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Plant Growth and Yield as Affected by Application of Organic Inputs with Fertilizer in Rice Wheat Cropping Sequence

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Abstract

The present study was taken up on Alluvial soils of Varanasi to evaluate the effect of organics with chemical fertilizer on growth and yield in rice-wheat cropping sequence. The experiment was laid out in randomized block design with nine treatments with three replications. Treatments consists of control (no fertilizer), 100% NPK and combinations of 70% NPK with different organics viz., FYM, pressmud and vermicompost were applied on nitrogen basis (36 kg). The results reveal that highest plant height of rice and wheat at 90 DAT (122.9, 96.67 cm), number of tillers per meter row length (77.53, 156.84), chlorophyll content at 60 DAT (39.67, 38.54 SPAD), number of grains per panicle (45.03, 67.12), test weight (23.02, 37.51g), grain yield (47.78, 41.63 q ha^{-1}) and straw yield (72.78, 65.47 q ha^{-1}) was found from T_8 (70% NPK + 15% N by FYM and 15% by pressmud) and closely followed by T_7 (70% NPK + 15% N by vermicompost and 15% by pressmud). Among the organics, pressmud reported higher in all above parameters. The 100% NPK recorded significantly lower as compared to T_8 and control plot recorded lowest value of all above parameters. The study showed that integrated use of organics with fertilizer produced higher and sustainable yield of rice and wheat.

Keywords

Growth; Yield; Organics; Fertilizer; Rice and wheat.

Introduction

Agriculture remains a soil-based system, there is no another way that increases yield of the major crops without ensuring that plants have an adequate and balanced supply of nutrients [1,2]. The relevant environment must exist for nutrients to be available to a particular crop in the right form, in the correct absolute and relative amounts, and at the right time for high yields to be realized in the short and long term [3,4]. At present, the environmental drawbacks of heavy fertilizer use are limited to some developed countries and a few regions in developing countries [4,5]. Appropriate and responsible application of fertilizers will help to maintain yields and minimize pollution [6,5]. By contrast, levels of fertilizer use in most developing countries are so low that there is little likelihood of major environmental problems from their application. In fact, greater application of organic and inorganic fertilizers in an integrated manner in these areas could benefit the environment and increase the yields of field crops [7].

The basic concept underlying the integrated nutrient management system (INMS), nevertheless, remains the maintenance and possible improvement

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of soil fertility for sustained crop productivity on long-term basis without deteriorating environment quality and also to reduce inorganic (fertilizer) input cost [8,9]. Thus, integrated nutrient management (INM) aims to maintenance or adjustment of soil fertility and of plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of benefit from all possible sources of plant nutrients in an integrated manner [10,11].

A suitable combination of organic and inorganic sources of nutrients is necessary for sustainable agriculture that can ensure food production with high quality. Integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility [12]. It is generally believed that combining organics with inorganic fertilizer will increase synchrony and reduce losses by converting inorganic N into organic forms. Studies have shown that it is not always true [13]. The application of organic manures influences the physical and chemical properties of soil and also enhances the biological activities. It is also positively correlated with soil porosity and enzymatic activity [14]. Applications of both chemical and organic fertilizers need to be applied for the improvement of soil physical properties as well as supply of essential plant nutrients for higher production [15].

Materials and Methods

The present investigation conducted at Agricultural Research Farm, Banaras Hindu University, Varanasi during two consecutive season *viz.*, *Kharif* 2013 and *Rabi* 2014 using paddy and wheat as test crop. The experimental site was located between 25.14^0 to 25.33^0 N latitude and 82.56^0 to 83.03^0 E longitudes and falls in a semi arid to sub humid climate. The mean ambient temperature and relative humidity during the experiment ranged from 17.3^0C to 34.8^0C and 75% to 86%, respectively. The experiment was conducted in randomized block design with 9 treatments replicated thrice. The treatments consisted of different organics which applied on nitrogen basis and inorganic fertilizer *viz.*, T_1- Control (no fertilizer), T_2- 100% RDF (120:60:60 kg $N:P_2O_5:K_2O$ ha-1), T_3- 70% RDF + 30% N by FYM, T_4- 70% RDF + 30% N by vermicompost (VC), T_5- 70% RDF + 30% N by pressmud (PM), T_6- 70% RDF + 15% N by FYM + 15% VC, T_7 - 70% RDF + 15% N by VC + 15% PM, T_8 - 70% RDF + 15% N by FYM + 15% PM, T_9 - 70% RDF + 10% N by FYM + 10% PM + 10% VC. The FYM had pH 7.42, EC 1.44 dS m^{-1}, total carbon 22.8%, total N, P, K and S contents were 0.78, 0.36, 0.50 and 0.18%, respectively with C:N ratio 29.2:1. Vermicompost having pH 7.42, EC 1.26 dS m^{-1}, total carbon 31.3%, total N, P, K and S contents were 1.41, 0.43, 0.63 and 0.42%, respectively with C:N ratio 22.2:1. Similarly pressmud had pH 7.56, EC 1.58 dS m^{-1}, total carbon 35.0%, total N, P, K and S contents were 2.0, 1.78, 0.42 and 2.28%, respectively with C:N ratio 17.5:1. Organic manures were applied before 15 days of transplanting. The soil fertility dynamics of experimental field was estimated by soil analysis of composite soil sample from each plot before transplanting and after harvesting of crop. The soil of the experimental site was sandy clay loam, moderately alkaline in reaction with pH 8.4, medium in organic carbon 0.49%, deficient in nitrogen (205.7 kg ha^{-1}) medium in phosphorus (12.82 kg ha^{-1}) and medium in potassium (184.65 kg ha^{-1}). Observations on growth and yield attributes *viz.*, plant height, tillers, chlorophyll content (SPAD value), grains $panicle^{-1}$/ear and test weight were recorded. The crops were harvested at maturity, dried in the sun, threshed and weighed for yield.

Results and Discussion

Growth and yield

The fertilizers along with organic manures significantly enhance plant height of rice and wheat as compared to control plot at different growth stages. Meanwhile, the plant height at harvest in rice varied from 89.7 to 128.1 cm, however, in case of wheat it ranged between 71.1 to 99.2 cm. The significantly higher plant height at harvest of rice (128.1 cm) as well as in wheat (99.2 cm) was recorded in plot with treatment T_8 (70% RDF + 15% FYM + 15% PM). In rice, treatment T_8 significantly superior to rest of all the treatments except T_5, T_7 and T_9. Hence, plots with the substitution of 30% N through organic amendments produced higher plant height as compared to sole application of 100% NPK (T_2) in rice and significant residual effect of organic inputs also reported in wheat. Plot with the treatment T_8 recorded ~ 12% higher over 100% RDF in both crops.The higher response of organic inputs over 100% NPK in rice is explainable on the basis that these were applied in rice crop only and wheat receives 100% NPK, which was similar in all plots. But in wheat crop, the residual effects of treatments were found significantly different. Almost similar trend was noticed with the plant height recorded at 30, 60 and 90 days after transplanting of rice and sowing of wheat. Residual effect of organic manures

in succeeding wheat crop was significant in rice-wheat cropping system [12]. The combination of FYM, pressmud with inorganic fertilizers might have released the sufficient amounts of nutrients by mineralization which resulted in adequate amount of available nutrients and better environment for increased uptake of nutrients and consequently better crop growth. The increase in plant height in response to combined application of organics and chemical fertilizer is probably due to enhanced availability of nitrogen which enhanced more leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation [16] (Table 1).

The number of tillers at harvest in rice ranged between 42.3 to 73.6. The significantly higher numbers of tillers (73.6) were recorded with plot received treatment T_8 (70% RDF + 15% FYM+ 15% PM). The treatment in which 100% NPK (T_2) was applied which produced significantly lower (59.2) tillers as compared to integrated treatments. It was ~20% below as compared to plot with the treatment T_8. Similarly, the residual effect of treatments also found significant on number of tillers at harvest of wheat. The number of tillers of wheat at harvest varied between 52.1 (in control) to 94.8 (in T_8). In treatment $T_{8,}$ number of tillers was ~28 and 82% higher over T_2 and control, respectively. Meanwhile it was observed that the plot with T_8 showed at par with plot with T_7 (90.4). The residual effect of organic inputs observed significant on tillers of wheat, it proved by that all treatment received 30% nitrogen by organic inputs reported significantly higher than the sole application of 100% NPK (73.9). The variation in number of tillers due to nutrient sources was considered to be due to variation in the availability of major nutrients. The chemical fertilizer offers nutrients which are readily soluble in soil solution and thereby instantaneously available to plants and rest of nutrient lost in environment. But nutrient availability from organic sources was slowly and adequately to plant during entire growth period. These results were supported by researcher [17]. Almost similar trend was also noticed with the number of tillersrecorded at 30, 60 and 90 days. Number of tillersincreased from 30 to 90 DAT in rice and DAS in wheat after that it was reduced because of tiller mortality and senescence of plants.The combination of FYM and pressmud with fertilizer shows greatest number of tillers per meter row in both crops was may be due to the pressmud showed quick action in the first season and rapid decomposition of organic matter to release organic acids. Also, oxidation of S present in pressmud was expected to affect an ameliorating action on soil to provide beneficial affect by shifting soil pH towards neutrality [18]. The lowering of soil pH might have played a major role in releasing nutrients as many nutrients are plenty towards neutrality. On other hand, FYM continued the beneficial effect in the next season due to slower decomposition rate and application of organic materials in higher quantities compared to pressmud [19] (See Table 2 in next page).

Meanwhile, the chlorophyll content at 60 days in rice varied from 33.5 to 40.0 SPAD, however, in case of wheat it ranged between 28.4 to 38.6 SPAD. The significantly greatest chlorophyll content at 60 days of rice (40.0 SPAD) as well as in wheat (38.6 SPAD) was recorded in plot with treatment T_2 (100% RDF) which were significantly superior to the control and also T_3 in wheat. Plot with the treatment T_2 recorded ~20 and 36% higher over control in rice and wheat, respectively. Followed by T_2, treatment T_8 recorded ~17 and 36% higher over control treatment in rice and wheat, respectively. Chlorophyll content of leaves (SPAD) is closely related with concentration of leaf

Table 1: Effect of integrated nutrient management on plant height at different growth stages of rice and wheat

Treatment	Plant height (cm)							
	30 DAT/DAS		60 DAT/DAS		90 DAT/DAS		At harvest	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
T_1	46.17	20.78	68.13	51.71	88.4	68.52	89.67	71.14
T_2	55.87	26.06	85.53	67.22	111.8	85.19	114.88	88.89
T_3	48.40	26.14	77.73	72.23	105.7	92.69	109.20	94.89
T_4	46.87	24.59	85.13	68.63	105.7	91.68	111.05	92.69
T_5	52.28	26.48	91.73	72.88	119.6	93.05	123.23	96.03
T_6	51.10	26.40	88.73	72.61	114.2	92.69	117.64	95.45
T_7	55.27	27.15	97.80	74.04	120.9	94.61	127.85	98.34
T_8	55.34	28.12	102.93	74.26	122.9	96.67	128.12	99.24
T_9	54.85	26.77	96.07	73.00	120.5	93.63	125.42	96.83
SEm±	2.23	1.18	2.14	3.68	2.76	4.26	2.28	4.11
CD (p=0.05)	6.69	3.53	6.42	11.03	8.29	12.76	6.83	12.32

nitrogen which depends on more availability and uptake of nutrient at optimum levels of fertilization. The increase in chlorophyll content in present study may be attributed to supply of nitrogen by fertilizer and organics. However, the supply of nitrogen is similar in all treatments by different sources; hence in first year of experimentation the 100% RDF was higher over integrated treatments due to quick supply of nitrogen to plants. But in second year the residual effect of organic sources of nutrients was noticed and recorded higher in chlorophyll content of leaves. Significant residual effect of organic inputs in succeeding wheat crop in rice-wheat cropping system also reported also reported by researcher [16] (Table 3).

The number of panicles at harvest in rice ranged between 32.1 to 45.0. The significantly higher numbers of panicles (45.0) were recorded with plot received treatment T_8 (70% RDF + 15% FYM+ 15% PM). The treatment in which 100% NPK (T_2) was applied which recorded lower (40.3) panicles as compared to integrated treatments. It was ~ 11% below as compared to plot with the treatment T_8. Similarly, the residual effect of treatments also found significant on number of spikes of wheat at harvest. The number of spikes of wheat at harvest varied between 39.1 (in control) to 67.1 (in T_8). In treatment $T_{8,}$ number of spikes was ~31 and 72% higher over T_2 and control, respectively. Meanwhile it was observed that the plot with T_8 showed at par with T_7 plot (63.8) [18,17].

Results showed that the significantly higher test weight in rice and wheat was 23.0 and 37.5 g, respectively in treatment T_8 in which 70% NPK with 15% N by FYM and another 15% by pressmud was given and closely followed by treatment T_7, in which received 70% NPK with 15% nitrogen by vermicompost and another 15% by pressmud was applied. The treatment T_1 gave lowest test weight while other INM treatments gave poor test weight as compared to T_8. However, among the INM treatments, T_5, T_6 and T_7 in rice and T_5 and T_7 inwheat also found significantly superior over T_2 (21.3 and 35.4g, respectively). Besides the positive effect of organic fertilizer on soil structure that

Table 2: Effect of integrated nutrient management on number of tillers per meter row at different growth stages of rice and wheat

Treatment	Number of tillers per meter row							
	30 DAT/DAS		60 DAT/DAS		90 DAT/DAS		At harvest	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
T_1	35.62	34.88	44.62	89.79	50.70	80.69	42.32	52.10
T_2	41.20	43.84	55.60	114.85	60.47	127.42	59.21	73.89
T_3	34.27	44.05	51.20	127.85	55.73	137.37	52.41	78.71
T_4	33.54	43.54	53.47	117.63	58.07	130.60	53.82	74.22
T_5	38.61	50.10	61.73	132.73	70.60	145.13	66.12	83.11
T_6	35.10	47.97	58.80	129.27	65.53	139.53	62.25	79.66
T_7	39.63	51.38	67.80	135.33	74.93	153.78	73.01	90.40
T_8	40.61	52.47	72.93	139.06	77.53	156.84	73.58	94.83
T_9	39.27	50.50	66.07	133.52	74.07	151.65	71.10	88.12
SEm±	1.73	2.00	2.42	5.19	2.65	2.03	2.15	1.49
CD (p=0.05)	5.18	5.99	7.25	15.56	7.93	6.08	6.46	4.46

Table 3: Effect of integrated nutrient management on chlorophyll content (SPAD) at 60 days and yield attributes of rice and wheat

Treatment	Chlorophyll content (SPAD)		Number of panicles/ spikes meter^{-1} row		Test weight (g)		Number of grains per panicle/spike	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
T_1	33.48	28.38	32.11	39.07	20.55	31.90	84.42	29.05
T_2	40.02	38.58	40.26	51.41	21.32	35.42	97.53	40.58
T_3	37.79	36.38	35.63	55.03	21.12	36.29	91.87	41.55
T_4	37.88	36.50	36.59	51.66	21.47	35.84	94.47	40.83
T_5	38.77	38.02	39.96	58.33	22.38	36.62	104.67	43.48
T_6	38.70	37.22	37.33	55.74	22.28	36.41	100.03	42.30
T_7	39.27	37.66	44.64	63.80	22.67	37.38	117.75	45.25
T_8	39.67	38.54	45.03	67.12	23.02	37.51	123.09	46.34
T_9	39.14	37.43	43.35	62.09	22.43	36.81	111.62	44.03
SEm±	1.01	0.72	1.66	1.12	0.26	0.35	2.70	0.53
CD (p=0.05)	3.02	2.16	4.97	3.34	0.78	1.06	8.10	1.58

lead to better root development that result in more nutrient uptake, organics not only slowly releases nutrients but also prevents the losses of chemical fertilizers through denitrification, volatilization and leaching by binding to nutrients and releasing with the passage of time [20,21]. The better root growth with higher nutrient uptake by crops improved its grain quality and test weight.

Number of grains per panicle in rice as well as per spike in wheat significantly increased by integrated fertilizations of organic and inorganic sources. The number of grains per panicle/spike ranged between 84.4 to 123.1 and 29.1 to 46.3 in rice and wheat, respectively. The significantly higher number of grains per panicle/spike (123.1 and 46.3, respectively) was obtained in plot with treatment T_8 in rice and wheat. The plot with receiving 100% NPK (T_2) which produced significantly lower (97.5) number of grains per panicle as compared to T_7 (117.8), T_8 (123.1) and T_9 (111.6) treatments and in terms of percent it was ~21% below to treatment T_8. Similarly, the residual effect of treatments also found significant on number grains per spike of wheat and almost similar trend also noticed (as in rice) in which treatment T_8 produced 14% more grains per spike. The plots which received combination of FYM, pressmud with mineral fertilizations showed highest number of grains per panicle/spike in both crops. It may be due to the pressmud showed quick action in the first season and rapid decomposition of organic matter to release organic acids. On other hand, FYM continued the beneficial effect in the next season due to slower decomposition rate and application of organic materials in higher quantities compared to pressmud [22,17].

The maximum grain and straw yield (47.8 & 73.8 q ha^{-1}) of rice recorded with T_8 in which 70% NPK with 15% nitrogen by FYM and another 15% by pressmud was given followed by plot T_7 (46.9 & 71.9 q ha^{-1}) in which 70% NPK with 15% nitrogen by vermicompost and another 15% by pressmud. In rice, the treatment $T_8$was significantly higher over treatment T_1, T_2, T_3, T_4 and T_6 but statically at par with treatment T_5, T_7 and T_9. Similarly, in wheat, the significantly highest grain and straw yield 41.6 & 65.5 q ha^{-1} in treatment T_8. In rice, the plot with T_8 found ~25 and 74% higher over treatment T_2 and T_1, respectively. The residual effect of integrated nutrient management showed significant effect on grain and straw yield of wheat. In wheat, the treatment T_8 recorded ~19 and 56% higher over treatment T_2 and T_1, respectively. The harvest index ranged from 35.0 to 39.6% and 38.0 to 39.8% in rice and wheat, respectively. Maximum harvest index of 39.6% in rice was recorded with T_8 treatment, however, in wheat the highest harvest index was noted with T_6 which received 70% RDF + 15% N by FYM and 15% by vermicompost (Table 4).

Higher yields of rice and wheat obtained with the application of integrated nutrients was mainly due to their positive effect on various yield contributing characters like number of tillers, test weight, number of grains per panicle/spike etc. Earlier [18;17] also found significant and consistent increase in grain and straw yield with combined application of organic and mineral fertilizers. Concomitant release of nitrogen at most critical stages of their need is a key to ensure higher yields. Rice straw yield significantly increased with the application of 10 ton FYM along with zinc sulphate [10]. Similarly, many other researchers like [23]. Harvest index which denotes the proportion of economically produced part to the above ground biomass varied significantly only in rice, however maximum value in both crops reported in integrated treatments. It suggests that plant maintained a higher supply of photosynthates to reproductive part as compared to vegetative biomass to sustain higher index [20,24].

Table 4: Effect of integrated nutrient management on grain and straw yield of rice and wheat

Treatment	Grain yield (q ha^{-1})		Straw yield (q ha^{-1})		Harvest index (%)	
	Rice	Wheat	Rice	Wheat	Rice	Wheat
T_1	27.41	26.76	51.28	43.86	34.98	37.96
T_2	41.34	34.99	66.34	52.90	38.33	39.87
T_3	38.33	36.51	65.02	56.34	37.12	39.26
T_4	39.77	35.80	64.77	54.43	38.00	39.64
T_5	43.42	38.70	68.42	58.63	38.77	39.76
T_6	41.55	37.67	66.55	56.88	38.41	39.83
T_7	46.87	41.00	71.87	63.89	39.46	39.10
T_8	47.78	41.63	72.78	65.47	39.63	38.92
T_9	44.23	39.09	69.23	61.75	38.99	38.77
SEm±	1.72	1.53	2.07	2.14	0.90	1.35
CD (p=0.05)	5.16	4.57	6.21	6.41	NS	NS

Note: NS - Non Significant

Conclusion

It may be concluded from the present study that application of 70% RDF + 15% N as FYM + 15% as PM is most effective for improving the nutrients uptake and productivity of rice. Practically it is difficult for the Indian farmers to apply high amount (10 t FYM ha^{-1}) of manures every year as recommended by many researchers; therefore, application of available organic amendments at a lower rate in conjunction with chemical fertilizers can maximize the yield. Thus, the study emphasizes that higher nutrient content, improvement in soil health and higher yield of rice and wheat can be achieved with the treatment 70% RDF + 15% N by FYM and 15% by PM, and in addition to this it also saving 30% cost on chemical fertilizers.The results clearly indicated the need of integrated use of 70% RDF + 15% N as FYM+15% as PM to meet the nutrient requirement of rice for sustaining the high productivity.

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