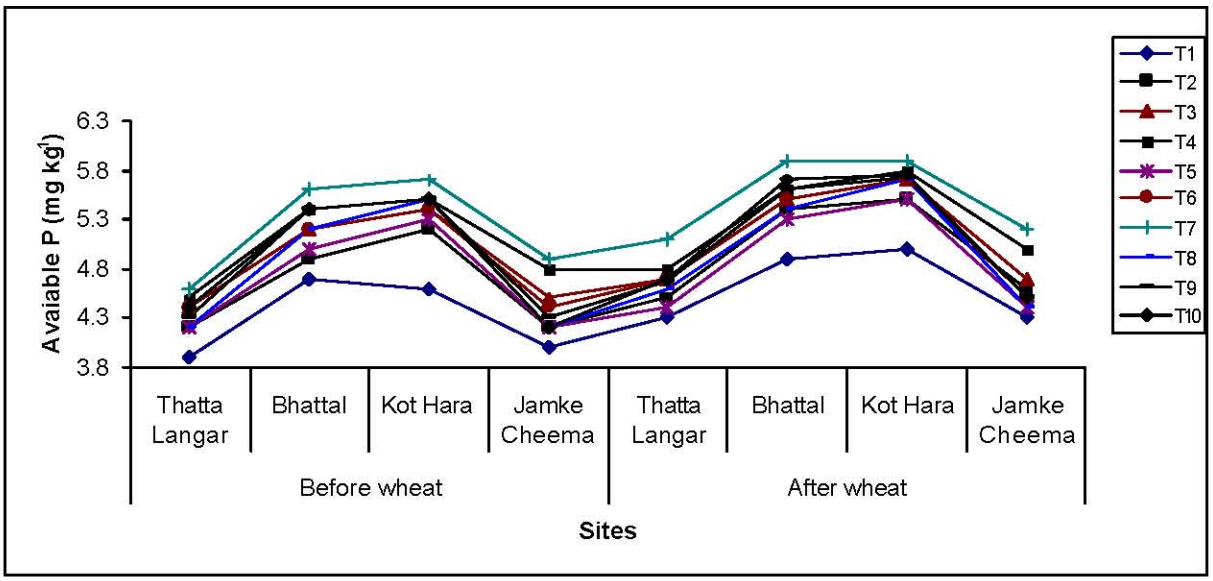
LSD value	Before wheat				After wheat			
	Thatta Langar	Bhattal	Kot Hara	Jamke Cheema	Thatta Langar	Bhattal	Kot Hara	Jamke Cheema
	0.9734	1.625	2.634	1.916	1.700	1.542	1.401	NS

Fig. 3: Changes in SAR of soils



LSD value	Before wheat				After wheat			
	Thatta Langar	Bhattal	Kot Hara	Jamke Cheema	Thatta Langar	Bhattal	Kot Hara	Jamke Cheema
	NS	0.005079	NS	NS	NS	0.002987	0.3431	0.003325

Fig. 4: Changes in nitrogen content of soils



LSD value	Before wheat				After wheat			
	Thatta Langar	Bhattal	Kot Hara	Jamke Cheema	Thatta Langar	Bhattal	Kot Hara	Jamke Cheema
	0.1766	0.3069	0.1435	0.1627	0.3676	NS	0.3431	0.4882

Fig. 5: Changes in available phosphorus content of soils

LSD value	Before wheat				After wheat			
	Thatta Langar	Bhattal	Kot Hara	Jamke Cheema	Thatta Langar	Bhattal	Kot Hara	Jamke Cheema
	NS	NS	5.092	NS	NS	NS	5.709	NS

Fig. 6: Changes in extractable potassium content of soils

rice root and increasing biomass of wheat roots produced acidic exudates which dissolved $CaCO_3$ present in these soils resulted in the production of gypsum that helped in reclamation. Hence these parameters were reduced.

Nitrogen contents in soil after the harvest of rice and wheat crops are presented in Fig. 4, which showed a non-significant increase in N contents at Thatta Langar (S_1), Kot Hara (S_3), Jamke Cheema (S_4) and significant at Bhattal (S_2) after rice, in case of rice and also at Kot Hara in case of wheat only. These results also indicate that increasing rates of N increased N contents in soils and increasing rates of P and K did not increase the N contents in soils significantly with all the treatments except control. Total nitrogen contents in soil remained non-significant after wheat harvest at Thatta Langar site. At Bhattal site, maximum N was recorded in T_9 treatment that remained at par with T_4, T_6, T_7, T_8 T_9 and T_{10} while minimum value of total nitrogen concentration was noted in T_1. The total nitrogen concentration at Kot Hara site was non-significant in all the treatments. At Jamke Cheema site, T_{10} remained statistically at par with all the treatments except control. The results are in line with Awan *et al.* [14] and Singh [6].

The available P contents in soil after harvest of rice and wheat are presented in Fig. 5. The data showed that the increasing rates of P application had significant effect on soil available P at all the sites and minimum available P was noted in control at all the sites. The available phosphorus concentration after the harvest of wheat indicated that available P concentration in soil at Thatta Langer site ranged from 4.30 to 5.10 being maximum in T_7 treatment, which is at par statistically with T_4 and differed significantly with all the remaining treatments. The available P concentration in soil after wheat harvest at Bhattal site remained non significant. The available P concentration in soil at Kot Hara site ranged between 5.00 to 5.90 being maximum in T_7(130-140-60 kg ha^{-1}) and minimum in T_1 (control). The available P concentration observed in Jamke Cheema showed maximum value in T_7 (130-140-60 kg ha^{-1}) treatment that was statistically at par with T_3 and T_4 treatments and differed significantly with all the remaining treatments. The results substantiate the findings of Obaid-ur-Rehman [15] and Singh [6] who also observed similar concentrations of available P.

The data regarding extractable K contents of soil after harvest of rice and wheat are presented in Fig. 6. The data showed that application of different rates of NPK fertilizers had non-significant effect on the K contents of soils at Thatta Langar (S_1) and Bhattal (S_2), Jamke Cheema (S_4) while in Kot Hara (S_3) it was significantly affected after rice. Where as after wheat it was significantly affected at Kot Hara (S_3). Overall, the effect of K application rates on soil K at all site was non-significant. The potassium concentration in soil after wheat was maximum in T_{10}(130-105-80 kg ha^{-1}) treatment, which differed significantly with all the treatments, except T_9(130-105-40 kg ha^{-1}) treatment. The results are in line with Singh [6] and Ranjha *et al.* [16] who found that K contents in soil increases with increasing rates of K application.

CONCLUSION

- There was increase in grain (9.76-44.72 %) and straw (11.30-56.76 %) yield by the application of each increment of N fertilizer.
- The optimum dose determined was 175-105-60 kg ha^{-1}as N, P_2O_5 and K_2O respectively.
- In recently reclaimed soils, 25 % more nitrogen fertilizer is required as compared to normal soils for optimum wheat yield.

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