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Fertilizer Requirement of Different Crop Rotations in Recently Reclaimed Soil

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Abstract: A field study was undertaken to determine the fertilizer requirement of three crop rotations i.e. a) Rice-Wheat b) Rice-Berseem and c) Sorghum-Wheat in recently reclaimed soils. For this purpose, a field having EC_e 11.4 dS m^{-1}, pH_s 9.4 and gypsum requirement 4.7 t $acre^{-1}$ was reclaimed by applying gypsum @ 100% G.R. The study remained continued for three consecutive years from 2000-2003. The treatments applied to all the crops were: T_1 Control (No fertilizer), T_2 75% Recommended dose (R.D.) NPK, T_3 R.D. NPK, T_4 R. D. NPK+25% additional NPK and T_5 R. D. NPK + 50% additional NPK. The system of layout was RCBD with three replications. The plot size was 6 m x 4 m. All required cultural practices were applied uniformly. The paddy and straw yield data indicated that there was a significant increase in these parameters by applying fertilizers and highest yield was recorded in rice-wheat and rice-berseem rotations where R.D. + 25% additional NPK was applied. Similar trend was noted in case of sorghum fodder. In the same layout wheat crop was sown. The wheat grain and straw yield data showed that highest yield was again obtained in R.D. + 25% additional NPK that was at par with R.D. + 50% additional NPK. Same trend was observed in case of berseem fodder. The soil analysis showed that in all the rotations there was an improvement in the fertility status of the soil and salinity/sodicity parameters were decreased.

Key words: Rice · wheat · berseem · sorghum · fertilizer and reclaimed soils

INTRIDUCTION

Soil salinity is indeed a global problem posing a major threat to the permanency of agriculture in the world. Irrigated land is estimated to extend over 230 million hectare of which 45 million hectare is believed to be affected by salinity in the world [1, 2]. According to another estimate [3] salinity is seriously limiting crop production on 20 million hectare in the world.

Out of 79.61 million hectare of geographic area of Pakistan, 6.67 million hectare, including about 18.4 percent of canal commanded area, is salt affected and is confined almost exclusively to the Indus plain. About 56% of the salt affected soils of Pakistan are saline-sodic [4].

Amelioration of saline-sodic/sodic soils require the application of amendments preferably gypsum and adoption of rice-based cropping is recommended due to high tolerance of rice to exchangeable sodium and its reclaiming effect. Rice (*Oryza sativa* L.) basically a tropical plant permits its cultivation under the most varied conditions of soil moisture and climate. The application of mineral fertilizers in well balanced proportion of NP and K in recently reclaimed soils has acquired a fundamental role in the production requirements of modern agriculture. Recently reclaimed soils are low in plant nutrients because of leaching of nutrients during reclamation process [5]. Pakistani soils are mostly alkaline and calcareous in nature, low in organic matter, N, P and micronutrients particularly in rice growing area [6]. Maqsood *et al.* [7] found that by the application of N, yield and yield components of rice Basmati 385 were significantly increased. Awan *et al.* [8] reported the response of rice line PB.95 to different NPK levels and found that optimum fertilizer dose was 120-100-75 (N-P_2O_5-K_2O kg ha^{-1}). They also found that N contents remained non-significant only in paddy while maximum P contents were noted at 120-100-75 kg ha^{-1} and K contents were maximum at 120-75-100 kg ha^{-1} in both paddy and straw of rice. Hussain *et al.* [9] evaluated three rates each of N (75, 100, 125 kg ha^{-1}) and P (50, 75, 100 kg ha^{-1}) in various combinations on rice Basmati 385. They found that all the fertilizer treatments significantly increased the yield over control. Gurmani *et al.* [10] studied response of paddy to balanced application of N, P and K in fourteen field trials. They applied four rates each of N (0, 80, 120, 160 kg ha^{-1}), P (0, 60, 90, 120 kg ha^{-1}) and K (0, 50, 100, 150 kg ha^{-1}) in various combinations. The application of N, P and K at the rate of 120-90-150 kg ha^{-1} proved better

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than the other treatments. Rafiq *et al.* [11] also reported similar results when they studied the effect of N, P and K in various combinations on Basmati 385. Sarfraz *et al.* [12] determined the fertilizer requirements of a new fine rice cultivar Shaheen Bas. in normal as well as saline sodic soils and reported that Shaheen Basmati yielded highest paddy of 3.37 t ha^{-1} in saline sodic and 4.39 t ha^{-1} in normal sandy loam soil with 125-75-50 kg NPK ha^{-1} in two consecutive years (1998-1999) at SSRI, Pindi Bhattian.

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 [13] and partly it can be attributed to the imbalanced and inadequate fertilizer use.

Singh [14] reported the response of P and K applied to rice and wheat. There were eight treatment combinations of NPK which were applied @ 120-22-42 kg ha^{-1}. 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 no effect on yields. Application of N alone or in combination with P and K significantly enhanced the N concentration in grain and straw of wheat over control. Phosphorus fertilization increased the P concentration significantly over no P fertilization. The concentration of K increased significantly in grain as well as straw of wheat due to K application. The total uptake of N, P and K by wheat was significantly more due to application of N, P and K respectively over no application of theses nutrients. The treatment in which N was applied alone or in combination with P and K had slightly higher available N in the soil as compared to no application. 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 conclusion drawn from the study showed that 120-22-0 kg ha^{-1} NPK should be applied to wheat in reclaimed alkali soils.

Hayee *et al.* [15] investigated the response of two wheat varieties i.e. Pak-81 and Pb-85 using different combinations of NPK. All the NPK levels significantly affected the number of fertile tillers, plant height, 1000-grain weight, grain and straw yield of both the wheat varieties. The highest grain and straw yields in both the wheat varieties were recorded at 125-50-50 kg NPK ha^{-1}.

Imtiaz *et al.* [16] determined the response of wheat cultivars to different fertilizer levels under rain fed conditions. Six wheat varieties were tested. The results showed that each additional unit of fertilizer increased grain yield and protein content. Significantly higher grain yield and protein contents were produced by 90-60-0 kg NPK ha^{-1}. Potash application neither increased the grain yield nor protein content in all the cultivars. Keeping all this in view, the present studies were conducted with the objective to determine the fertilizer requirement of different crop rotations in recently reclaimed soils.

MATERIALS AND METHODS

A field experiment was conducted for three consecutive years from 2000-2003 in a saline sodic soil at SSRI, Research farm having EC_e 11.4 dS m^{-1}, pH_s 9.4 and gypsum requirement 4.7 t $acre^{-1}$. This field was reclaimed by applying gypsum @ 100% G.R. After reclamation the field was divided into three portions and three crop rotations were tried. These were a) Rice-Wheat b) Rice-Berseem c) Sorghum-Wheat. The treatments applied were: T_1Control (No fertilizer), T_2 75% of recommended dose of NPK, T_3 Recommended dose of NPK, T_4 Recommended dose of NPK + 25 % additional NPK and T_5 Recommended dose of NPK + 50% additional NPK. Shaheen basmati was transplanted. The recommended dose for rice was 110-90-60 NPK (kg ha^{-1}) while for sorghum it was 40-70 NP (kg ha^{-1}). All the NPK were applied at the time of transplanting of rice and sowing of sorghum fodder. The system of layout was randomized complete block design with three replications. The plot size was 6x4 m. All required cultural practices were applied uniformly. The rice crop was harvested at maturity in two rotations i. e. rice-wheat and rice-berseem while in the third rotation i. e. sorghum-wheat, sorghum fodder was harvested after 45 days of sowing. The paddy, straw of rice and sorghum fodder yields were recorded. Soil samples from each rotation were collected for monitoring of chemical and nutritional characteristics of soils. In the same layout wheat crop (variety Inqulab-91) was sown in two rotations i. e. rice-wheat and sorghum-wheat while in the third rotation I. e. rice-berseem, berseem was sown. Same sets of treatments were applied to wheat crop. The recommended dose for wheat was 1120-110-70 NPK (kg ha^{-1}). The dose for berseem was 25-90 NP (kg ha^{-1}). All the PK and 1/3 N fertilizer were applied to wheat at the time of sowing while 1/3 N at first irrigation and remaining 1/3 N at 2nd irrigation was applied while whole NP were applied to berseem at the time of sowing. Chemical herbicides were used for the control of weeds. All standard cultural practices were applied. The wheat crop was harvested at maturity while three cuttings of berseem were done. The grains, straw of wheat and berseem fodder yields were recorded. Soil samples from each rotation were collected for monitoring of chemical and nutritional characteristics of soils. The experiment was repeated for three consecutive years in the same layout.

All the analyses were done according to the methods given in Hand Book No. 60 [17] except total nitrogen in soil by Jackson [18] and available P in soil by Watanabe and Olsen [19]. All the data were statistically analysed using RCBD and means were compared by Least Significance Test [20].

RESULTS AND DISCUSSION

The data of the three crop rotations i.e. rice-wheat, rice-berseem and sorghum-wheat is presented in Fig. 1-6. The results showed that paddy and straw yield of rice in two rotations i.e. rice-wheat and rice-berseem was significantly increased with the increasing rates of fertilizers during all the three years i.e. 2000 to 2002. The maximum paddy and straw yield was recorded in the treatment where recommended dose with 25% additional of recommended dose was applied which remained non-significant with T_5 where recommended dose with 50% additional of recommended dose was applied during all the three years in both the rotations. The reason for increase in paddy and straw yield of rice in both the rotations might be due to the reason that soil was reclaimed by applying gypsum followed by flooding which resulted in leaching of nutrients along with salts, due to which soil became infertile. So, the paddy and straw yield was increased with the increasing rates of fertilizers. The data of the sorghum fodder of sorghum-wheat rotation is presented in Fig. 3. There was a similar trend in sorghum yield like paddy and straw of rice. Similar results were reported by Hussain *et al.* [9], Gurmani *et al.* [10], Rafiq *et al.* [11], Maqsood *et al.* [7] and Awan *et al.* [8].

The results of wheat crop also indicated that like paddy and straw, grain and straw yield of wheat was also increased with the increasing rates of fertilizers and

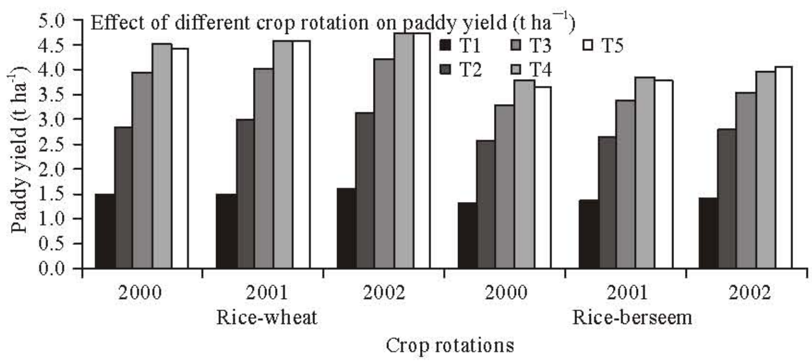

Fig. 1: Effect of fertilizers applications rates on paddy yield

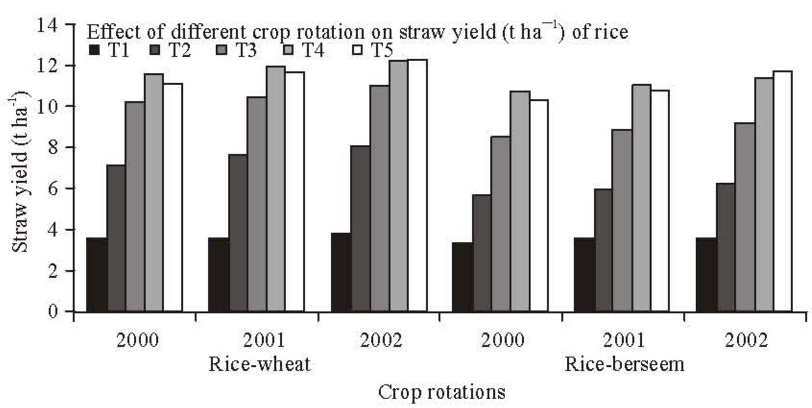

Fig. 2: Effect of fertilizers applications rates on straw yield

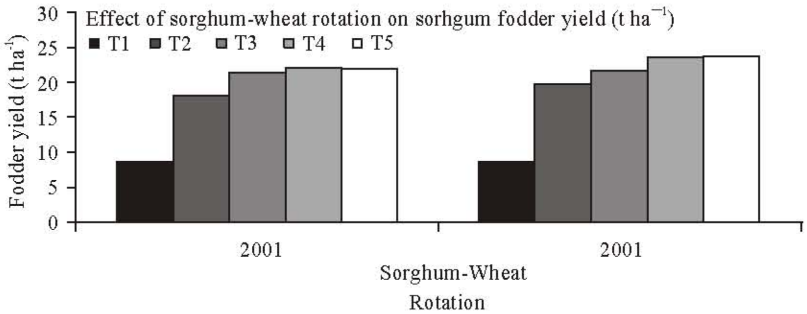

Fig. 3: Effect of fertilizers applications rates on sorghum fodder yield

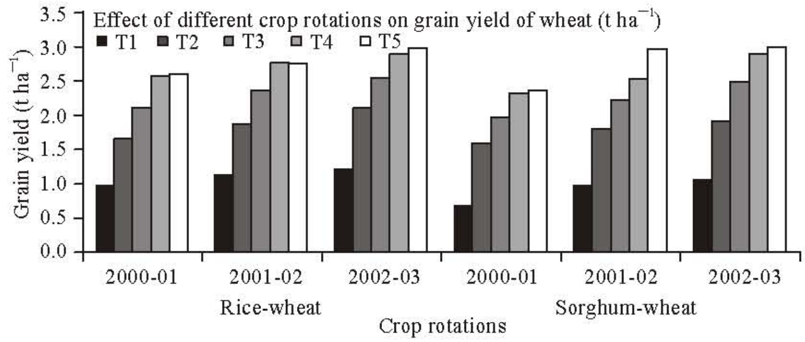

Fig. 4: Effect of fertilizers applications rates on grain yield of wheat

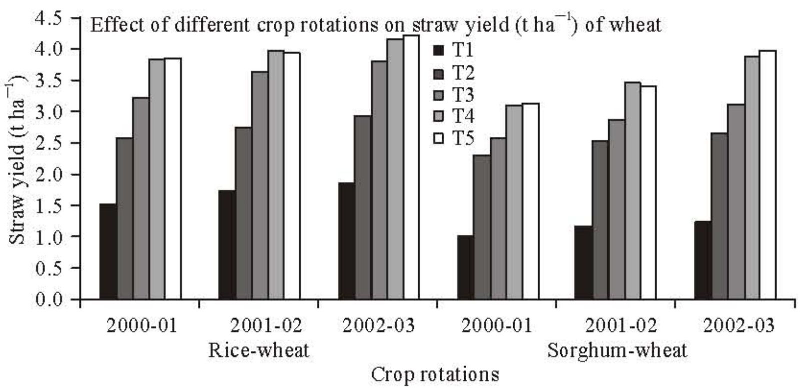

Fig. 5: Effect of fertilizers applications rates on straw yield of wheat

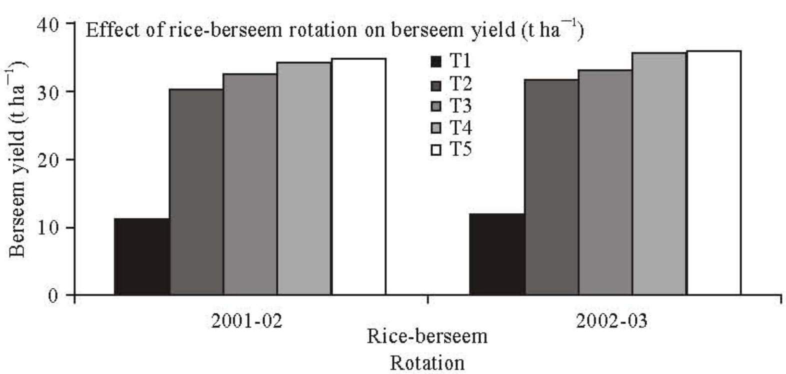

Fig. 6: Effect of fertilizers applications rates on berseem fodder yield

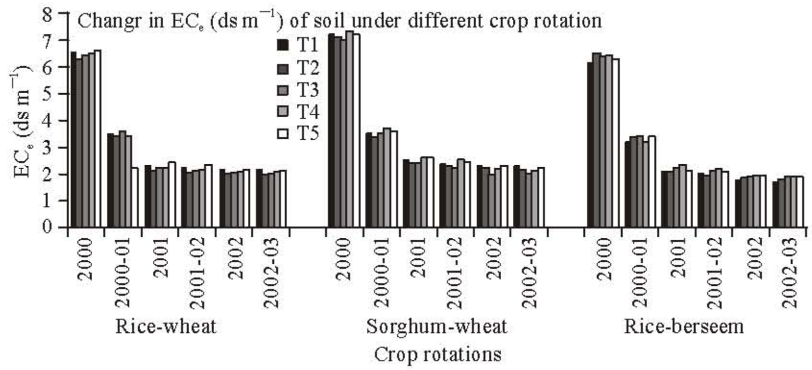

Fig. 7: Effect of crop rotations on soil EC_e (dS m^{-1})

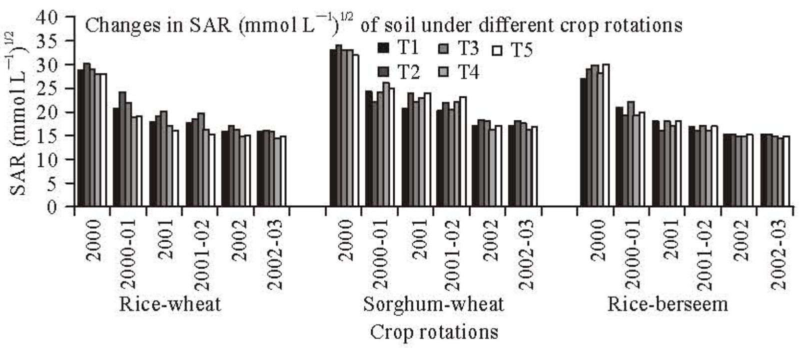

Fig. 8: Effect of crop rotations on soil SAR (mmol $L^{-1})^{1/2}$

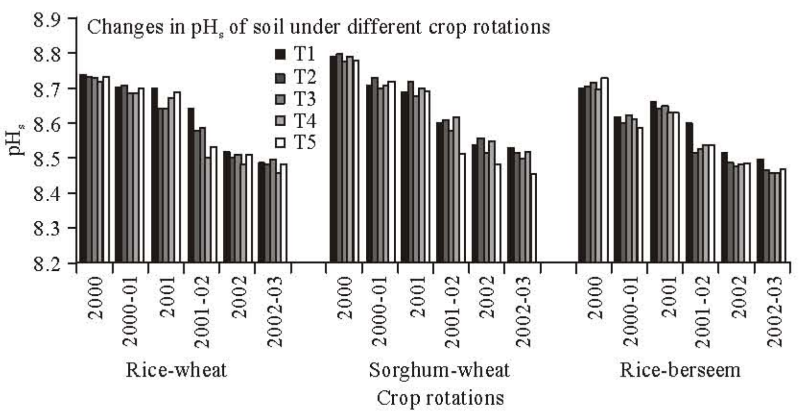

Fig. 9: Effect of crop rotations on soil pH_s

maximum yield was noted in T_4 treatment where recommended dose with 25% additional of recommended dose was applied in both the rotations i.e. rice-wheat and sorghum-wheat during all the three years. The higher fertilizer application rate i.e. recommended dose with 50% additional of recommended dose remained non-significant with T_4.

Berseem fodder yield in rice-berseem rotation is presented in Fig. 6. The data indicated that Berseem fodder was also significantly increased with the increasing rates of fertilizer and like grain and straw of wheat, it was found maximum in T_4 where recommended dose with 25% additional of recommended dose was applied which remained non-significant with higher rates during both the years. In first year, berseem was failed due to high salinity-sodicity level of field. The increase in grain and straw yield of wheat and fodder yield of berseem during all the years of study might be due

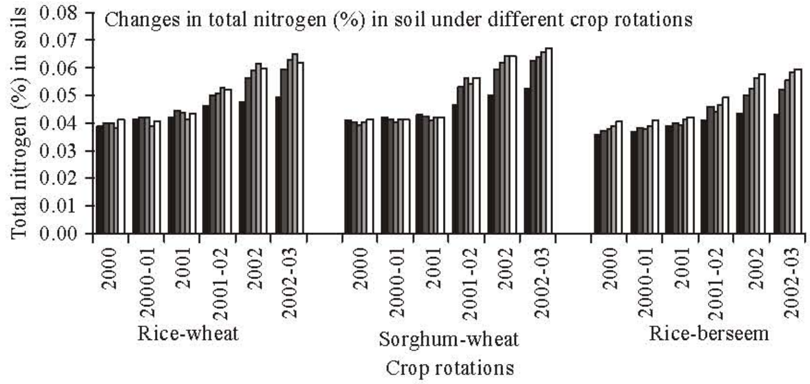

Fig. 10: Effect of crop rotations on total soil nitrogen (%)

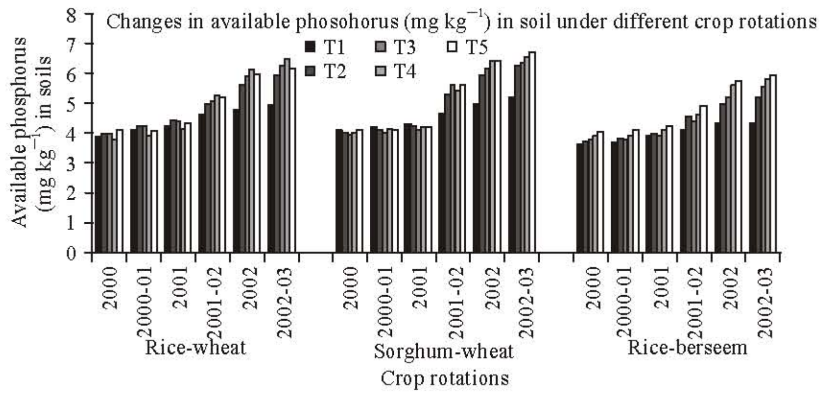

Fig. 11: Effect of crop rotations on available soil phosphorus (mg kg^{-1} soil)

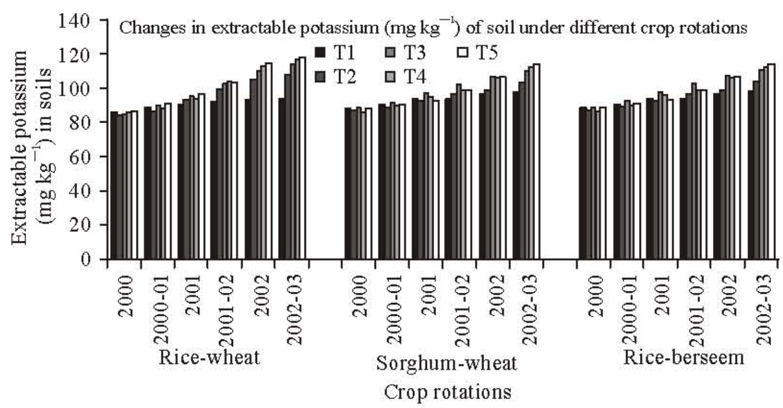

Fig. 12: Effect of crop rotations on extractable soil potassium (mg kg^{-1} soil)

to the reason that after reclamation nutrient level in soil was low and fertilizer application rate positively increased the yield. Similar results were reported by Singh [14], Hayee *et al.* [15] and Imtiaz *et al.* [16].

Chemical characteristics of soil i.e. EC_e, pH_s and SAR of all the three rotations Rice-Wheat, Rice-Berseem and Sorghum-Wheat is presented in Fig. 7-9. The results indicated that all the three parameters were decreased with the passage of time during all the study period. Minimum reduction in these parameters was noted in control in comparison to the fertilizer applied treatments.

The reason might be that more biomass was produced in the fertilized treatment over control, resulting in more reclamation of the soil than the control treatment because when crop is harvested, roots left over in the field are decayed and during this decaying process, they excrete organic acids which react with $CaCO_3$ present in the soil and activate it. After activation, it is converted from $CaCO_3$ to $CaSO_4$ that reclaimed the soils and on flooding the salts are produced during reclamation process that leaches down resulting in the decrease on EC_e, pH_s and SAR. The similar results were reported by Patrick *et al.* [21].

The fertility status of soil i.e. N, P and K under all the three rotations i.e. Rice-Wheat, Rice-Berseem and Sorghum-Wheat is presented in Fig. 10-12. The results indicated that fertility status of soils in all the three rotations during all the three years were continuously improved significantly over control with the application of fertilizer. Maximum N, P and K were improved in T_5 where recommended dose with 25% additional fertilizer of recommended dose was applied and minimum in control where no fertilizer was applied during all the three years in all the three rotations. The reason might be that more plant population was produced in fertilizer treated plot over control resulting in more number of roots. After harvest of each crop that on decaying produced more organic matter and increase in organic matter contents in soil always result in the improvement of fertility status of soil (N, P and K). Similar results were reported by Ranjha *et al.* [22], Awan *et al.* [8], Obaid-ur-Rehman [23] and Singh [14].

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