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Research Paper

Potential organic nutrient management practices for wheat (*Triticum aestivum*) in south-eastern Rajasthan

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ABSTRACT

A field experiment was conducted during winter (*rabi*) seasons of 2017–18 to 2021–22 at Agricultural Research Station, Ummedganj, Agriculture University, Kota, Rajasthan to develop natural and organic nutrient management technologies for sustainable wheat (*Triticum aestivum* L.) production to improve soil health and income security of the farmers. The experiment comprised of 8 treatments, viz. 100% N-FYM *fb* 10% cow urine (CU) spray at 25, 50 and 75 DAS; 50% N-FYM + 50% N-Vermicompost (VC) *fb* 10% vermiwash (VW) spray at 25, 50 and 75 DAS; 100% N-FYM + NPK consortia @1250 ml/ha as a soil application; 75% N-FYM + NPK consortia @1250 ml/ha as a soil application; 75% N-FYM + NPK consortia @1250 ml/ha as a soil application *fb* 10% cow urine spray at 25, 50 and 75 DAS; 75% N-FYM + NPK consortia @1250 ml/ha as a soil application *fb* amritasanjeevani spray @10% at 25, 50 and 75 DAS; jeevamrut @500 litre/ha at sowing, 25 and 50 DAS; and ghanjeevamrut @500 kg/ha at sowing, 25 and 50 DAS, in a randomized block design (RBD), replicated thrice. A critical examination of 5 years results revealed that significantly higher plant height (66.01 cm), tillers/plant (8.57), dry weight /meter row length (77.20 g), effective tillers/meter row length (80.60), ear length (8.93 cm), seeds/ear (44.90), test weight (41.90 g), seed yield (3756 kg/ha) and gross returns (₹100,605/ha) of wheat were obtained under the application of 50% N-FYM + 50% N-VC *fb*10% vermiwash spray at 25, 50 and 75 DAS over ghanjeevamrut @500 kg/ha at sowing, 25 and 50 DAS and jeevamrut @500 litre/ha at sowing, 25 and 50 DAS and on par with rest of treatments in pooled analysis. However, net returns (₹63,020/ha) and B:C ratio (1.77) of wheat were obtained significantly higher under application of 75% N-FYM+ NPK consortia @1,250 ml/ha as a soil *fb* amritasanjeevani spray @10% at 25, 50 and 75 DAS. Result on soil health improvement revealed that significantly higher organic carbon (0.66%), available phosphorus, potassium, sulphur (63.94, 432.8 and 28.21 kg/ha, respectively) and available zinc (0.90 mg/kg) were recorded with the application of 50% N-FYM + 50% N-VC *fb*10% vermiwash spray at 25, 50 and 75 DAS.

***Key words*:** Amritasanjeevani, Beejamrut, Ghanjeevamrut, Jeevamrut, Vermicompost

Wheat (*Triticum aestivum* L.) is a native of south west Asia and stood one of the most important staple food crops that has been labelled as King of Cereals". Wheat is the world's leading cereal crop cultivated over an area of 221.11 million ha with a production of 785.10 million tonnes. In india, wheat is cultivated in almost all parts of the country, occupied 34.30 million ha with the production of 110.60 million tonnes and an average productivity of 3552 kg/ha. The major wheat producing states are Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, Rajasthan and Bihar which occupies 9.59, 7.15, 3.50, 2.36, 2.96 and 2.20 million ha area with the production of 33.94, 22.41, 14.82, 10.44, 9.48 and 6.22 million tonnes in the country, respectively (Anonymous, 2022–23).

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Organic farming is a holistic production management system that sustains the health of soils, ecosystems and people which provides long-term benefits to people and environment (Hans, 2014). It is a unique production management system which promotes and enhances agro-ecosystem health including biodiversity, biological cycles and soil biological activity. Organic farming relies as much as possible on crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection (Raahinipriya and Rani, 2018). Farmyard manure (FYM) being a major source of all essential elements improves soil organic matter and humus part of the soil. It also plays an important role in inhabitation of beneficial bacterium thus making the nutrients available to crop (Raghuwanshi *et al*., 2016). Vermicompost is the microbial composting of organic wastes through earthworms' activity to form organic fertilizer which contains higher level of

organic matter, organic carbon, total and available N, P, K and micronutrients, microbial and enzyme activities (Pandey *et al*., 2017; Verma *et al*., 2017). It increased the availability of nutrients, considerably resulting in a positive effect on growth parameters such as increased plant height, number of tillers/plant and number effective tillers per plant in wheat.

Supply of sufficient nutrient through organic sources in organic farming is the major issue responsible for low yield in conversion period. Combining more than one organic source for supplying nutrients to wheat has been found to be very effective instead of meeting the nutrient requirement by single source. Under the present situation, balanced nutrients supply by application of different organic formulations (Solid and liquid organic manures and NPK liquid consortia) with the important agronomic practices for enhancing wheat yield without deterioration soil fertility is the best option. Hence, an attempt has been made in the present study to find out the response of different organic formulations in combination with solid and liquid organic manures with the objective to improve wheat productivity and soil health in south- eastern Rajasthan.

MATERIALS AND METHODS

A field experiment was conducted during the *rabi* seasons of 2017–18 to 2021–22 at Agricultural Research Station, Ummedganj, Kota at fixed site in organic block under Maharshi Parashar Krishi Shodh Peeth to study the agronomic response of wheat under different organic nutrient formulations in south-eastern Rajasthan. The experiment was laid out in randomized block design with 3 replications and 8 treatments, viz. 100% N-FYM *fb* 10% cow urine (CU) spray at 25, 50 and 75 DAS; 50% N-FYM + 50% N-Vermicompost (VC) *fb* 10% vermiwash (VW) spray at 25, 50 and 75 DAS; 100% N-FYM + NPK consortia @1250 ml/ha as a soil application; 75% N-FYM + NPK consortia @1250 ml/ha as a soil application; 75% N-FYM + NPK consortia @1250 ml/ha as a soil application *fb* 10% cow urine spray at 25, 50 and 75 DAS; 75% N-FYM + NPK consortia @1250 ml/ha as a soil application *fb* amritasanjeevani spray @10% at 25, 50 and 75 DAS; jeevamrut @500 litre/ha at sowing, 25 and 50 DAS and ghanjeevamrut @500 kg/ha at sowing, 25 and 50 DAS, in a randomized block design (RBD). The experimental soil was clay loam in texture with a *p*H of 8.0, medium in organic carbon (0.55%), available nitrogen (362 kg/ha), phosphorus (55.5 kg/ha) sulphur (18.55 kg/ha), normal in zinc (0.68 mg/kg soil) and high in available potassium (417 kg/ha). Initial and post-harvest soil samples during 5 years were collected from 0–15 cm depth, dried processed and analysed for oxidizable organic carbon, N, P, K, S and Zn using standard procedures. The FYM (0.52% N, 0.24% P and 0.49% K) and vermicompost (1.5% N, 0.8% P and 1.0% K) were incorporated into the soil before sowing as per the treatments. A seed rate of 100 kg/ha of variety 'Raj 4037' was used during all the study years. Wheat was sown as *rabi* season crop in the second week of November in all years and harvested after attaining maturity. NPK liquid consortia (IFFCO made) was mixed with organic manures and applied as soil application at sowing time. The liquid organic manure was sprayed on standing crop at different growth stages. All the solid and liquid organic manures were applied as per treatments which were calculated on the basis of recommended dose of 120 kg/ha nitrogen equivalency in bulky organic manures. Wheat seeds were treated uniformly by beejamrut @50 ml/kg seed for 15–30 minutes in all treatments. All the agronomic and organic biopesticide plant-protections techniques were carried out uniformly as and when required. Yield attributes and yield of wheat were workout as per standard procedures, whereas economics was worked out on the basis of decided sell price at the centre.

Amritasanjeevani was prepared with the use of 5 components (fresh cow dung 60 kg, urea 3 kg, SSP 3 kg, potah 1 kg and groundnut cake 2 kg) firstly, kept urea, single super phosphate (SSP) and potash in a wide mounted plastic durm with 300 litre capacity and added water and closed the lid of drum for a period of 48 hours. Then after added remaining cow dung and ground nut cake, leave for next 4 days for fermentation. At the time of use, fill the drum completely with water. Sieved solution of amritasanjeevani @10% (50 litre/ha) was sprayed on standing crops. Jeevamrut was prepared with the mixture of 5 components (fresh cow dung 10 kg, 10 litre cow urine, 2 kg jaggery, 2 kg chickpea flour and 1 kg living soil, subsequently added in 200 liter water. All the items added to a wide mouthed plastic tank having a capacity of 300 liters. The container was kept under shade. This mixture was stirred twice a day in clock wise direction both in morning and evening. The jeevamrut stock solution was ready after 7 days. This solution was applied @500 liter/ha at a time with irrigation water. Ghanjeevamrut was prepared with a mixture of 5 components (200 kg fresh cow dung, 10 litre cow urine, 1 kg jaggery, 2 kg chickpea flour and 1 kg living soil (soil below baniyan tree). All the items mixed well and mixed material was kept under shade for 7 days, then after prepared materials was crushed/bating by stick/stone in fine particles before use in field. The ghanjeevamrut was ready for use after 7 days and kept in the shade. The rate of application was 500 kg/ha at each application on soil when it is wetted as per treatment. Vermiwash is a liquid extract obtained from vermicomposting process and used as an organic fertilizer for crop plant as 10% spray volume. To keep the moisture level in cow dung, water was sprayed

drop by drop on the vermicompost heap or plastic tank. The moist organic waste was consumed and digested by the earthworms. The vermiwash produced during the vermicomposting process is an extract of both the earthworms' bodily fluids and the biomass they worked on. It is drained from the vermi-bed or heap and continues to be enriched with nutrients. This yellowish liquid released by the earthworms is known as vermiwash. Beejamrut was made from a mixture of 6 ingredients in the ratio 10:5:5:0.5:0.1:0.025, including water, cow dung, cow urine, milk, lime, and living soil, respectively (for treat 100 kg seeds) and it was fermented for 12 hours before treating the wheat seeds uniformly at the rate of 50 ml/kg for 15–30 minutes. All the data during individual years as well as in pooled analysis were statically analyzed by adopting appropriate method standard analysis of variance.

RESULTS AND DISCUSSION

Growth attributes

A critical examination of data revealed that application of different organic nutrient management practices significantly enhanced growth parameters at 60 DAS (Table 1). Data referred that organic nutrient management practice significantly influenced plant height, tillers/plant and dry weight g/mrl over the application of ghanjeevamrut. Further pooled data inferred that significantly higher plant height (66.01 cm), tillers/plant (8.57) and dry weight g/mrl (77.20) of wheat were recorded with the application of 50% N-FYM + 50% N-VC *fb* 10% vermiwash spray at 25, 50 and 75 DAS over ghanjeevamrut @500 kg/ha at sowing, 25 and 50 DAS and jeevamrut @500 litre/ha at sowing, 25 and 50 DAS which was found on par with 75% N-FYM + NPK consortia @1250 ml/ha as soil *fb* amritasanjeevani spray 10% at 25,50 and 75 DAS; 100% N-FYM *fb* 10% CU spray at 25, 50 and 75 DAS; 100% N-FYM + NPK consortia @1250 ml/ha as soil and 75% N-FYM + NPK consortia @1250 ml/ha as soil *fb* 10% CU spray at 25, 50 and 75 DAS. Increments in growth values might be owing to the increased availability of all essential nutrients due to application of organic manures such as farmyard manure, vermicompost along with three sprays of vermiwash (Ranva *et al*., 2022), which improves water holding capacity and increases macro and micro elements availability in the rhizosphere around roots system which in turns increased plant growth (Radwan *et al*., 2021).

Additionally, the significantly increased number of tillers/plants might have been due to the ready availability of nutrients like nitrogen, phosphorus, through liquid organic formulations, i.e. vermiwash as foliar spray at critical stages, which would have triggered tillers/plant. Similar findings were reported by Meena *et al*., (2021). The increased supply of optimum nutrition involving combination of all nutrients improved the growth parameters resulted in enhanced photosynthetic process led to higher interception and absorption of radiant energy, resulting into greater photosynthesis and finally increase dry matter accumulation. In fact, leaf is the factory for conversion of solar energy into chemical energy by the process of photosynthesis due to their increased amount of dry matter production. Our results are supported by the findings of

Table 1. Effect of organic nutrient management practices on growth and yield attributes of wheat (pooled data of 5 years)

Treatment	Growth attributes at 60 DAS			Yield attributes			
	Plant height (cm)	Tillers/ plant	Dry weight g/mrl	Effective tillers/mrl	Ear length (cm)	Seeds/ ear	Test weight (g)
100% N-FYM *fb* 10% CU spray at 25, 50 and 75 DAS	64.44	7.66	73.43	78.43	8.80	43.56	41.23
50% N-FYM + 50% N-VC *fb* 10% Vermiwash spray at 25, 50 and 75 DAS	66.01	8.57	77.20	80.60	8.93	44.90	41.90
100% N-FYM + NPK consortia @1250 ml/ha as soil	61.81	7.54	71.60	76.26	8.70	42.90	40.90
75% N-FYM + NPK consortia @1250 ml/ha as soil	58.31	7.02	67.93	72.26	7.93	38.90	38.90
75% N-FYM + NPK consortia @1250 ml/ha as soil *fb* 10% CU spray at 25, 50 and 75 DAS	60.47	7.13	69.26	74.60	8.33	41.90	40.56
75% N-FYM + NPK consortia @1250 ml/ha as soil *fb* amritasanjeevani spray 10% at 25, 50 and 75 DAS	65.34	7.91	74.66	79.26	8.86	44.23	41.56
Jeevamrut @500 litre/ha at sowing, 25 and 50 DAS	58.04	6.79	65.26	69.26	7.66	38.90	37.56
Ghanjeevamrut @500 kg/ha at sowing, 25 and 50 DAS	53.11	6.24	62.76	66.26	7.50	36.56	36.90
SEm±	2.15	0.34	2.36	2.19	0.27	1.55	0.86
CD (P=0.05)	6.52	1.04	7.14	6.63	0.81	4.68	2.60

N-FYM, nitrogen-farmyard manure; CU, cow urine; VC, vermicompost; fb, followed by; DAS, days after sowing.

Choudhary *et al*., (2017), Radwan *et al*., (2021) and Kumawat *et al*., (2022).

Yield attributes

Results (Table 1) revealed that application of different organic manures along with liquid formulations significantly influenced the yield attributes of wheat. Pooled data inferred that significantly higher effective tillers/mrl (80.60), ear length (8.93 cm), seeds/ear (44.90) and test weight (41.90 g) were obtained with the application of 50% N-FYM + 50% N-VC *fb* 10% vermiwash spray at 25, 50 and 75 DAS over ghanjeevamrut @500 kg/ha at sowing, 25 and 50 DAS and jeevamrut @500 litre/ha at sowing, 25 and 50 DAS which was found statistically on par with the application of 75% N-FYM + NPK consortia @1250 ml/ha as soil *fb* amritasanjeevani spray 10% at 25, 50 and 75 DAS; 100% N-FYM *fb* 10% CU spray at 25, 50 and 75 DAS; and 100% N-FYM + NPK consortia @1250 ml/ha as soil and 75% N-FYM + NPK consortia @1250 ml/ha as soil *fb* 10% CU spray at 25, 50 and 75 DAS. Moreover, liquid organic manure in combination with solid organic manures showed additive effect on yield attributes, this might be due to stimulatory effect of liquid organic manure on many physiological processes, such as respiration activities, cell division and many enzymes' activities. It also plays an important role in the regulation of photosynthetic carbon reduction. Yield of the wheat crop is a function of several yield components which are dependent on complementary interaction between vegetative and reproductive growth of the crop. As most of these growth and yield attributes showed significantly positive correlation with grain yield of wheat evidently resulted in higher yield in treatments (50% FYM + 50% VC *fb* VW spray 10%) which got timely nitrogen, appears to be on account of their influence on dry matter production and indirectly via increase in plant height, number of total tillers, number of effective tillers and possibly as a result of higher uptake of nutrients (Sen *et al*., 2011; Mathukia *et al*., 2014).

Yield

Results revealed that application of different organic nutrient sources significantly influenced the grain yield of wheat (Table 2). Significantly higher grain yield (3756 kg/ha) obtained with application of 50% N-FYM + 50% N-VC *fb* 10% vermiwash spray at 25, 50 and 75 DAS over application of ghanjeevamrut @500 kg/ha and jeevamrut @500 litre/ha at sowing, 25 and 50 DAS and found statistically on par with the application of 75% N-FYM + NPK consortia @1250 ml/ha as soil *fb* amritasanjeevani spray 10% at at 25, 50 and 75 DAS; 100% N-FYM *fb* 10% CU spray at 25, 50 and 75 DAS, 100% N-FYM + NPK consortia @1250 ml/ha as soil; 75% N-FYM + NPK consortia @1250 ml/ha as soil *fb* 10% CU spray at 25, 50 and 75 DAS; and 75% N-FYM + NPK consortia @1250 ml/ha as

Table 2. Effcet of organic nutrient management practices on yield, economics and soil available nutrients after harvest of wheat (pooled data of 5 years)

Treatment	Grain yield (kg/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio	OC (%)	Available nutrients (kg/ha)			
						P_2O_5	K_2O	S	Zn (mg/kg)
100% N-FYM *fb* 10% CU spray at 25, 50 and 75 DAS	3511	92573	55523	1.49	0.64	61.91	429.4	25.81	0.83
50% N-FYM + 50% N-VC *fb* 10% Vermiwash spray at 25, 50 and 75 DAS	3756	100605	60352	1.50	0.66	63.94	432.8	28.21	0.90
100% N-FYM + NPK consortia @1250 ml/ha as soil	3412	91393	54568	1.48	0.63	60.55	427.0	25.11	0.82
75% N-FYM + NPK consortia @1250 ml/ha as soil	3332	89425	55000	1.59	0.61	60.41	425.5	24.01	0.80
75% N-FYM + NPK consortia @1250 ml/ha as soil *fb* 10% CU spray at 25, 50 and 75 DAS	3398	91029	55854	1.64	0.62	60.75	426.4	24.61	0.77
75% N-FYM + NPK consortia @1250 ml/ha as soil *fb* amritasanjeevani spray 10% at 25, 50 and 75 DAS	3739	98522	63020	1.77	0.63	62.27	427.0	25.01	0.75
Jeevamrut @500 litre/ha at sowing, 25 and 50 DAS	2961	79297	49797	1.69	0.60	58.39	424.9	22.11	0.73
Ghanjeevamrut @500 kg/ha at sowing, 25 and 50 DAS	2892	77378	48478	1.58	0.61	58.98	425.9	23.11	0.75
SEm±	155	3716	3716	0.11	0.006	0.55	4.24	0.22	0.005
CD (P=0.05)	435	10455	10455	NS	0.016	1.56	NS	0.61	0.014

N-FYM, nitrogen-farmyard manure; CU, cow urine; VC, vermicompost; fb, followed by; DAS, days after sowing

soil. The overall growth and development of crop is reflected in the development of yield contributing characters which affect the final yield of the crop as these parameters are positively correlated to seed yield. These results corroborate with the findings of Verma *et al.,* (2020); Ravisankar *et al*., (2021) and Ranva *et al*., (2022).

Economics

Economics of wheat under different organic sources is presented in the Table 2. Among the different organic nutrient management options, the significantly higher gross returns (₹100,605/ha) and net returns (₹60,352/ha) were obtained with application of 50% N-FYM + 50% N-VC *fb* 10% vermiwash spray at 25, 50 and 75 DAS over ghanjeevamrut @500 kg/ha and jeevamrut @500 litre/ha at sowing, 25 and 50 DAS which remained statistically on par with application 75% N-FYM + NPK consortia @1250 ml/ha as soil + amritasanjeevani spray 10% at 25, 50 and 75 DAS; 100% N-FYM *fb* 10% CU spray at 25, 50 and 75 DAS; 100% N-FYM + NPK consortia @1250 ml/ha as soil; and 75% N-FYM + NPK consortia @1250 ml/ha as soil *fb* 10% CU spray at 25, 50 and 75 DAS. Whereas, significantly higher net returns (₹63020/ha) was obtained with application of 75% N-FYM + NPK consortia @1250 ml/ha as soil *fb* amritasanjeevani spray 10% at 25,50 and 75 DAS, which was statistically on par with application of 50% N-FYM + 50% VC *fb* 10% vermiwash spray at 25, 50 and 75 DAS; 75% N-FYM + NPK consortia @1250 ml/ha as soil *fb* 10% CU spray at 25,50 and 75 DAS; 100% N-FYM *fb* 10% CU spray at 25, 50 and 75 DAS; 75% N-FYM + NPK consortia @1250 ml/ha as soil; and 100% N-FYM + NPK consortia @1250 ml/ha as soil. While the highest B:C ratio (1.77) of wheat was recorded with the application of 75% N-FYM + NPK consortia @1250 ml/ha as soil *fb* amritasanjeevani spray 10% at 25, 50 and 75 DAS as compared to rest of treatments due to low cost of cultivation during pooled of entire crop season. The cost of integration of organic nutrient formulation was compensated with the higher yield of wheat. Similar results were also reported by Chauhan *et al*., (2020) and Parewa *et al*., (2021).

Available nutrient status in soil

The available nutrients status in soil at the end of 5 years crop cycle revealed a positive effect of different organic nutrient management practices over initial value of nutrients in soil. Results revealed a significantly higher organic carbon (0.66%), available phosphorus, potassium and sulphur (63.94, 432.8 and 28.21 kg/ha) and available zinc (0.90 mg/kg) with application of 50% N-FYM + 50% N-VC *fb* 10% vermiwash spray at 25, 50 and 75 DAS over rest of the treatments in pooled basis. Soil organic carbon (SOC) concentrations in soil were probably enhanced by continuous application of carbon (C) inputs from FYM and vermicompost, higher root biomass and stubbles, rhizodepositions etc., and also from more microbial population that hastened decomposing of root biomass leading to higher accumulation of carbon in humified carbon fractions of soil. Similar findings were reported by Gopinath *et al*., (2008) and Bairwa *et al*., (2021). The increased available P, K and S status may be ascribed due to mineralization of organic sources and solubilization by microbes from native source, which probably increased the availability of P, K and S in the soil. Presumably combine application of solid and liquid organic manure such as farmyard manure, vermicompost and vermiwash increased the micronutrient content by supplying complexing agents, which formed stable complexes with these micronutrients as reported by Verma *et al.,* (2020) Ravisankar *et al*., (2021) and Ranva *et al*., (2022).

Based on results of 5 years experimentation, it may be concluded that application of 50% N-FYM + 50% N-vermicompost *fb* 10% vermiwash spray at 25, 50 and 75 DAS obtained significantly higher grain yield (3756 kg/ha) and gross returns (₹100,605/ha) of wheat over application of ghanjeevamrut @500 kg/ha and jeevamrut @500 litre/ha at sowing, 25 and 50 DAS, remained statistically at par to the rest of the treatments. Significantly maximum net returns (₹63,020/ha) and highest B: C ratio (1.77) of wheat were obtained under the application of 75% N-FYM + NPK consortia @1,250 ml/ha as soil *fb* amritasanjeevani spray 10% at 25, 50 and 75 DAS due to low cost of cultivation and better yield. While superior B:C ratio (1.69) of wheat was recorded with the application of jeevamrut @ 500 litre/ha at sowing, 25 and 50 DAS as compared to the rest of treatments except this treatment due to low cost of cultivation. A positive effect on available nutrients status in soil were also observed under these practices.

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