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Research Paper

Effect of conjoint application schedules of organic and inorganic sources of nutrients on growth, yield and economics of rice

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ABSTRACT

A field experiment was conducted during (*kharif)* summer season of 2019 and 2020 at Crop Research Centre, Sardar Vallabh Bhai Patel University of Agriculture and Technology, Modipuram, Meerut, Uttar Pradesh to study the effect of integrated use of chemical nitrogen fertilizer and green manure on performance of rice (*Oryza sativa* L.). The experiment consists of fourteen treatment combinations of conjoint application of organic and inorganic sources of nutrients was laid-out in randomized block design with three replications. The results showed that the significant highest dry matter accumulation (1,205.90 g/m^2) at harvest stage, leaf-area index (4.18), crop growth rate (16.34 g/m^2/day), relative growth rate (7.09 mg/g/day), grain yield (3.88 t/ha) and straw yield (6.64 t/ha) recorded in the 25% recommended N through *dhaincha* incorporated + 75% N through chemical fertilizer was found at par with RDF (120N : 60P : 50K) and 25% recommended N through vermicompost incorporated 10 days before transplanting + 75% N through chemical fertilizer and it was significantly superior over rest of the treatment combinations. The substitution of 25% N through incorporated *dhaincha* at planting was found most promising in terms of productivity, profitability and performed better than other treatments and may be recommended for farmers of Uttar Pradesh and similar agro-eco regions.

Key words: Economics, growth parameters, rice, ntegrated, yield

Rice (*Oryza sativa* L.) is one of the world's most consumed cereal crops. 'Rice is life' is the most appropriate statement for India since this crop plays a vital role in country's food security and is the backbone of livelihood for millions of rural households. It is a prince among the cereals and the premier staple food for many Asian, African, Latin American and Caribbean countries. At the global level, rice is grown in an area of about 163.2 million ha with production of 751.9 million tonnes and productivity of about 400–600 kg/ha (FAO, 2017). India ranks first in respect of area of 39.43 million ha and second in production of 107.04 million tonnes, only after China, but the rice productivity is very low, only 200–700 kg/ ha. In Uttar Pradesh it covers 5.29 million ha area with 11.94 million tonnes of production, but the productivity of rice is only 200 kg/ha (Anonymous, 2017). The demand for rice is increasing with growing population pressure, and its production has to be raised to 160 million tonnes by 2030 with a minimum annual growth rate of 2.35%. Basmati is of special importance among rice, since it is much remunerative than coarse rice due to vast scope of its export. The demand for basmati is much more in USA, European Union and Gulf countries but due to deteriorating quality, the export of Indian basmati to these countries is not increasing. Many factors are responsible for the deterioration of quality of produce; among them nutrient management is major. Therefore, it is important to cultivate basmati rice with the restricted use of chemicals so our produce may be competitive at the global market. As the land area is decreasing with time, increasing land use intensity with inadequate and imbalanced chemical fertilizers with little or no organic manure has caused severe fertility deterioration, stagnating or even declining crop productivity and quality (Thakur *et al.,* 2021). Integrated use of fertilizers, bio-fertilizers and farmyard manure seems to be the practicable alternative to the present malady of unsustainable agriculture. Farmyard manure is an easily available, cheap, proven source of nutrition to agricultural crops and has been used by the farmers traditionally. Besides supplying major and micronutrients, it also improves the physical, chemical and biological properties of soil. Use of farmyard manure supplies essential nutrients, improves soil health and enhances yield on sustained basis (Bana *et al.,* 2016). The conjoint use of organic manure and fertilizers is promising in maintaining

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stability in crop production on certain soil through correction of the marginal deficiency of secondary and micronutrient elements in the course of mineralization of organic manure on the one hand and providing favorable physical, chemical, and soil ecological conditions (Sharma *et al.,*2020). There is no doubt about the role of organic sources on crop productivity and soil sustainability, but to establish a synchrony between the supply and demand of plant nutrients from organic sources, optimization of application timing is most important. Indian farmers are poor in resources and cannot afford chemical fertilizers due to escalating prices. However, it is imperative to use technologies in a conjoint manner so that the potential of rice could be realized on sustained basis. The objective of this study was to assess the effect of conjoint application of organic and chemical fertilizers on growth, yield and economics of basmati rice in western Uttar Pradesh.

MATERIALS AND METHODS

The present investigation was carried out during the *kharif* seasons of 2019 and 2020 at Crop Research Center, Sardar Vallabh Bhai Patel University of Agriculture and Technology, Modipuram, Meerut, Uttar Pradesh. The soil of the experimental field was sandy loam and neutral in reaction, low in organic carbon (0.47%) and available nitrogen (206.30 kg/ha), and medium in available phosphorus (12.40 kg/ha), potassium (137.00 kg/ha) and zinc (0.78 kg/ha). The experiment was laid out with 14 treatments of conjoint use of organic and chemical fertilizers viz. T_1, Control; T_2, RDF (120N : 60P : 50K); T_3, 25% recommended N through *dhaincha* incorporated 10 days before transplanting + rest N through chemical fertilizer (30 kg N SES 10 D + 75% RDN-F); T_4, 25% Recommended N through *dhaincha* incorporated 5 days before transplanting + rest N through chemical fertilizer (30 kg N SES 05 D + 75% RDN-F); T_5, 25% recommended N through *dhaincha* incorporated on planting date + rest of N through chemical fertilizer, 30 kg N SES P D+ 75% RDN-F; T_6, 25% recommended N through vermicompost incorporated 10 days before transplanting + rest N through chemical fertilizer, 30 kg N V 10 D + 75% RDN-F; T_7, 25% recommended N through vermicompost incorporated 5 days before transplanting + rest N through chemical fertilizer, 30 kg N V 05 D + 75% RDN-F; T_8, 25% recommended N through vermicompost incorporated on planting date + rest N through chemical fertilizer, 30 kg N V PD + 75% RDN-F; T_9, 37.5% recommended N through *dhaincha* incorporated 10 days before transplanting + rest N through chemical fertilizer, 45 kg N SES10 D + 62.5% RDN-F; T_{10}, 37.5% recommended N through *dhaincha* incorporated 5 days before transplanting + rest N through chemical fertilizer, 45 kg N SES 05 D + 62.5% RDN-F; T_{11}, 37.5% recommended N through *dhaincha* incorporated on planting date + rest N through chemical fertilizer, 45 kg N SES PD+ 62.5% RDN-F; T_{12}, 37.5% recommended N through vermicompost incorporated 10 days before transplanting + rest N through chemical fertilizer, 45 kg N V 10 D + 62.5% RDN-F; T_{13}, 37.5% recommended N through vermicompost incorporated 5 days before transplanting + rest N through chemical fertilizer, 45 kg N V 05 D+ 62.5% RDN-F and T_{14}, 37.5% recommended N through vermicompost incorporated on planting date + rest N through chemical fertilizer, 45 kg N V PD + 62.5% RDN-F in randomized block design with three replications. Rice seedlings 'Pusa Basmati 1509' with a plot geometry (20 cm × 10 cm) were transplanted on 15 July and 16 July 2019 and 2020, respectively. The recommended dose of fertilizer, *i.e.* P_2O_5 and K_2O were applied through DAP, SSP and MoP, and nitrogen was applied through urea and organic sources *dhaincha*, vermicompost. A full dose of phosphorus and potassium was applied at the time of transplanting, while 25 to 37.5 percent N through organic sources as per treatment and 12.5 to 25.0 percent through chemical fertilizer were applied before or at the time of transplanting. The remaining 50% nitrogen was applied in two equal splits at the maximum tillering and panicle initiation stage. The crop was raised with a recommended package of practices. During the crop-growing period, data with respect to different parameters of growth, yield attributes and yield of rice were collected. Leaf area index (LAI) was computed from the samples collected for dry matter estimation; leaves of 5 hills were plucked at tillering, panicle initiation and flowering and leaf area was measured using leaf area meter (LA-3100). The leaf area for each sample recorded was averaged to give the leaf area of plants/ hill. The following relationship was used to compute LAI (Watson, 1952) at each stage.

$$\text{LAI} = \frac{\text{Leaf area (cm2)}}{\text{Land area (cm2)}}$$

The relative growth rate (RGR) is the rate of increase in dry weight per unit dry weight already existent, and it is measured in milligrams per gram of dry weight everyday (mg/g day) (Blackman, 1919).

$$\text{RGR} = \frac{\text{Loge W2} - \text{LogeW1}}{\text{T2} - \text{T1}} gg - 1\, day - 1$$

Where W1 and W2 are the dry weight values at time T1 and T2, respectively. T1 and T2 are time in days.

The crop growth rate (CGR) is the rate at which dry matter is produced per unit of ground area per unit of time. CGR was determined using Watson (1952) formula and expressed in grams per square meter daily (g/ m^2 / day).

$$\text{CGR} = \frac{\text{W2} - \text{W1}}{\text{T2} - \text{T1} \times \text{land area}} gday - 1m - 2$$

The economics of different treatments were calculated by using the following formulae.

Gross returns (₹/ha)= Monetary returns of seed yield (₹/ha) + Straw yield (₹/ha)

Net returns (₹/ha)= Gross return (₹/ha) – Total cost of cultivation (₹/ha)

Gross returns (₹/ha)

B: C ratio = $\frac{PV\ of\ the\ benefit\ expected}{PV\ of\ the\ cost}$

The data collected from different parameters were subjected to appropriate statistical analysis under a randomized complete block design by following the procedure of ANOVA analysis of variance (SAS Software packages, SAS EG 4.3). Significance of difference between means was tested through 'F' test and the least significant difference (LSD) was worked out where the variance ratio was found significant for the treatment effect. The treatment effects were tested at 5% probability level for their significance.

RESULT AND DISCUSSION

Growth parameters

There was significant variation in dry-matter accumulation under different treatments at almost all the growth stages during both years of experimentation. At 0–30 DAT, the maximum dry matter accumulation of 145.00 and 149.50 g/m^2 during 2019 and 2020, respectively, recorded with T_2 was significantly higher than T_1, T_8, T_9, T_{10}, T_{12}, T_{13}, T_{14} during 2019 and except for T_4, T_5, T_6, T_7 during 2020. At 30–60 DAT, the maximum dry-matter accumulation of 449.70 and 473.70 unit g/m^2 during 2019 and 2020, respectively recorded with T5 was significantly higher than T_1, T_3, T_8, T_9, T_{10}, T_{11}, T_{12}, T_{13} and T_{14} during 2019 and with exception of T_2, T_4, T_6 during 2020. At 60–90 days, the maximum dry matter accumulation of 701.30 and 715.70 g/m^2 during 2019 and 2020, respectively, found with the application of T_5 was significantly higher than the treatment except for T_2, T_4, T_6, T_7 during 2019 and 2020. The maximum dry matter accumulation 1,157.50 and 1,205.90 g/m^2 during 2019 and 2020 at harvest recorded in T5 was significantly higher than the treatments except for T_2, T_3, T_4, T_6, T_7 during 2019 and 2020. It might be due to the beneficial effect of *dhaincha* and vermicompost along with chemical fertilizers in improving the physical, chemical and biological environment of soil is conducive for better plant growth (Paul *et al*., 2014). This improvement in soil fertility might have favored the growth and development of rice crop in current study. The overall additive effect of *dhaincha*/vermicompost and chemical fertilizer additions on the improvement of soil properties might have resulted in significant improvement in the growth of crop plants.

Leaf area index (LAI)

Leaf-area is regarded to be optimum when photosynthesis is maximum. Below optimum LAI, the photosynthetic activity is less owing to sparse sunlight interception. At 0–30 days, the maximum leaf area index 2.24 and 2.46 during 2019 and 2020 respectively recorded in T_2 was *at par* with T_4, T_5, T_6, T_{11} and T_{12} during 2019 and T_5, T_6, T_{10}, T_{11}, T_{12} during 2020 while significantly higher than the rest of treatments (Table 1). At 30-60 days, the maximum leaf area index 4.98 and 4.94 during 2019 and 2020, respectively recorded with T_5 during both years was significantly higher than T_1, T_9, T_{13}, T_{14} and statistically *at par* with rest of the treatments.

At 60–90 days, the maximum leaf area index 4.12 and 4.18 during 2019 and 2020, respectively found with the application of T_5 was significantly higher than T_1 and T_{14} during both the years and statistically *at par* to the remaining treatments. Treatments consisting application of *dhaincha* or vermicompost to substitute 25 or 37.5% N did not differ significantly among themselves in respect of leaf-area index. Increase in LAI with the application of nutrients either in inorganic, organic or in their combinations is reported. This may be due to the fact that the presence of adequate N supply resulted in better utilization of carbohydrates to form more protoplasm. The cells produced under such conditions tend to be large with thin walls which may cause increase in leaf area (Black, 1967). Biomass production has shown an increasing trend with an increasing rate of NPS+Organic sources. The better performance under integrated nutrient application was closely associated with improved LAI and yield attributes (Birhanu, 2017).

Crop growth rate (CGR)

At 0–30 days, the maximum CGR 10.48 unit g/day/m^2 (T7) and 10.87 (T5) during 2019 and 2020, respectively was *at par* with T_2, T_4, T_5 and T_6 during 2019 and T_4 & T_6 during 2020 while significantly higher than the rest of treatments (Table 2). At 30–60 days, the maximum CGR 8.39 unit (T_5) and 8.40 (T7) during 2019 and 2020, respectively was *at par* with T_2, T_4 and T_6 during 2019 and T_2, T_3, T_4, T_5, T_6, T_8 and T_{12} during 2020 while significantly higher than the rest of treatments (Table 2). At 60–90 days, the maximum CGR 15.77 (T_4) and 16.58 (T_2) during 2019 and 2020, respectively was *at par* with T_2, T_3, T_5, T_7, T_8, T_{11} and T_{13} during 2019 and T_3, T_4, T_5, T_6, T_9, T_{10} and T_{11} during 2020 while significantly higher than the rest of treatments (Table 2).

Rice crop is a moderate feeder of nutrients required in available forms throughout the growing season. Growing of rice under combined application of both organic and inorganic sources of nutrients helped in supplying nutrients throughout the growing season that led to improved growth

Table 1. Effect of application timings of organic N sources on dry matter accumulation g/m^2 and LAI at different growth stages of rice on the basis of 2-years data

Treatment	Dry matter accumulation (g/m^2)								LAI					
	0–30 DAS		30–60 DAS		60–90 DAS		90–at harvesting		0–30 DAS		30–60 DAS		60–90 DAS	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
T_1, Control	91.3	84.2	214.9	196.5	381.3	395.6	545.0	580.0	1.39	1.56	3.76	3.88	3.05	3.08
T_2, RDF (120N : 60 P : 50K)	145.0	149.5	449.3	447.6	678.3	690.0	1,137.5	1,187.5	2.24	2.46	4.82	4.64	3.98	4.06
T_3, 30 kg N SES 10 D + 75% RDN-F	131.3	124.6	394.3	393.1	607.5	637.1	1,048.3	1,111.9	2.00	1.94	4.63	4.54	3.80	3.84
T_4, 30 kg N SES 05 D + 75% RDN-F	135.0	137.7	440.1	449.2	671.7	688.9	1,144.9	1,171.7	2.06	2.10	4.56	4.76	3.96	3.84
T_5, 30 kg N SES P D+ 75% RDN-F	143.8	147.6	449.7	473.7	701.3	715.7	1,157.5	1,205.9	2.18	2.31	4.98	4.94	4.12	4.18
T_6, 30 kg N V 10 D + 75% RDN-F	144.0	141.8	448.0	446.5	691.7	693.3	1,110.0	1,176.7	2.19	2.32	4.91	4.82	4.02	4.10
T_7, 30 kg N V 05 D+ 75% RDN-F	132.3	138.2	446.7	429.8	658.7	681.9	1,094.6	1,130.0	1.98	2.18	4.60	4.78	3.76	3.98
T_8, 30 kg N V PD + 75% RDN-F	125.2	125.7	389.6	380.8	601.3	623.3	1,035.0	1,053.0	1.92	2.14	4.48	4.32	3.85	3.90
T_9, 45 kg N SES10 D + 62.5% RDN-F	122.5	116.4	375.2	357.9	588.8	585.0	976.7	1,050.0	1.90	2.10	4.46	4.32	3.86	3.90
T_{10}, 45 kg N SES 05 D+ 62.5% RDN-F	123.8	122.7	394.3	382.8	590.0	601.0	998.0	1,062.0	1.98	2.24	4.58	4.66	3.97	3.95
T_{11}, 45 kg N SESPD+ 62.5% RDN-F	131.3	127.5	399.0	394.2	600.0	613.0	1,025.0	1,080.0	2.20	2.36	4.84	4.74	4.08	4.02
T_{12}, 45 kg N V 10 D + 62.5% RDN-F	128.8	122.6	397.1	389.5	606.0	630.0	1,015.0	1,030.0	2.20	2.31	4.78	4.66	3.88	4.01
T_{13}, 45 kg N V 05 D+ 62.5% RDN-F	127.5	120.4	379.2	382.3	565.0	612.0	993.3	995.0	1.97	2.20	4.46	4.40	3.81	3.91
T_{14}, 45 kg N V PD + 62.5% RDN-F	126.3	116.0	370.5	365.7	540.0	590.0	958.9	975.0	1.86	2.18	4.31	4.38	3.66	3.68
SEm±	4.8	4.7	14.7	14.5	22.4	23.1	37.8	39.4	0.07	0.07	0.17	0.17	0.14	0.14
CD (P=0.05)	13.9	13.6	42.7	42.1	65.4	67.2	109.9	114.4	0.21	0.21	0.50	0.49	0.42	0.40

Table 2. Effect of application timings of organic N sources on crop growth rate and relative growth rate at different stages on the basis of 2-years data

Treatment	CGR (g/m^2/ day)						RGR (mg/g/day)					
	30–60 DAS		60–90 DAS		90–at harvesting		30–60 DAS		60–90 DAS		90–at harvesting	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
T_1, Control	4.12	3.74	5.55	6.64	5.46	6.15	5.37	5.28	5.94	5.98	6.30	6.36
T_2, RDF (120N : 60 P : 50K)	10.14	9.94	7.63	8.08	15.31	16.58	6.11	6.10	6.52	6.54	7.04	7.08
T_3, 30 kg N SES 10 D + 75% RDN-F	8.77	8.95	7.11	8.13	14.69	15.83	5.98	5.97	6.41	6.45	6.95	7.01
T_4, 30 kg N SES 05 D + 75% RDN-F	10.17	10.38	7.72	7.99	15.77	16.09	6.09	6.11	6.51	6.54	7.04	7.07
T_5, 30 kg N SES P D+ 75% RDN-F	10.20	10.87	8.39	8.07	15.21	16.34	6.11	6.16	6.55	6.57	7.05	7.09
T_6, 30 kg N V 10 D + 75% RDN-F	10.13	10.16	8.12	8.23	13.94	16.11	6.10	6.10	6.54	6.54	7.01	7.07
T_7, 30 kg N V 05 D+ 75% RDN-F	10.48	9.72	7.07	8.40	14.53	14.94	6.10	6.06	6.49	6.52	6.99	7.03
T_8, 30 kg N V PD + 75% RDN-F	8.81	8.50	7.06	8.08	14.46	14.32	5.96	5.94	6.40	6.43	6.94	6.96
T_9, 45 kg N SES10 D + 62.5% RDN-F	8.42	8.05	7.12	7.57	12.93	15.50	5.93	5.88	6.38	6.37	6.88	6.95
T_{10}, 45 kg N SES 05 D+ 62.5% RDN-F	9.02	8.67	6.52	7.27	13.60	15.37	5.98	5.95	6.38	6.40	6.91	6.97
T_{11}, 45 kg N SESPD+ 62.5% RDN-F	8.92	8.89	6.70	7.29	14.17	15.57	5.99	5.97	6.40	6.42	6.93	6.98
T_{12}, 45 kg N V 10 D + 62.5% RDN-F	8.94	8.90	6.96	8.02	13.63	13.33	5.98	5.96	6.40	6.44	6.92	6.94
T_{13}, 45 kg N V 05 D+ 62.5% RDN-F	8.39	8.73	6.19	7.66	14.28	12.77	5.94	5.95	6.34	6.41	6.90	6.90
T_{14}, 45 kg N V PD + 62.5% RDN-F	8.14	8.32	5.65	7.48	13.96	12.83	5.92	5.90	6.29	6.37	6.87	6.88
SEm±	0.33	0.33	0.26	0.29	0.51	0.54	0.04	0.04	0.04	0.04	0.04	0.04
CD (P=0.05)	0.96	0.95	0.75	0.84	1.49	1.58	0.11	0.12	0.10	0.11	0.11	0.12

parameters of rice varieties (Choudhary and Suri, 2014).

Relative Growth Rate (RGR)

The RGR was computed at 3 different intervals, i.e. at 30–60 days, 60–90 days and 90– at harvest in both the years. The maximum RGR 6.108 g/g/day 6.160 (30–60 days), 6.552; 6.572 (60–90 days) and 7.053; 7.094 (90 days – at harvest) in the year 2019 and 2020 respectively was recorded in T_5 which was *at par* with T_2, T_4, T_6 and T_7 at 30-60 days, with T_2 and T_6 at 60–90 days and with T_2, T_4 and T_6 at 90- at harvest, while significantly higher than the rest of treatments (Table 2). The increase in RGR between 30–60 days and 60–90 days under different treatments varied from 109.31 to 158.98 per cent. Also, the increase in RGR between 60–90 days and 90– harvest under different treatments varied from 109.31 to 158.98%.

Although RGR reported under 25% recommended N through *dhaincha* incorporated on planting date + rest N through chemical fertilizer (T_5) treatment was at par with recommended dose of N P K (T_2) treatment. Yet, in the long-term considering soil fertility point of view, application of *dhaincha* or vermicompost would be more beneficial than chemical fertilizers alone.

Grain and straw yield

The grain yield varied significantly under different treatments, ranging from 1.97 to 4.15 and 1.97 to 4.01 t/ha during 2019 and 2020 respectively. Substitution of 25% N through *dhaincha* applied at the planting time or vermicompost applied 10 days before transplanting yielded non significantly higher than T_2, where 100% N was applied through chemical fertilizers during both years. The increment in yield was 7.7% with the application of *dhaincha* and 3.6% with vermicompost in 2019, while this increment was 4.8 and 1.4% in 2020. All the treatments of *dhaincha* except for T_9 during 2020 yielded statistically at par with T_2. Similarly, treatments consisting of substitution of 25% N through vermicompost incorporated at different timings also yielded at par with T_2, but this effect was not noticed with substitution of 37.5% N through vermicompost, where yield was significantly lower than T_2. Yield reduced drastically without fertilization during both years, and almost 52% of yield declined from the best treatment. Fertilization is an important technology in crop production, which could significantly improve the grain yield per unit area, and the combined application of organic and inorganic fertilizers is an effective cultivation measure to gain sustainable high rice yields (Wang *et al.,* 2021). It is clear from the table that the straw yields differ significantly under treatments from 3.42 to 6.92 and 3.49 to 6.70 t/ha during 2019 and 2020 respectively. Substitution of 25% N through *dhaincha* applied at the time of planting or

Table 3. Effect of application timing of organic N sources on Cost of cultivation, grossreturns, net returns and B:C ratio of basmati rice

Treatment	Grain yield (t/ha)		Straw yield (t/ha)		Cost of cultivation ₹/ha		Gross returns ₹/ha		Net returns ₹/ha		Benefit: cost ratio	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
T_1, Control	1.97	1.97	3.82	3.89	31,507	31,507	42,578	45,852	11,071	14,345	1.4	1.5
T_2, RDF (120N : 60 P : 50K)	3.85	3.83	6.45	6.44	37,788	38,052	83,260	89,001	45,472	50,949	2.2	2.3
T_3, 30 kg N SES 10 D + 75% RDN-F	3.53	3.46	6.14	6.4.2	41,960	42,224	76,433	81,268	34,473	39,044	1.8	1.9
T_4, 30 kg N SES 05 D + 75% RDN-F	4.12	3.65	6.15	6.41	41,960	42,224	87,053	84,836	45,093	42,612	2.1	2.0
T_5, 30 kg N SES P D+ 75% RDN-F	4.15	3.88	6.85	6.64	41,960	42,224	89,076	90,005	47,116	47,781	2.1	2.1
T_6, 30 kg N V 10 D + 75% RDN-F	4.12	4.01	6.55	6.80	44,960	46,224	87,551	92,175	42,591	45,951	1.9	2.0
T_7, 30 kg N V 05 D+ 75% RDN-F	3.85	3.91	6.20	6.38	44,960	46,224	81,700	90,521	36,740	44,297	1.8	2.0
T_8, 30 kg N V PD + 75% RDN-F	3.84	3.62	6.10	5.99	44,960	46,224	81,554	83,680	36,594	37,456	1.8	1.8
T_9, 45 kg N SES10 D + 62.5% RDN-F	3.47	3.38	6.21	6.09	43,058	43,192	74,597	80,040	31,539	36,848	1.7	1.9
T_{10}, 45 kg N SES 05 D+ 62.5% RDN-F	3.75	3.48	5.67	5.99	43,058	43,192	79,384	80,863	36,326	37,671	1.8	1.9
T_{11}, 45 kg N SESPD+ 62.5% RDN-F	3.64	3.69	6.34	6.50	43,058	43,192	78,337	86,417	35,279	43,225	1.8	2.0
T_{12}, 45 kg N V 10 D + 62.5% RDN-F	3.40	3.13	5.93	6.06	47,558	49,192	73,229	73,072	25,671	23,880	1.5	1.5
T_{13}, 45 kg N V 05 D+ 62.5% RDN-F	3.12	3.07	5.98	5.84	47,558	49,192	68,364	73,845	20,806	24,653	1.4	1.5
T_{14}, 45 kg N V PD + 62.5% RDN-F	2.99	3.05	5.65	5.74	47,558	49,192	64,866	71,716	17,308	22,524	1.4	1.5
SEm±	0.24	0.13	0.33	0.29								
CD (P=0.05)	0.69	0.38	0.96	0.84								

vermicompost 10 days before planting yielded significantly higher than T_1, T_7, T_8, T_9, T_{10}, T_{12}, T_{13}, T_{14} in 2019, and T_1 in 2020 and *at par* to rest of the treatment during both the year. The increment in straw yield was 2.0% with the application of *dhaincha* and 1.0% with vermicompost in 2019, while this increment was 7.1 and 6.4% in 2020. The exception of T_1 and T_{14} during 2019, straw yield did not differ significantly among the other treatments, although straw yield declined slightly with the substitution of 37.5% N *dhaincha* and vermicompost in most cases. These results are supported by the report by Kumari *et al*. (2014).

Economics

The economic analysis of any experimental research is an important aspect for getting the most beneficial treatment combination from soil health and the farmer's point of view. A treatment with more chemical fertilizers may obtain the highest net returns with a minimum cost of cultivation compared to a treatment that includes organic sources but from soil health point of view. Its recommendation cannot make the maximum cost of cultivation is obtained under T_{12}, T_{13}, T_{14} (47558/ha) and (49192/ha), gross returns (89075/ha) and (92174/ha) net returns (47115/ha) and (50948/ha) minimum in control (T1), Highest gross returns found under T_5 in 2019 and T_6 in 2020, application of 25% N through *dhaincha* at planting date or vermicompost at 10 days before planting and net returns maximum found under T_2 in 2019 and T_5 in 2020. In 2020, T_2 and T_5 variation only Rs 3168/ha but T_5 is more beneficial from soil health point of view because it includes organic source *dhaincha,* which improve the physical, chemical and biological properties of soil. All the economic (Table 3) aspects like cost of cultivation, gross returns, net returns and benefit: cost ratio is maximum under T_2 (2.2) and (2.3), and the minimum is T_1 (1.4) and (1.5) during 2019–2020. Our results confirm the findings of Sharma *et al*., (2015) and Jat *et al*., (2021)

It can be inferred that the application of nitrogen through combination of *dhaincha*/vermicompost and chemical fertilizer will have a better response in terms of yield, growth and economics as compared to chemical fertilizers alone and may be recommended for the farmers of Uttar Pradesh and similar agro-Eco regions.

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