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Integrated nutrient management for rice-wheat cropping system in a recently reclaimed soil

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Abstract

A field experiment was conducted for integrated nutrient management in a recently reclaimed soil. For this purpose a saline sodic field was selected at soil salinity research farm having EC_e, 7.40 (dS m^{-1}); pH_s, 8.90; SAR, 38.26 (mmol $L^{-1})^{½}$ and gypsum requirement, 3.52 (ton $acre^{-1}$); deficient in total nitrogen (0.017%) and available phosphorus (4.20 mg kg^{-1}) and medium in extractable K (90 mg kg^{-1}). This field was reclaimed by applying gypsum at 100% G.R. After reclamation, different combinations of FYM, Sesbania and chemical fertilizers were applied. The experiment was layed out in randomized complete block design with three replications. Rice variety Shaheen basmati was transplanted. The data showed that different combinations of organic manures with chemical fertilizers increased paddy and straw yield significantly over application of organic manures alone. Among different combinations, Sesbania at 20 ton ha^{-1} + 75% recommended dose (R.D.) proved to be the best combination followed by Sesbania 20 ton ha^{-1} + 50% R.D. and least in FYM alone at 20 ton ha^{-1}. It was also noted that sesbania green manuring alone was found superior to FYM alone. The NPK contents both in paddy and straw were increased significantly by applying various combinations of organic manures with chemical fertilizers over application of organic manures. Maximum contents of NPK both in paddy and straw of rice were recorded in the combination of Sesbania at 20 ton ha^{-1} + 75% R.D. followed by Sesbania 20 ton ha^{-1} + 50% R.D. and least in FYM alone at 20 ton ha^{-1}.The soil analysis after harvest of rice showed that it was still slightly sodic in nature but free from salinity, deficient in total N and available P but adequate in extractable K. After harvest of rice crop in the same layout wheat variety Inqulab 91 was sown. Percent recommended dose of NPK was applied to all the plots as per treatment plan to see the residual effect of the organic manures applied to rice crop. Crop was harvested at maturity. The results of grain and straw yield showed that different combinations of organic manures (residual) and chemical fertilizers increased grain and straw yield significantly over alone application of organic manures (residual). Recommended dose of chemical fertilizers alone applied to wheat gave the maximum yield of grain and straw followed by combinations of FYM at 20 ton ha^{-1} + 75% R.D (residual) which was non significant with FYM 20 ton ha^{-1} + 50% R.D (residual) combination and least in FYM and Sesbania alone at 20 ton ha^{-1} (residual). The NPK contents both in grain and straw were increased significantly by applying various combinations of organic manures (residual) and chemical fertilizers over alone application of organic manures (residual). Maximum contents of NPK both in grain and straw of wheat were recorded in the combination of seabania at 20 ton ha^{-1} (residual) + 75% R.D. followed by Sesbania at 20 ton ha^{-1} + 50% R.D. and least in alone Sesbania and FYM (residual) treatments. Soil analysis after harvest of wheat showed that salinity/ sodicity parameters of the soil decreased, while fertility status of the soil improved further.

Key Words: Recently reclaimed soil, organic manures, rice wheat, NPK contents, soil fertility

Introduction

Organic manure when applied to gypsum amended alkali soils along with chemical fertilizers helps in efficiently maintaining the fertility status of the soil besides their role in sustaining crop yields. Organic amendments invariably contain plant nutrients, which are released into the soil solution upon their decomposition by microorganisms. Increased bacterial activity accompanying organic matter addition especially with wide C:N decreases volatilization of nitrogen in alkali soils because a considerable fraction of native and applied nitrogen is metabolized by the bacteria and is released slowly upon their death (Somani, 1980). The CO_2 and organic acids produced as a consequence of application of organic amendments have a solublizing effect on less soluble calcium phosphate (Subba-Rao, 1982). Green manuring before transplanting of rice has been advocated to improve

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yields and to partially substitute for nitrogen requirement of the crop (Singh, 1984). Application of green manuring or FYM with 50% recommended dose of NPK equaled rice yield to that obtained at 100% or 150% NPK recommended dose in gypsum amended alkali soil (Yaduvanshi, 2001). Addition of FYM and inorganic fertilizers to soil has been reported to increase the efficiency of applied fertilizers (Ahmad *et al*., 1998). Residual effect of FYM or green manuring plus 100% recommended dose of NPK significantly increased the yield of wheat over 100% recommended dose of NPK. Additions of green manure or FYM resulted in higher removal of nutrients by the crops as compared to chemical fertilizers and build up of soil N, P, K, Zn and organic carbon while reduced the soil pH (Sharma *et al*., 2001). Sen and Bandyopadhyay (2001) reported that application of chemical fertilizers supplemented through organic manure produced significantly higher yield of rice (both grain and straw) than chemical fertilizers alone. Higher N concentration in rice grain (1.7%) and straw (1.08%) was obtained in case of city compost combined with urea. Ahmad *et al.* (2001) reported that application of organic manures plus fertilizers increased growth parameters of rice crop. Maximum tillers pot^{-1}, paddy and straw yield of rice were recorded where 20 ton ha^{-1} green manure plus 150-100-100 kg ha^{-1} NPK were applied.

The residual effect of organic manures on following wheat crop showed that maximum tillers pot^{-1}, grain and straw yields were noted from FYM 20 ton ha^{-1} plus 300-200-100 kg ha^{-1} NPK treatment. The NPK contents in paddy and straw of rice and grain of wheat were significantly higher and maximum in treatment where green manure/ poultry manure at 20 ton ha^{-1} plus 300-200-100 kg ha^{-1} NPK in case of rice and 300-200-200 kg ha^{-1} NPK in case of wheat were applied. Dang and Verma (1996) studied the direct and residual effect of press mud cake in rice-wheat cropping system. Sulphitation press mud cake (SPMC) and carbonation press mud cake (CPMC) were used to determine fertilizer equivalence, press mud cake for rice and the residual effect on succeeding wheat crop. Application of either type of cake was beneficial for both the rice and wheat crop. The SPMC was better than CPMC. The fertilizer equivalence of 10 ton ha^{-1} of SPMC was 50% while that of CPMC was 28% of fertilizer recommendation for rice. The residual effect of CPMC on wheat showed improvement in its efficiency but was lower than SPMC. Increase in organic carbon, available P, K and Zn in soil were pronounced from the SPMC than from CPMC. Keeping this in view, the present study was conductor to determine a suitable combination of organic manure and chemical fertilizer for restoration of fertility of a newly reclaimed soil.

Materials and Methods

A field was selected at soil salinity research farm having EC_e, 7.40 (dS m^{-1}); pH_s, 8.90; SAR, 38.26 $(mmolL^{-1})^{0.5}$ and gypsum requirement, 3.52 (ton $acre^{-1}$). The field was deficient in total nitrogen (0.017%) and available phosphorus (4.20 mg kg^{-1}) and medium in extractable K (90 mg kg^{-1}). This field was reclaimed by applying gypsum at 100% G.R. After reclamation, different combinations of FYM, Sesbania and chemical fertilizers were applied as given below.

T_1: R.D. (140-115-80 kg ha^{-1})
T_2: FYM at 20 ton ha^{-1}
T_3: Sesbania at 20 ton ha^{-1}
T_4: 75% R.D. + FYM at 20 ton ha^{-1}
T_5: 50% R.D. + FYM at 20 ton ha^{-1}
T_6: 75% R.D. + Sesbania at 20 ton ha^{-1}
T_7: 50% R. D. + Sesbania at 20 ton ha^{-1}
T_8: 75% R.D. + FYM at 15 ton ha^{-1}
T_9: 50% R. D. + FYM at 15 ton ha^{-1}
T_{10}: 75% R.D. + Sesbania at 15 ton ha^{-1}
T_{11}: 50% R.D. + Sesbania at 15 ton ha^{-1}
T_{12}: 75% R.D. + FYM at 10 ton ha^{-1}
T_{13}: 50% R.D. + FYM at 10 ton ha^{-1}
T_{14}: 75% R.D. + Sesbania at 10 ton ha^{-1}
T_{15}: 50% R.D. + Sesbania at 10 ton ha^{-1}

Sesbania and FYM were applied fifteen days before transplanting of rice, while chemical fertilizers were applied at the time of rice transplanting. Rice variety Shaheen basmati was transplanted in the month of July. All the PK and half N fertilizer were applied at the time of transplanting while remaining half N was applied after 30 days of transplanting. Chemical herbicides were used for the control of weeds. Zinc sulphate (33%) at 12.5 kg ha^{-1} was also applied ten days after rice transplanting. All cultural practices were performed. Crop were harvested at maturity. Paddy and straw yield data was collected. Paddy and straw samples were analysed for NPK contents. The system of layout was randomized complete block design with three replications. The plot size was 6 m x 12 m. After harvest of rice crop wheat variety Inqulab 91 was sown in the same layout. Percent recommended dose of NPK was applied to all the plots as per treatment plan to see the residual effect of the organic manures applied to rice crop. Crop was harvested at maturity. The sources of NPK were urea, single super phosphate and potassium sulphate. All the soil analyses were done according to the methods given in Hand Book No. 60 (U.S. Salinity Lab. Staff, 1954) except total nitrogen in soil and plants by Jackson (1962), Available P in soil by Watanabe and Olsen (1965) and soil texture by Moodie *et al*. 1959). All the data were statistically analysed by using randomized complete block

design and treatment mean were compared by using least significance difference (LSD) test (Steel and Torrie, 1984).

Results and Discussion

Paddy and straw yield of rice

The data regarding the effect of different rates of organic manures in combination with various doses of NPK are given in Table1 which showed that combined application of organic manures and mineral nutrients remained superior compared to individual application of mineral and organic fertilizers. Maximum paddy (4.16 ton ha^{-1}) and straw yield (15.18 ton ha^{-1}) was observed in the treatment where 75% recommended dose in combination with Sesbania at 20 ton ha^{-1} was applied. It was followed by the treatment in which 50% R.D. + Sesbania at 20 ton ha^{-1} was applied which was followed by the treatment in which 75% R.D. + Sesbania at 15 ton ha^{-1} was applied which remained statistically at par with recommended dose of NPK(140-115-80 kg ha^{-1}), while minimum paddy and straw yield was recorded in the treatment where Sesbania at 20 ton ha^{-1} was applied and it was followed by FYM application at 20 ton ha^{-1} alone.

metabolic transformation of organic material, as the green manuring is continuously subject to degradation, thus more susceptible to change in metal uptake than inorganic soil fractions. The results get support from the findings of Sarwar (2005) who reported that yield and different yield parameters of rice increased significantly with the use of chemical fertilizers alone or in combination with various organic materials applied in the form of Sesbania green manure, FYM and compost in field and pot experiments.

The improvement in paddy and straw yield of rice followed a chain process. Addition of different organic materials like Sesbania green manure, FYM and compost enhanced the organic matter percentage of the soil that played a key role for improving soil fertility and crop productivity. The increase in organic matter content of soil improved the physical properties of the soil. The betterment in physical properties of soil reduced the soil pH as various acid and acid forming compounds were released with the addition of organic materials. The reduction in soil pH increased the availability of plant nutrients and resultantly more uptake of various nutrients by the plants occurred. The increased uptake of nutrients by rice improved metabolic activities in the plants. As a result of all above

Table 1: Integrated nutrient management for rice production in recently reclaimed soils

Treatment	Paddy yield	Straw yield
	(ton ha^{-1})	
R.D. (140-115-80 kg ha^{-1})	3.51 CD	12.56 C
FYM at 20 ton ha^{-1}	2.28 H	9.76 GH
Sesbania at 20 ton ha^{-1}	2.83 E	11.61 DE
75% R.D.+ FYM at 20 ton ha^{-1}	3.36 DE	11.96 CD
50% R.D. + FYM at 20 ton ha^{-1}	3.07 FG	10.68 EFG
75% R.D. + Sesbania at 20 ton ha^{-1}	4.16 A	15.18 A
50% R. D. + Sesbania at 20 ton ha^{-1}	3.85 B	13.97 B
75% R.D. + FYM at 15 ton ha^{-1}	2.61 I	8.82 HI
50% R. D. + FYM at 15 ton ha^{-1}	2.65 HI	9.06 HI
75% R.D. + Sesbania at 15 ton ha^{-1}	3.59 C	12.63 C
50% R.D. + Sesbania at 15 ton ha^{-1}	3.25 EF	11.34 DEF
75% R.D. + FYM at 10 ton ha^{-1}	2.58 I	8.55 I
50% R.D. + FYM at 10 ton ha^{-1}	2.61 I	8.76 I
75% R.D. + Sesbania at 10 ton ha^{-1}	3.03 G	10.49 FG
50% R.D. + Sesbania at 10 ton ha^{-1}	2.65 HI	8.97 HI
LSD	0.1979	0.8991

Mean sharing similar letter(s) do no differ significantly at p = 0.05

The comparison of Sesbania and FYM applied at 20 (ton ha^{-1}) showed that Sesbania remained superior over the farm yard manure for improving the paddy and straw yield of rice. The increased efficiency of NPK fertilizer with green manuring may be due to chemical, enzymatic and processes various yield components like plant height, number of tillers per plant of rice were positively affected which contributed towards increase in paddy and straw yield of rice. Similarly Zaka *et al.* (2003) observed significant increase in rice and wheat yield with the use of FYM, rice

straw and Sesbania. Similarly, many other researchers like Dixit and Gupta (2000), Ahmad *et al*. (2001), Selvakumari *et al*. (2000) Parmer and Sharma (2002) also claimed increased yield of rice with the use of different organic materials alone and in combination with mineral fertilizer.

Nitrogen, phosphorus and potassium concentration in paddy and straw of rice

The data regarding the integrated use of organic manures and inorganic fertilizers on N, P and K concentration in paddy are given at Table 2, which showed that among the different combinations, maximum NPK content in paddy were observed in the treatment where a combination of Sesbania at 20 ton ha^{-1} + 75% R.D was applied to rice which was followed by a combination of Sesbania at 20 ton ha^{-1} + 50% R.D. The minimum NPK content in paddy were observed in the treatment where FYM at 20 ton ha^{-1} was applied and it remained statistically at par with the treatment where Sesbania at 20 ton ha^{-1} alone was applied. As for as the effect of different combination of organic manures along with chemical fertilizers for improving NPK content in straw is concerned, maximum NPK contents in straw were observed where a combination of Sesbania at 20 ton ha^{-1} + 75% R.D. were applied. It was followed by a combination where Sesbania at 20 ton ha^{-1} + 50% R.D were applied. The minimum NPK content in straw were recorded where only FYM at 20 ton ha^{-1} was applied and it remained statistically at par with the treatment where only Sesbania at 20 ton ha^{-1} was applied. The increase in NPK content of paddy and straw of rice with integrated application of nutrients may be due to improvement of the soil environment which encouraged proliferation of roots resulting in more absorption of water and nutrients from larger area and depth. Moreover, organic manures after decomposition released nutrients which became available to the plants and thus increased NPK concentration. Results corroborate the findings of Sarwar (2005) who reported increased concentration of NPK in paddy and straw of rice with the combined use of FYM, Sesbania green manure and chemical fertilizer compared with application of chemical fertilizer and organic manures alone. Tiwari *et al*. (2001) noticed faster rate of mineralization and greater utilization of nutrients through the use of green manure in combination with chemical fertilizer. The results also get support from the findings of Tabassam *et al.* (2002) and Yaduvanshi (2001).

Soil analysis after rice harvesting

The data regarding the effect of combined application of organic and inorganic fertilizers after the harvest of rice on soil chemical properties and nutrients i.e. EC_e, pH_S, SAR, Total N, available P (mg kg^{-1}) and extract able K (mg kg^{-1}) of soil is given in Table (3) which showed that combination of organic and in organic fertilizer remained superior for decreasing the soil characteristics (EC_e, pH_S, SAR). Minimum values of EC_e, pH_S and SAR after rice harvest were observed where 75% R.D + FYM at 10 ton ha^{-1} was applied. It was followed by 75% R.D, 50% R.D + Sesbania at 20 ton ha^{-1}. The maximum value of EC_e, pH_s, SAR after rice harvest was noted where only R.D (140-115-80 kg ha^{-1}) was applied. The comparison of Sesbania and FYM applied at 20 ton ha^{-1} showed that Sesbania remained superior compared to FYM for improving the basic soil characteristics.

The decrease in pH of soil after rice harvest in the integrated treatments might be due to higher production of CO_2 and organic acids released during the decomposition of organic materials, while decrease in EC and SAR of the soil after rice harvest in the integrated treatment plots might be due to the fact that organic acids produced during decomposition of organic manures activated the native $CaCo_3$ which was converted into $CaSo_4$ that reclaimed the soil and during reclamation the salts was leached down during flooding resulting in decreased EC_e, pH_s and SAR of the soil . Similar results were also reported by Patrick *et al*. (1985). As for as total N, available P and extractable K status of soil after the rice harvest is concerned, combined application of organic and mineral fertilizers remained superior compared to individual application. Maximum NPK contents in soil after the rice harvest were observed where a combination of 75% R.D + Sesbania at 20 ton ha^{-1} was applied and it was followed by the treatment where 50% R.D. + Sesbania at 20 ton ha^{-1} were applied. The minimum NPK content in soil after the harvest of rice were noted where combinations of 75% R.D + FYM at 10 ton ha^{-1} + 50% R.D + FYM at 10 ton ha^{-1} were applied. The comparison of FYM and Sesbania applied at 20 ton ha^{-1} showed that Sesbania remained superior to FYM for improving NPK content of soil after the harvest of rice. The increase in nitrogen contents of soil in the integrated treatments might be due to mineralization of N by green manuring and FYM in soil. Similar results were reported by Zia (1992) who reported that residual N fertility was the highest with Sesbania green manure followed by FYM and wheat straw. The increase in available P of the soil might be due to mineralization of organic P, production of organic acids making soil P more available. Similar results were also reported by Yadvinder *et al*. (1991) who reported that incorporation of green manure into the soil increased P availability. This is attributed to reduced energy bonding and P sorption capacity of flooded soils to green manuring (Handel *et al*., 1988). Significant improvement in P availability due to incorporation of Sesbania straw under lab flooded soil conditions (Khind *et al*., 1987). The

Table 2: Nitrogen, phosphorus and potassium concentration in paddy and straw of rice as affected by the application of different rates of chemical fertilizers and organic manures

Treatment	Paddy			Straw		
	Total N	P	K	Total N	P	K
		(%)			(%)	
R.D. (140-115-80 kg ha^{-1})	1.31 a	0.27 d	0.46 d	0.71 abc	0.13 cd	2.20 bc
FYM at 20 ton ha^{-1}	1.21 b	0.21 e	0.40 e	0.64 c	0.09 e	2.00 d
Sesbania at 20 ton ha^{-1}	1.23 b	0.23 e	0.42 e	0.66 bc	0.11 de	2.10 cd
75% R.D. + FYM at 20 ton ha^{-1}	1.35 a	0.31 abc	0.50 abc	0.76 a	0.16 abc	2.40 a
50% R.D. + FYM at 20 ton ha^{-1}	1.34 a	0.30 abcd	0.50 abc	0.75 a	0.15 bc	2.35 ab
75% R.D. + Sesbania at 20 ton ha^{-1}	1.36 a	0.33 a	0.52 a	0.78 a	0.19 a	2.45 a
50% R. D. + Sesbania at 20 ton ha^{-1}	1.36 a	0.32 ab	0.51 ab	0.78 a	0.19 a	2.45 a
75% R.D. + FYM at 15 ton ha^{-1}	1.34 a	0.30 abcd	0.48 bcd	0.74 ab	0.15 bc	2.41 a
50% R. D. + FYM at 15 ton ha^{-1}	1.34 a	0.30 abcd	0.47 cd	0.73 ab	0.15 bc	2.39 a
75% R.D. + Sesbania at 15 ton ha^{-1}	1.35 a	0.31 abc	0.50 abc	0.74 ab	0.17 ab	2.43 a
50% R.D. + Sesbania at 15 ton ha^{-1}	1.33 a	0.30 abcd	0.50 abc	0.73 ab	0.17 ab	2.40 a
75% R.D. + FYM at 10 ton ha^{-1}	1.31 a	0.28 cd	0.47 cd	0.71 abc	0.14 bcd	2.38 a
50% R.D. + FYM at 10 ton ha^{-1}	1.31 a	0.27 d	0.46 d	0.71 abc	0.14 bcd	2.38 a
75% R.D. + Sesbania at 10 ton ha^{-1}	1.33 a	0.29 bcd	0.48 bcd	0.73 ab	0.16 abc	2.41 a
50% R.D. + Sesbania at 10 ton ha^{-1}	1.33 a	0.28 cd	0.47 cd	0.72 abc	0.15 bc	2.40 a

Mean sharing similar letter(s) do no differ significantly at p = 0.05

Table 3: Soil analysis after rice

Treatment	EC_e (d S m^{-1})	pH_s	SAR (m mol L^{-1})$^{0.5}$	Total N (%)	Available P (mg kg^{-1})	Extractable K (mg kg^{-1})
R.D. (140-115-80 kg ha^{-1})	4.40 a	8.72 NS	29.24 a	0.020 c	4.80 e	92 d
FYM at 20 ton ha^{-1}	3.38 bcd	8.60	24.60 d	0.028 b	5.20 de	96 cd
Sesbania at 20 ton ha^{-1}	3.32 bcde	8.66	23.98 d e	0.030 b	5.40 cd	98 bcd
75% R.D. + FYM at 20 ton ha^{-1}	3.42 b	8.64	22.68 efg	0.037 a	5.90 abc	104 abc
50% R.D. + FYM at 20 ton ha^{-1}	3.40 bc	8.62	23.42 def	0.037 a	5.80 abc	106 ab
75% R.D. + Sesbania at 20 ton ha^{-1}	3.30 bcde	8.65	27.08 bc	0.040 a	6.20 a	110 a
50% R. D. + Sesbania at 20 ton ha^{-1}	3.28 cde	8.63	24.62 d	0.039 a	6.00 ab	110 a
75% R.D. + FYM at 15 ton ha^{-1}	3.38 bcd	8.66	28.48 ab	0.036 a	5.80 abc	105 ab
50% R. D. + FYM at 15 ton ha^{-1}	3.42 b	8.72	27.56 abc	0.036 a	5.70 abcd	104 abc
75% R.D. + Sesbania at 15 ton ha^{-1}	3.36 bcd	8.64	23.84 de	0.039 a	5.80 abc	108 a
50% R.D. + Sesbania at 15 ton ha^{-1}	3.39 bcd	8.62	21.89 fg	0.038 a	5.80 abc	108 a
75% R.D. + FYM at 10 ton ha^{-1}	3.21 e	8.61	21.59 c	0.036 a	5.60 bcd	104 abc
50% R.D. + FYM at 10 ton ha^{-1}	3.28 cde	8.63	21.36 g	0.035 a	5.50 bcd	104 abc
75% R.D. + Sesbania at 10 ton ha^{-1}	3.33 bcde	8.65	21.48 g	0.038 a	5.70 abcd	107 a
50% R.D. + Sesbania at 10 ton ha^{-1}	3.27 de	8.62	27.26 bc	0.038 a	5.70 abcd	106 ab

NS: Non-significant

Mean sharing similar letter(s) do no differ significantly at p = 0.05

increase in available K in the integrated treatments may be due to the additional K applied through it, the solublizing action of certain organic acids produced during organic manures decomposition and their capacity to hold K in the available form. Similar results were reported by Swarup, (1987) and Nagarajah *et al*. (1989). Katyal (1977) reported marked increase in K concentration which was attributed to release of Fe^{2+} and Mn^{2+} under highly reduced condition created by green manuring.

Residual effect of organic manures on grain and straw yield of wheat

The results regarding the residual effect of organic manures and chemical fertilizers on grain and straw yield of

wheat are given in Table 4 which showed that maximum grain and straw yield of wheat was recorded where only recommended dose (175-140-80 kg ha^{-1}) was applied. Among the different combinations of organic and mineral fertilizers, maximum residual effect on grain and straw yield of wheat was observed where FYM at 20 ton ha^{-1} (residual) along with 75% R.D. was applied and it remained statistically at par with the combination of 75% R.D + Sesbania at 20 ton ha^{-1} (residual) and 50% R.D. + FYM at 20 ton ha^{-1}. The minimum residual effect among the combined application of organic and mineral fertilizers was noted where 50% R.D. and Sesbania at 10 ton ha^{-1} (residual) were applied. It was followed by a combination of 50% RD + FYM at 10 ton ha^{-1} (residual), 75% R.D + Sesbania 10 ton ha^{-1} (residual), 50% R.D + Sesbania at 15 ton ha^{-1}.

Among the organic sources alone, residual effect of FYM remained superior to Sesbania when it was applied at 20 ton ha^{-1} to rice crop. Green manuring surely improves the fertility status of the soil, which helps to enhance the crop yield. It is excellent source of N for the first rice crop and becomes a poorer source for the subsequent wheat crop. Green manures that decompose slowly will increase organic matter content and may have residual effects on N supply to future crop (Bouldin, 1988). Significant residual effect of green manuring on wheat yield after rice has been reported (Mian *et al*. 1988). In an other study, 9% improvement in wheat yield was recorded after green manuring (RRI, 1988). Singh *et al.* (2001) noted an increase in grain yield of rice with the use of FYM and green manure in combination with mineral fertilizer. They also observed the significant residual effect of FYM and green manure on grain and straw yield of wheat. Tiwari *et al*. (2001) claimed that to achieve the highest grain production of rice under saline sodic conditions, the use of FYM would be more profitable probably increasing the cynobacterial N fixation. They also noted the carryover effect of FYM applied to rice crop on the grain production of succeeding wheat crop. The results also get support from the findings of Dang and Verma (1996) and Ahmad *et al*. (2001).

NPK concentration in grain and straw of wheat

The data regarding the NPK content of wheat grain and straw as affected by the residual effect of different organic sources in combination with chemical fertilizers is given in Table (5) which showed that maximum NPK content in grain were observed where 75% R.D + Sesbania at 20 ton ha^{-1} (residual) was applied. It was followed by the treatment where 50% R.D + Sesbania at 20 ton ha^{-1} (residual) was applied. The minimum NPK content were observed in grain where 50% R.D + FYM at 10 ton ha^{-1} (residual) was applied. The comparison of FYM and Sesbania applied at 20 ton ha^{-1} (residual) showed that Sesbania applied at 20 ton ha^{-1} (residual) was better than FYM at 20 (ton ha^{-1}) for improving the NPK content of wheat grain. As for as the residual effect of organic + mineral fertilizer application for improving the NPK content of straw is concerned, maximum NPK content in wheat straw were observed where 75% R.D + Sesbania at 20 ton ha^{-1} (residual) was

Table 4: Residual effect of organic manures and chemical fertilizers on grain and straw yield of wheat

Treatment	Grain yield (ton ha^{-1})	Straw yield (ton ha^{-1})
R.D. (175-140-80) kg ha^{-1}	2.92 A	3.67A
FYM at 20 ton ha^{-1}	1.72 H	1.92 J
Sesbania at 20 ton ha^{-1}	1.66H	1.81J
75% R.D. + FYM at 20 ton ha^{-1}	2.52 B	3.13B
50% R.D. + FYM at 20 ton ha^{-1}	2.41 BC	2.97BCD
75% R.D. + Sesbania at 20 ton ha^{-1}	2.39 BCD	2.94CDE
50% R. D. + Sesbania at 20 ton ha^{-1}	2.28 DEF	2.78EFGH
75% R.D. + FYM at 15 ton ha^{-1}	2.48 D	3.08BC
50% R. D. + FYM at 15 ton ha^{-1}	2.29 CDEF	2.80DEFG
75% R.D. + Sesbania at 15 ton ha^{-1}	2.33 CDE	2.85DEF
50% R.D. + Sesbania at 15 ton ha^{-1}	2.19 EFG	2.65 GH
75% R.D. + FYM at 10 ton ha^{-1}	2.26 DEF	2.75FGH
50% R.D. + FYM at 10 ton ha^{-1}	2.11 G	2.36 I
75% R.D. + Sesbania at 10 ton ha^{-1}	2.17 FG	2.62 H
50% R.D. + Sesbania at 10 t. ha^{-1}	2.10G	2.34 I
LSD	0.1583	0.1583

Mean sharing similar letter(s) do no differ significantly at p = 0.05

Table 5: Nitrogen, phosphorus and potassium concentration in grain and straw of wheat

Treatment	Grain			Straw		
	Total N	P	K	Total N	P	K
		(%)			(%)	
R.D. (175-140-80) kg ha^{-1}	2.30 abc	0.47cde	0.58 bc	0.80 cde	0.15 bc	2.40 bcd
FYM at 20 ton ha^{-1}	2.20 bc	0.40 f	0.44 e	0.74 e	0.10 d	2.32 d
Sesbania at 20 ton ha^{-1}	2.24 abc	0.42 ef	0.47 de	0.76 de	0.13 cd	2.34 cd
75% R.D. + FYM at 20 ton ha^{-1}	2.36 ab	0.55 ab	0.66 ab	0.89 ab	0.19 ab	2.48 ab
50% R.D. + FYM at 20 ton ha^{-1}	2.36 ab	0.54 ab	0.66 ab	0.89 ab	0.18 ab	2.48 ab
75% R.D. + Sesbania at 20 ton ha^{-1}	2.41 a	0.58 a	0.70 a	0.92 a	0.21 a	2.55 a
50% R. D. + Sesbania at 20 ton ha^{-1}	2.40 a	0.58 a	0.70 a	0.91 a	0.21 a	2.54 a
75% R.D. + FYM at 15 ton ha^{-1}	2.14 c	0.51 bcd	0.60 abc	0.85 abc	0.18 ab	2.46 abc
50% R. D. + FYM at 15 ton ha^{-1}	2.32 ab	0.51 bcd	0.58 bc	0.84 abcd	0.17 abc	2.46 abc
75% R.D. + Sesbania at 15 ton ha^{-1}	2.38 a	0.53 abc	0.66 ab	0.89 ab	0.19 ab	2.51 ab
50% R.D. + Sesbania at 15 ton ha^{-1}	2.38 a	0.52 bcd	0.64 abc	0.87 abc	0.18 ab	2.49 ab
75% R.D. + FYM at 10 ton ha^{-1}	2.31 ab	0.47 cde	0.56 bcd	0.81 bcde	0.17 abc	2.44 abcd
50% R.D. + FYM at 10 ton ha^{-1}	2.29 abc	0.46 de	0.54 cd	0.80 cde	0.15 bc	2.42 abcd
75% R.D. + Sesbania at 10 ton ha^{-1}	2.35 ab	0.51 bcd	0.62 abc	0.84 abcd	0.19 ab	2.47 abc
50% R.D. + Sesbania at 10 ton ha^{-1}	2.33 ab	0.49 bcd	0.60 abc	0.82 bcde	0.17 abc	2.43 abcd

Mean sharing similar letter(s) do no differ significantly at p = 0.05

Table 6: Soil analysis after wheat

Treatment	EC_e (d S m^{-1})	pH_s	SAR (mmol L^{-1})$^{0.5}$	Total N (%)	Available P (mg kg^{-1})	Extractable K (mg kg^{-1})
R.D. (175-140-80) kg ha^{-1}	4.31 a	8.62 b	25.72 ab	0.023 d	5.00 g	94 c
FYM at 20 ton ha^{-1}	3.28 bcd	8.51 d	22.46 de	0.030 c	5.40 f	98 bc
Sesbania at 20 ton ha^{-1}	3.26 cde	8.54 cd	21.52 ef	0.031 c	5.50 f	101 abc
75% R.D. + FYM at 20 ton ha^{-1}	3.34 b	8.53 cd	20.62 fgh	0.039 ab	6.30 ab	107 ab
50% R.D. + FYM at 20 ton ha^{-1}	3.22 de	8.51 d	21.58 ef	0.040 ab	6.20 bc	107 ab
75% R.D. + Sesbania at 20 ton ha^{-1}	3.23 cde	8.54 cd	26.72 a	0.042 a	6.40 a	112 a
50% R. D. + Sesbania at 20 ton ha^{-1}	3.25 cde	8.55 c	22.40 de	0.042 a	6.20 bc	112 a
75% R.D. + FYM at 15 ton ha^{-1}	3.31 bc	8.53 cd	24.28 bc	0.039 ab	6.00 cde	108 ab
50% R. D. + FYM at 15 ton ha^{-1}	3.36 b	8.52 cd	25.40 ab	0.039 ab	5.90 de	107 ab
75% R.D. + Sesbania at 15 ton ha^{-1}	3.28 bcd	8.68 a	21.38 efc	0.040 ab	6.10 cd	111 a
50% R.D. + Sesbania at 15 ton ha^{-1}	3.21de	8.52 cd	23.68 cd	0.040 ab	6.10 cd	110 a
75% R.D. + FYM at 10 ton ha^{-1}	3.18 e	8.51 d	19.46 h	0.037 b	5.80 e	107 ab
50% R.D. + FYM at 10 ton ha^{-1}	3.24 cde	8.53 cd	19.82 gh	0.037 b	5.80 e	107 ab
75% R.D. + Sesbania at 10 ton ha^{-1}	3.22de	8.50 d	24.72 bc	0.039 ab	6.00 cde	110 a
50% R.D. + Sesbania at 10 ton ha^{-1}	3.23 cde	5.51 d	24.90 bc	0.039 ab	6.00 cde	109 ab

Mean sharing similar letter(s) do no differ significantly at p = 0.05

applied. It was followed by combination of 50% R.D. + Sesbania at 20 ton ha^{-1} (residual). The minimum NPK content in straw were noted where 50% R.D + FYM at 10 ton ha^{-1} (residual) was applied. It was followed by a combination 50% R.D + Sesbania at 10 ton ha^{-1} (residual) and 50% R.D + FYM at 15 ton ha^{-1} (residual). The comparison of FYM and Sesbania at 20 ton ha^{-1} (residual) showed that Sesbania applied at 20 ton ha^{-1} (residual) is better than FYM for improving the NPK content of wheat straw.

The reason might be that increased organic matter content of soil by the application of Sesbania and FYM in combination with chemical fertilizer to rice crop improved soil aeration, permeability, aggregation, water holding capacity and biological properties of soil. Resultantly the efficiency of chemical fertilizer applied to wheat crop and NPK uptake by wheat increased. The results get support form the findings of Dixit and Gupta (2000). Similarly, Shafique (2000) reported that NPK concentration in wheat grain and straw increased with application of NPK

fertilizers at 300-150-100 kg ha^{-1} along with FYM, poultry manure and wheat straw (residual) at 25 ton ha^{-1} applied to rice crop before sowing of wheat.

Soil analysis after wheat harvest

The soil analysis after the harvest of wheat crop in rice-wheat rotation as affected by the combined application of organic and mineral fertilizer after the wheat harvest is given in Table (6) which showed that salinity/sodicity parameters (EC_e, pH_S, SAR) of the soil decreased while the fertility status of the soil improved. Maximum reduction in EC_e, pH_S and SAR of soil was observed where 75% R.D + Sesbania at 10 ton ha^{-1} (residual) was applied. As far as the fertility parameters of the soil is concerned, maximum NPK content were noted where 75% R.D + Sesbania at 20 ton ha^{-1} (residual) were applied. It was followed by the treatment where 50% R.D + Sesbania at 20 ton ha^{-1} (residual) were applied. The comparison of FYM and Sesbania at 20 ton ha^{-1} (residual) showed that improvement of soil fertility by the application of Sesbania is better than FYM. The results are in line with the findings of Yaduvanshi (2001), Dang and Verma (1996).

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