

Effect of mustard oilcake integration in organic nutrient management on the performance of wheat during conversion period

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ABSTRACT

An experiment was conducted in the Upper Gangetic Plain zone to study the effects of mustard oilcake (MC) application in combination with farm yard manure (FYM) and vermicompost (VC) on wheat growth, yield, and economics in organic farming. Results showed that mustard oilcake significantly improved wheat growth, yield attributes, and productivity. Plant height and tiller number increased by 20.1-44.8% and 22.8-64.9%, respectively, compared to the control. Mustard oilcake application also increased spike weight, number of grains per spike, and for MC treatments 1000-grain weight in wheat. Grain yield was highest with inorganic management, followed by mustard oilcake + biofertilizer, and the lowest in control. Mustard oilcake application improved wheat grain yield by 31.0-136.5% compared to the control. The treatment with a 50% recommended dose of nutrients (RDN) through FYM + 50% RDN through MC + biofertilizer showed the highest net return and benefit-cost ratio. Positive correlations were found between different growth and yield parameters of wheat with mustard oilcake application. Results inferred that integrating mustard oilcake with bulky organic manure can be an effective strategy to improve productivity and profitability in organic farming in the Upper Gangetic Plain zone.

Key words: Economics, Organic farming, Productivity, Wheat

The excessive use of agrochemicals in agriculture after the green revolution has raised concerns about the safety and sustainability of food production. In response, approximately 191 countries worldwide have adopted organic agriculture, covering a total area of 76 million hectares in 2021 (Willer *et al.*, 2023). Oceania has the largest share at 49.6% of the world's organic land area, followed by Europe at 22.9%. Developing countries in Asia are also witnessing significant growth in organic farming, with India having the highest number of organic growers (1.37 million) and ranking fifth in terms of organic cultivation area with 2.30 million hectares. Over the past six years, India has seen a rapid annual growth rate of 22% in organic farming, involving around 1.7 million farmers who cultivate various crops. To promote organic/natural farming in different parts of the country, the Indian government

has launched schemes such as Pramparagat Krishi Vikas Yojana (PKVY in 2015) and Bhartiya Prakritik Krishi Padhati (BPKP in 2020-21). The conversion period (initial 2-3 years) of organic farming presents challenges for marginal and small growers, including reduced productivity and poor marketing networks. Lack of awareness, particularly in nutrient management, is a major factor affecting crop productivity. Organic growers rely on bulky organic manure such as farmyard manure, compost, and locally prepared liquid manures for nutrient management. However, the slow mineralization of bulky organic manures during the initial period may not meet the nutrient demands of crops during critical growth stages. Previous research has focused on increasing nutrient availability through the application of different combinations of inputs, including the use of biofertilizers in conjunction with bulky organic manures (Meena *et al.*, 2023). Additionally, efforts have been made to incorporate non-edible oilcakes, such as neem cake, in combination with bulky organic manure to enhance crop productivity. However, the limited availability and higher prices of neem cake have hindered its adoption for nutrient management in organic farming. Therefore, there is potential to explore locally available edible oilcake as an alternative source for nutri-

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ent management to improve productivity and profitability, particularly during the conversion period. Mustard oilcake, which is readily available in North-Indian states where mustard is commercially cultivated, has not been extensively studied for its potential in organic nutrient management. Hence, an experiment was designed to assess the feasibility of integrating mustard oilcake for organic nutrient management in wheat cultivation in intensively cultivated alluvial soils of the Upper Gangetic Plain Zone, taking into consideration its easy availability in the region.

MATERIALS AND METHODS

Experimental location

The experiment was executed during *rabi* (winter) 2020-21 and 2021-22 at the research farm of ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut, India situated at 29°04'38.8"N (latitude) and 77°42'09.9"E (longitude), 237 m (altitude) above mean sea level (Arabian sea). The experimental site falls under the semi-arid and sub-tropical zone with hot summers and cold winters. The experimental sites represented the part of the Upper Gangetic Plain region, alkaline in reaction, having sandy loam texture soil (52.5% sand, 30.9% clay, and 16.6% silt) of Gangetic alluvial origin, very deep (> 20 m), well-drained, and with at 1% slope topography. The soil of the experimental site was medium in soil organic carbon, low in available nitrogen (159 kg/ha), medium in available P (25.4 kg/ha), and K (186 kg/ha).

The experiment was laid out in a randomized complete block design with three replications. Six nutrient management practices *viz.* T1: Application of 50% recommended dose of nitrogen (RDN) through FYM + 50% RDN through vermicompost + biofertilizer (Control), T2: 50% RDN through FYM + 25% RDN through VC + 25% RDN through mustard cake (MC) + biofertilizer, T3: 50% RDN through FYM + 50% RDN through MC + biofertilizer, T4: 25% RDN through FYM + 75% RDN through MC + biofertilizer, T5: 100% RDN through MC + biofertilizer and T6: 100 % inorganic management used for experimentation. The recommended dose of fertilizer for wheat was 120 kg/ha N, 60 kg/ha P₂O₅ and 60 kg/ha K₂O. Nitrogen content in FYM, VC, and MC was 0.55%, 1.64 %, and 5.21%, respectively. *Azotobacter* biofertilizer as soil application was used at the rate of 5 kg/ha. Under inorganic management, nutrients were applied through Urea, DAP, and MOP. Organic nutrients were applied at the time of final field preparation. Wheat variety DBW 90 was sown during the last week of December and harvested during the second week of April.

Growth parameters (plant height and number of tillers)

and SPAD value of (10) randomly selected wheat plants in each treatment were observed at periodic intervals. The yield attributes such as length of the spike, spike weight, number of grains/spikes, and 1,000-grain weight were recorded from a sample of 10 spikes collected randomly from the plot. The grain yield of wheat was estimated at 14% moisture content and expressed in kg/ha. Gross and net returns were calculated based on the grain and straw yield and the prevailing market prices of wheat in respective seasons. Premium prices (25% higher) were used for the grain yield of organic treatments. The benefit-to-cost ratio was calculated by dividing the gross return by the cost of cultivation.

The experimental data on different parameters recorded during the study period were investigated statistically using the F-test, as per the procedure given by Gomez and Gomez (1984). The correlation of different parameters was analyzed in R studio (R 4.2.2). The significant differences between treatment means were compared with the least significant at a 5% level of probability.

RESULTS AND DISCUSSION

Growth parameters

Nutrient management using mustard oilcake significantly improved the growth and physiological parameters of wheat. Among the different nutrient management practices, growth parameters of wheat were recorded as highest under 100% inorganic management. Among the organic nutrient management, the application of mustard oilcake improved plant height of wheat by 33.1-42.4% at 30 days after sowing (DAS), 37.6-92.8% at 60 DAS, and 20.1-44.8% at harvest over control. Similarly, the no. of tillers was increased by the tune of 11.0-19.3% at 30 DAS, 18.5-52.2% at 60 DAS, and 22.8-64.9% at harvest with the application of mustard oilcake. Maximum SPAD meter reading (46.8) and green seeker reading (0.945) were registered under 100% inorganic management followed by 100% mustard oilcake + biofertilizer application. SPAD meter reading and green seeker reading at maximum tiller stage (45 DAS) were enhanced by 23.7-46.8% and 4.6-8.4% under different mustard oilcake applied treatment over control, respectively (Table 1). Improvement in different growth and physiological parameters of wheat with the integration of mustard oilcake could be due to better nutrient mineralization and availability to the plants as compared to control. Sehti *et al.* (2021) reported that the application of mustard oilcake along with biofertilizers improved the *Mycorrhizal* colonization in soil, growth, nutrient uptake, and biomass of *Acacia mangium*. Mustard oilcake, having a narrow C/N ratio, decomposes faster as compared to other bulky organic manures having a wider

C/N ratio and releasing mineral nitrogen quickly in soil (Paul and Mannan 2007). Improvement in growth and nutrient uptake with the integration of mustard oilcake was also reported in okra (Ullah *et al.*, 2008), chili (Pariari and Khan 2013), and rice (Mondal *et al.*, 2016; Dekhane *et al.*, 2019; Yasmin *et al.*, 2020).

Yield and yield attributes

Superior yield attributes of wheat viz. spike weight (2.40 g) and no. of grains/spike (51.4) were found in 100% inorganic management. The lowest yield attributes were recorded under control and the application of mustard oilcake significantly increased the spike weight (25.2-48.3%), no. of grains/spike (17.7-32.7%), and 1000-grain weight (3.9-8.1%) in wheat. Maximum grain yield (4912 kg/ha), straw yield (6631 kg/ha), and biological yield (11544 kg/ha) was found under 100% inorganic management followed by 100% mustard oilcake + biofertilizer application and least under control (Table 2). Grain yield was reduced by 62.3% under control as compared to 100% inorganic management. However, the yield gap between 100% inorganic and organic nutrient management was reduced to 10.9-50.6% due to mustard oilcake application and the lowest gap was recorded under 100% mustard oilcake + biofertilizer application. Similarly, mustard oilcake application for nutrient management improved the harvest index from 34.5% in control to 41.7% in 100% mustard oilcake + biofertilizer application. A significantly

positive correlation was found among different growth parameters, yield attributes, and yield of wheat (Fig. 1). As compared to FYM and vermicompost, the presence of high nutrient content especially N in mustard oilcake allows soil microbes to multiply faster for its decomposition and release of nutrients. Therefore, the crop gets better nutrition, particularly at the critical growth stage which is reflected in better growth and production under mustard oilcake-applied treatments over control. Integration of mustard oilcake by 25-50% with chemical fertilizers along with biofertilizer significantly improved the productivity and factor productivity for N in rice (Mondal *et al.*, 2016) and maize (Sahoo *et al.*, 2021; Adhikari *et al.*, 2022). Similarly, the replacement of 25% nutrients through neem cake considerably improved the growth and productivity of okra over FYM and vermicompost (Mishra *et al.* 2020). Improvement in yield due to mustard oilcake application along with *Azotobacter* and bulky manures was also reported in wheat (Verma *et al.*, 2018) and mustard (Ghasal *et al.*, 2022).

Economics

Irrespective of treatments, organic nutrient management treatments had having higher cost of cultivation as compared to 100% inorganic management (Table 3). Integration of mustard oilcake under different organic nutrient management treatments further enhanced the cost of cultivation. The highest cost of cultivation (₹75,500/ha) was

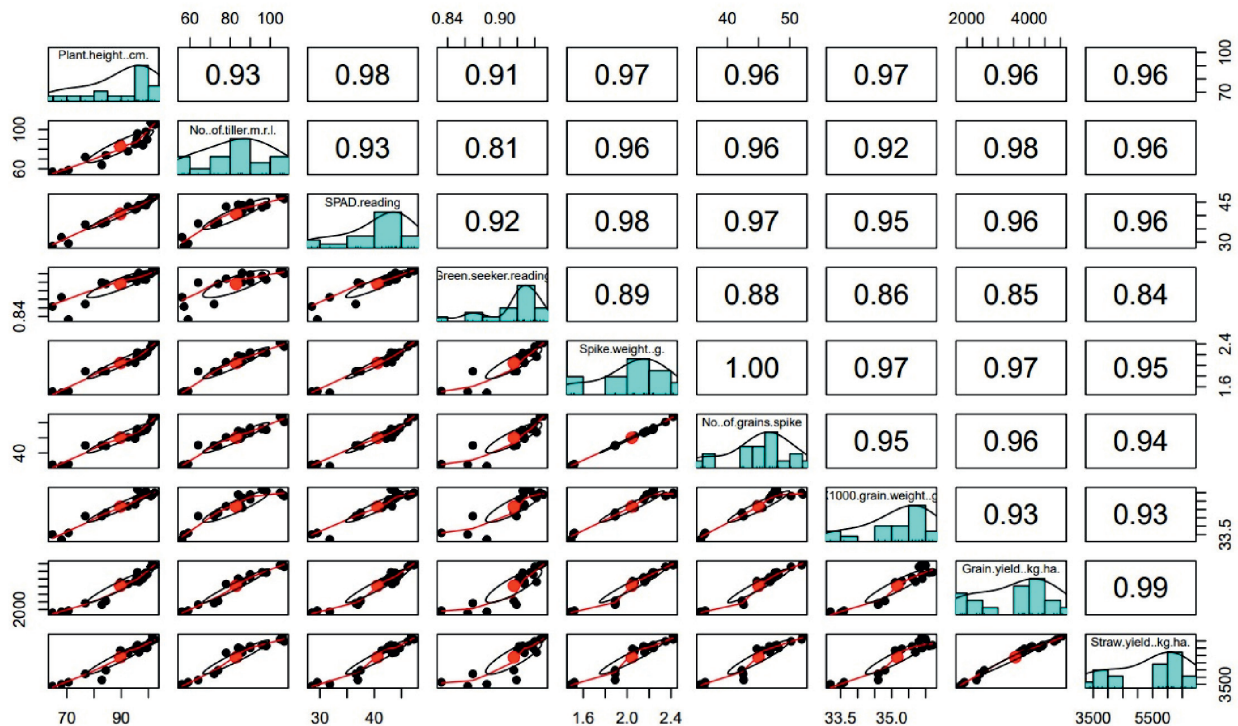


Fig. 1. Correlation matrix between different parameters of wheat.

Table 1. Influence of mustard oil cake application on growth and physiological parameters of wheat (mean of 2 years)

Treatment	Plant height (cm)			No. of tillers/m.r.l.			SPAD meter reading at 45 DAS	Green seeker reading at 45 DAS
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest		
50% FYM + 50% VC + biofertilizer	17.2	27.9	67.8	109	92	57	29.9	0.861
50% FYM + 25% VC + 25% MC + biofertilizer	22.9	38.4	81.4	121	109	70	37.0	0.901
50% FYM + 50% MC + biofertilizer	23.8	48.2	92.4	123	119	83	42.3	0.925
25% FYM + 75% MC + biofertilizer	23.7	52.1	96.7	127	127	87	43.6	0.930
100% MC + biofertilizer	24.5	53.8	98.2	130	140	94	43.9	0.933
100% inorganic	26.8	54.2	101.5	130	143	106	46.8	0.945
SEm±	0.67	0.51	1.57	1.25	2.00	1.59	0.512	0.009
CD (P=0.05)	2.14	1.62	5.01	4.00	6.38	5.09	1.633	0.029

Table 2. Influence of mustard oil cake application on yield and yield attributes of wheat (mean of 2 years)

Treatment	Spike weight (g)	Grains/spike	1000-grain weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
Control (50% FYM + 50% VC + biofertilizer)	1.51	36.1	33.4	1851	3517	5367	34.5
50% FYM + 25% VC + 25% MC + biofertilizer	1.89	42.5	34.7	2425	4168	6593	36.8
50% FYM + 50% MC + biofertilizer	2.06	45.2	35.2	3760	5828	9587	39.2
25% FYM + 75% MC + biofertilizer	2.17	46.9	35.7	3969	5954	9923	40.0
100% MC + biofertilizer	2.24	47.9	36.1	4377	6127	10504	41.7
100% inorganic	2.40	51.4	35.9	4912	6631	11544	42.6
SEm±	0.011	0.30	0.07	37.5	73.9	107.6	0.18
CD (P=0.05)	0.034	0.97	0.23	119.6	235.9	343.3	0.56

Table 3. Influence of mustard oil cake application on the economics of wheat (mean of 2 years)

Treatment	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
Control (50% FYM + 50% VC + biofertilizer)	40400	63279	22879	1.57
50% FYM + 25% VC + 25% MC + biofertilizer	49400	80721	31321	1.63
50% FYM + 50% MC + biofertilizer	58400	121968	63568	2.09
25% FYM + 75% MC + biofertilizer	66500	127772	61272	1.92
100% MC + biofertilizer	75500	138698	63198	1.84
100% inorganic	33494	130172	96678	3.89
SEm±	-	-	-	-
CD (P=0.05)	-	-	-	-

found under 100% mustard oilcake + biofertilizer application followed by the application of 25% FYM + 75% mustard oilcake + biofertilizer and the lowest under 100% inorganic management. The higher cost of cultivation under organic nutrient management was due to the application of bulky organic manures and comparatively high prices of mustard oilcake. Gross return was earned highest under

100% mustard oilcake + biofertilizer application followed by 100% inorganic management. However, net return (₹96678/ha) was received maximum under 100% inorganic management followed by 50% RDN through FYM + 50% RDN through mustard oilcake + biofertilizer application. Among organic nutrient management treatments, the integration of mustard oilcake for nutrient manage-

ment substantially improved the profitability of wheat by 1.37-2.78 times by improving the growth and productivity of wheat in comparison to the control. Similarly, B:C ratio was also improved from 1.57 under control to 2.09 under 50% FYM+ 50% mustard oilcake + biofertilizer application treatments. Karki *et al.* (2023) observed that the application of mustard oilcake realized maximum net returns and B:C ratio in rice.

Thus, it can be concluded that the integration of mustard oil cake with other bulky organic manures significantly improved the growth, yield attributes, and yield of wheat under organic production during the conversion period. Application of 50% RDN through FYM + 50% RDN through MC + biofertilizer was found superior for better productivity and higher profitability of wheat under organic cultivation during the initial year of adoption.

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