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EFFECT OF ORGANIC NUTRIENT AMENDMENTS ON GROWTH, YIELD ATTRIBUTES AND YIELD OF RAPESEED

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ABSTRACT

An experiment was conducted during the *rabi* season of 2018-19 at the Instructional-cum-Research (ICR) Farm, Assam Agricultural University, Jorhat to study the effect of various organic sources of nutrients on growth and yield of rapeseed. The treatments consisted of eleven levels of organic sources of nutrients laid out in a randomized block design with three replications. Results revealed that key growth parameters such as plant height, dry weight, plant population/m² and the number of primary, secondary, and total branches per plant, were significantly enhanced with the application of vermicompost 2.5 t/ha + poultry manure 2.5 t/ha + mustard oil cake 1 t/ha. This treatment was closely followed by FYM 5 t/ha + poultry manure 2.5 t/ha + mustard oil cake 1 t/ha. These treatments not only improved growth but also led to significantly higher yield attributes, including the number of siliquae per plant, seeds per silique, and both seed and stover yields of rapeseed, when compared to most other organic nutrient sources and the control. Specifically, the increase in seed yield was 330.7% and 307.2% over the control. The oil yield followed a similar trend, with the said treatments showing a substantial increase of 346.2% and 324.6%, respectively, over the control. Application of organic nutrient sources also significantly increased soil moisture content at two different depths, namely 0-20 cm and 20-40 cm, within the soil profile during the flowering and siliquae development stages compared to the control. These findings underscore the effectiveness of these organic nutrient combinations in significantly boosting both the productivity and oil content of rapeseed.

Key words: FYM, Mustard Oil cake Nutrient, Organic, Poultry manure, Vermicompost,

Introduction

India is the third largest producer of rapeseed-mustard globally, following China and Canada. Rapeseed-mustard is a vital crop for the country, accounting for nearly one-third of India's edible oil production (Kumar *et al.*, 2015). In the hierarchy of oilseed crops, rapeseed-mustard ranks third after soybean and groundnut, contributing approximately 27.8% to the nation's oilseed economy.

Globally, rapeseed and mustard production stands at around 38-42 million tonnes (Rai *et al.*, 2016), with the oil yield ranging between 12-14 million tonnes. India's contribution to the global rapeseed-mustard economy is significant, holding 28.3% of the area and 12% of the production. The country's annual production of rapeseed-

mustard is around 7.9 million tonnes, with an average yield of 11.02 quintals per hectare, placing it behind China and the European Union, whose outputs range between 11-12 million tonnes and 10-13 million tonnes, respectively (Hegde, 2012). India's role in the global mustard industry is therefore substantial, but it faces challenges in meeting future demands. By 2050, India's population is projected to reach 1.685 billion, necessitating the production of 17.84 million tonnes of vegetable oils to meet nutritional fat requirements (Anonymous, 2014). Achieving this target under the current agricultural practices and technological status is daunting. Thus, boosting the productivity of oilseeds is crucial for the country to attain self-sufficiency in edible oils.

Table 1: Total amount of nutrients (N, P₂O₅ and K₂O) applied through different organic sources.

Treatments	Amount of nutrients (kg/ha)		
	N	P ₂ O ₅	K ₂ O
T ₀ : Control	-	-	-
T ₁ : FYM (10 t/ha)	32.2	12.2	21.1
T ₂ : Vermicompost (5 t/ha)	66.7	32.6	38.8
T ₃ : Poultry manure (5 t/ha)	60.9	53.7	33.4
T ₄ : FYM (5t/ha) +V.C (2.5t/ha)	16.1+33.3= 49.4	6.1+16.3= 22.4	10.5+19.4= 29.9
T ₅ : FYM (5t/ha) +P.M (2.5t/ha)	16.1+30.5= 46.5	6.1+26.8= 32.9	10.5+16.7= 27.2
T ₆ : V.C(2.5 t/ha)+ P.M (2.5 t/ha)	33.3+30.5= 63.8	16.3+26.8= 43.1	19.4+16.7= 36.0
T ₇ : FYM (5 t/ha)+ V.C (2.5 t/ha) + MOC (1 t/ha)	16.1+33.3+21.5= 70.9	6.1+16.3+5.2= 22.4	10.5+19.4+ 10.0 = 39.9
T ₈ : FYM (5 t/ha) + P.M (2.5 t/ha) + MOC (1 t/ha)	16.1+30.5+21.5= 68.0	6.1+26.8+5.2= 38.1	10.5+16.7+10.0=37.2
T ₉ : V.C (2.5 t/ha) + P.M (2.5 t/ha) + MOC (1 t/ha)	33.3+30.5+21.5= 85.3	16.3+26.8+5.2= 48.3	19.4+16.7+5.2=41.2
T ₁₀ : FYM (5 t/ha) + V.C (1.25 t/ha) + P.M (1.25 t/ha) + MOC (1 t/ha)	16.1+15.6+15.2+5.2= 52.1	6.1+8.1+14.3+5.2= 33.8	10.5+9.1+8.3+5.2 = 33.1

The rising demand for food grains and oilseeds has driven farmers to enhance crop yields, often relying heavily on chemical fertilizers. However, the indiscriminate use of these fertilizers to supply essential nutrients poses a threat to food quality and soil health. Continuous use of inorganic inputs has led to the depletion of vital micronutrients such as boron and zinc, particularly in rainfed areas (De *et al.*, 2009 and Kumar *et al.*, 2018). This depletion has not only reduced soil productivity but has also negatively impacted soil fertility and microbial activity. Research has shown that organic sources of nutrients can improve the physical, chemical, and biological properties of soil, providing a sustainable alternative to chemical fertilizers.

Organic farming, despite its numerous benefits, often faces challenges in achieving immediate results, especially in soils with a wide carbon-to-nitrogen (C : N) ratio. Over the years, various organic inputs such as compost, farmyard manure (FYM), vermicompost, crop residues, green manures, green leaf manuring, and biofertilizers have been utilized to enhance soil organic carbon, provide essential plant nutrients, and improve soil properties (Yadav *et al.*, 2013 and Hadiyal *et al.*, 2017). Animal manure, in particular, has long been valued for its ability to enhance soil fertility, offering a cost-effective and environmentally friendly alternative to mineral fertilizers. Proper nutrient management through organic sources plays a pivotal role in maintaining soil health by increasing soil organic matter and promoting the activity of beneficial microbes and enzymes. Long-term application of organic materials has been shown to boost organic matter content, crop productivity, and soil biological activity.

However, despite the advantages of organic sources of nutrients, their impact on crop yields may not always be immediately cost-effective. Rapeseed-mustard, while being one of the most important edible oilseed crops,

suffers from low average yields in Assam compared to other regions in India. This low yield is primarily due to the use of low-yielding varieties, poor soil fertility, and inadequate nutrient management practices (Hutchison *et al.*, 2005). These issues are further exacerbated by crop intensification under organic farming, aimed at achieving self-sufficiency in oilseed production. In this context, nutrient management emerges as a crucial technology for maintaining and enhancing the production potential of rapeseed-mustard under organic farming systems. Given the challenges posed by the lower yields in Assam, a strategic approach to nutrient management, including the judicious use of organic inputs, is essential for improving soil health, sustaining productivity, and achieving the desired levels of self-sufficiency in oilseed production (Collins *et al.*, 1992). Organic farming practices, if properly managed, can offer a sustainable solution to the challenges faced in rapeseed-mustard production, ensuring that India continues to contribute significantly to the global mustard industry while also meeting its domestic nutritional needs.

Additionally, the practice of continuous and intensive cropping is causing a significant depletion of the soil's nutrient reserves. This depletion is leading to multiple nutrient deficiencies, which negatively impact both soil health and crop yields. Therefore, to achieve the potential effect of various organic amendments, the experiment was initiated to study the growth and yield effects of *rabi* rapeseed under different sources of organic treatments.

Materials and Methods

A field experiment was conducted during the *rabi* season of 2018-19 at the ICR farm of AAU, Jorhat (26°44' N latitude, 94°10' E longitude and 91.0 m above mean sea level) to investigate the effect of spontaneous organic

Table 2: Effect of organic nutrient management practices on growth parameters of rapeseed.

Treatment	PH	PP	DW	NBPB	NSBP	TNB
T ₀ : Control	50.9	44.7	4.7	1.4	1.0	2.4
T ₁ : FYM @ 10 t/ha	72.1	61.3	9.4	4.1	5.1	9.2
T ₂ : Vermicompost (V.C) @ 5 t/ha	71.5	63.3	9.8	4.0	3.7	7.7
T ₃ : Poultry manure (P.M) @ 5 t/ha	71.7	63.3	8.3	3.5	3.3	6.8
T ₄ : FYM @ 5 t/ha + V.C @ 2.5 t/ha	70.3	64.0	10.1	3.5	3.9	7.4
T ₅ : FYM @ 5 t/ha + P.M @ 2.5 t/ha	72.9	62.7	10.3	4.1	3.2	7.3
T ₆ : V.C @ 2.5 t/ha + P.M @ 2.5 t/ha	73.1	63.3	9.7	3.3	4.0	7.33
T ₇ : FYM @ 5 t/ha + V.C @ 2.5 t/ha + Mustard oil cake (MOC) @ 1 t/ha	76.6	62.7	12.3	3.2	4.3	7.6
T ₈ : FYM @ 5 t/ha + P.M @ 2.5 t/ha + MOC @ 1 t/ha	80.2	64.0	12.8	4.7	4.5	9.1
T ₉ : V.C @ 2.5 t/ha + P.M @ 2.5 t/ha + MOC @ 1 t/ha	85.0	65.3	13.5	4.3	5.1	9.4
T ₁₀ : FYM @ 5 t/ha + V.C @ 1.25 t/ha + P.M @ 1.25 t/ha + MOC @ 1 t/ha	83.0	62.7	13.7	4.0	4.4	8.4
SEm±	5.7	2.2	0.8	0.2	0.5	0.6
CD (P= 0.05)	16.7	6.6	2.2	0.7	1.4	1.7
PH: Plant height (cm); PP: Plant Population /m ² ; DW: Dry weight(g/plant); NBPB: Number of primary branches/plant; NSBP: Number of secondary branches/plant; TNB: Total number of branches						

management techniques on growth and yield of rapeseed. The climate of Jorhat is subtropical humid with hot summers (34-37°C) and cold winters (8-10°C), with monsoon rains from June to September, and during the crop season, maximum temperatures ranged from 21.3°C to 27.2°C and minimum from 8.1°C to 14.2°C, relative humidity averaged between 90-99% in the morning and 53-77% in the evening, an average rainfall of 75.6 mm against the total evaporation of 134.4 mm and bright sunshine averaged 6.64 hours/day. Soil was acidic in pH (5.1) with medium organic C (0.53%), medium in available nitrogen (274.2 kg/ha), available phosphorus (26.9 kg/ha) and available potassium (192.0 kg/ha). The experiment was laid out in a randomized block design with three replications and consisted of 10 levels of organic nutrient management treatments along with control treated plot viz., Control (T₀), FYM @ 10 t/ha (T₁), Vermicompost @ 5 t/ha (T₂), Poultry Manure @ 5 t/ha (T₃), FYM @ 5 t/ha + Vermicompost @ 2.5 t/ha (T₄), FYM @ 5 t/ha + poultry manure @ 2.5 t/ha (T₅), Vermicompost @ 2.5 t/ha + poultry manure @ 2.5 t/ha (T₆), FYM @ 5 t/ha + Vermicompost @ 2.5 t/ha + mustard oil cake @ 1 t/ha (T₇), FYM @ 5 t/ha + poultry manure @ 2.5 t/ha + mustard oil cake @ 1 t/ha (T₈), Vermicompost @ 2.5 t/ha + poultry manure @ 2.5 t/ha + mustard oil cake @ 1 t/ha (T₉), FYM @ 5 t/ha + Vermicompost @ 1.25 t/ha + poultry manure @ 1.25 t/ha + mustard oil cake @ 1 t/ha (T₁₀), respectively. TS-67 variety of rapeseed was sown @ 12 kg/ha at shallow furrows maintaining a distance of 30 cm between the furrows and were sown as uniformly as possible at a depth of 4-5 cm. The plots designated for FYM, vermicompost, poultry manure, and other organic inputs were marked, and the required amounts of each manure

(based on dry weight) were uniformly applied according to the treatment plans. This was done three days before sowing, and the inputs were thoroughly incorporated into the soil. Plant heights of the tagged plants were measured in cm using a meter scale from the ground level to the tip of the plant. Plant population/m² were computed within the net-plot by calculating the total number of plants from ten randomly selected quadrants of 0.5m × 0.5m (0.25 m²). Total number of branches/plant (primary and secondary) was counted just before harvesting from five randomly selected plants. The plants were chopped and sun-dried for 48 hours, then further dried in a hot air oven at 60 ± 5°C until a constant dry weight was achieved. Gravimetric soil moisture content (%) was determined at flowering and siliquae development stages of the crop growth from two soil depths viz., 0-20 and 20-40 cm. The total number of siliquae and number of siliqua per seed were counted and further statistically analysed to compute the seed yield (q/ha). After separating the seeds, the weight of the threshed crop biomass was recorded for each net plot to generate the stover yield (q/ha). Furthermore, the oil content was generated by placing 10g of the crushed samples in a thimble for extracting oil with light petroleum ether for 2 hours in a Soxhlet extraction unit as per the method described by AOAC (1960). The desired oil yield in kg/ha was calculated by multiplying the per cent oil content in seed by the respective seed yield (kg/ha). All relevant data from the present investigation were statistically analyzed using a randomized block design, following the 'analysis of variance' (ANOVA) method outlined by Panse and Sukhatme (1985). The significance of variance due to treatment effects was determined by calculating the corresponding 'F' values.

Table 3: Effect of organic nutrient management on per cent periodic soil moisture content at different growth stages of rapeseed.

Treatments	Flowering (30 DAS)		Siliquae Development (60 DAS)	
	0-20 cm (%)	20-40 cm (%)	0-20 cm (%)	20-40 cm (%)
T ₀ : Control	14.3	14.6	13.2	13.7
T ₁ : FYM @ 10 t/ha	16.3	16.7	16.1	16.2
T ₂ : Vermicompost @ 5 t/ha	16.6	16.8	15.9	16.4
T ₃ : Poultry manure @ 5 t/ha	16.3	16.5	14.7	15.4
T ₄ : FYM @ 5 t/ha + V.C @ 2.5 t/ha	16.1	16.7	15.2	15.9
T ₅ : FYM @ 5 t/ha + P.M @ 2.5 t/ha	15.6	16.6	14.9	15.4
T ₆ : V.C @ 2.5 t/ha + P.M @ 2.5 t/ha	15.4	16.2	14.8	15.3
T ₇ : FYM @ 5 t/ha + V.C @ 2.5 t/ha + MOC @ 1 t/ha	16.7	17.2	15.9	16.3
T ₈ : FYM @ 5 t/ha + P.M @ 2.5 t/ha + MOC @ 1 t/ha	16.8	16.9	15.5	15.8
T ₉ : V.C @ 2.5 t/ha + P.M @ 2.5 t/ha + MOC @ 1 t/ha	17.0	17.1	15.9	15.7
T ₁₀ : FYM @ 5 t/ha + V.C @ 1.25 t/ha + P.M @ 1.25 t/ha + MOC @ 1 t/ha	16.5	16.8	15.4	15.8

Results and Discussions

Growth attributes

Sources of various organic nutrients potentially led to significant results among the growth attributes *viz.*, plant height, dry matter accumulation, plant population/m² and number of primary and secondary branches. In all such cases, different organic sources of nutrients resulted in significantly higher values over the control. The growth of rapeseed measured in terms of plant height, dry weight of plants, leaf area index and number of primary, secondary as well as total branches per plant (Table 2) were significantly higher with the application of vermicompost 2.5 t/ha + poultry manure 2.5 t/ha + mustard oil cake 1 t/ha followed by FYM 5 t/ha + poultry manure 2.5 t/ha + mustard oil cake 1 t/ha over most of the other organic sources of nutrients and control. This was followed by the treatments of FYM 5 t/ha + vermicompost 1.5 t/ha + poultry manure 1.5 t/ha + mustard oil cake 1 t/ha, and FYM 5 t/ha + poultry manure 2.5 t/ha + mustard oil cake 1 t/ha, which also produced similar but comparatively higher values than most other organic nutrient sources, with a few exceptions. The application of organic manures in large quantities might have enhanced soil health and conserve soil moisture by increasing soil carbon content (Majumdar *et al.*, 2017), which positively influences crop growth parameters. This is further supported by the observation that soil moisture content, measured at two different profile depths (0-20 cm and 20-40 cm) during the flowering and siliquae development stages, was significantly higher with these treatments (Majumdar *et al.*, 2017). The improved soil moisture observed with the use of various organic manures can be attributed to the higher organic matter content, which enhances moisture retention and water

infiltration due to improved soil structure and macroporosity (Aluko and Oyedele, 2005). This increase in soil moisture favourably influenced crop growth compared to other organic nutrient sources and the control. Similar findings were observed by (Kumar and Kumar, 2007).

Yield Attributes and Yield

The treatment of FYM 5 t/ha + poultry manure 2.5 t/ha + mustard oil cake 1 t/ha resulted in the highest number of siliquae per plant (90.8). Meanwhile, the highest number of seeds per siliqua (15.9) was achieved with the treatment of vermicompost 2.5 t/ha + poultry manure 2.5 t/ha + mustard oil cake 1 t/ha. However, these treatments were generally at par with other combinations that included mustard oil cake along with FYM, vermicompost, and poultry manure. Previous studies have shown that the application of FYM 5 t/ha along with vermicompost 1.0 t/ha and castor cake 1.0 t/ha (Hadiyal *et al.*, 2017), as well as combinations of FYM and vermicompost (Yadav *et al.*, 2013), enhanced plant height, the number of primary and secondary branches per plant, the number of siliquae per plant, and the number of seeds per siliqua in Indian mustard.

The application of different organic nutrient sources significantly influenced the seed and stover yield of rapeseed compared to the control. The highest seed and stover yields were recorded with the treatment of vermicompost 2.5 t/ha + poultry manure 2.5 t/ha + mustard oil cake 1 t/ha (13.6 q/ha and 33.2 q/ha, respectively), followed by FYM 5 t/ha + poultry manure 2.5 t/ha + mustard oil cake 1 t/ha (12.9 q/ha and 32.4 q/ha, respectively), surpassing the other treatments and the control. Although the harvest index was not significantly affected, all organic treatments recorded higher values than the control.

Table 4: Effect of organic nutrient management on yield attributes and yield of rapeseed.

Treatments	NSP	NSS	SY	St.Y	HI	OC	OY
T ₀ : Control	44.3	8.8	3.2	8.1	28.3	36.8	118.3
T ₁ : FYM @ 10 t/ha	73.2	12.3	8.5	17.8	32.5	38.3	324.2
T ₂ : Vermicompost (V.C) @ 5 t/ha	69.9	12.9	9.9	20.4	32.6	38.3	378.3
T ₃ : Poultry manure (P.M) @ 5 t/ha	66.7	11.9	8.2	18.8	30.5	38.5	317.3
T ₄ : FYM @ 5 t/ha + V.C @ 2.5 t/ha	63.7	13.8	10.0	23.4	30.3	38.6	385.1
T ₅ : FYM @ 5 t/ha + P.M @ 2.5 t/ha	66.0	12.5	8.6	21.9	33.3	38.4	330.6
T ₆ : V.C @ 2.5 t/ha + P.M @ 2.5 t/ha	64.4	13.5	9.1	22.1	29.1	38.7	351.2
T ₇ : FYM @ 5 t/ha + V.C @ 2.5 t/ha + Mustard oil cake (MOC) @ 1 t/ha	81.8	15.1	10.1	25.0	29.0	38.8	392.3
T ₈ : FYM @ 5 t/ha + P.M @ 2.5 t/ha + MOC @ 1 t/ha	90.8	15.0	12.9	32.4	28.4	39.0	502.4
T ₉ : V.C @ 2.5 t/ha + P.M @ 2.5 t/ha + MOC @ 1 t/ha	84.3	15.9	13.6	33.2	29.1	38.8	528.0
T ₁₀ : FYM @ 5 t/ha + V.C @ 1.25 t/ha + P.M @ 1.25 t/ha + MOC @ 1 t/ha	81.3	14.7	10.5	24.1	30.4	39.1	411.1
SEm±	7.3	1.3	0.4	3.0	2.9	0.2	16.3
CD (P= 0.05)	21.5	3.8	1.3	8.8	NS	0.6	48.2
NSP: Number of siliquae/plant; NSS: Number of seeds/ siliquae; SY: Seed Yield (q/ha); St.Y: Stover Yield (q/ha) HI: Harvest Index (%); OC: Oil Content(%) OY: Oil Yield (kg/ha)							

The enhanced growth parameters, such as plant height, dry weight, plant population per unit area, number of primary and secondary branches per plant, and yield attributes, including the number of siliquae per plant, number of seeds per siliqua likely contributed to the significantly higher seed and stover yields under these treatments. Previous studies (Tomar *et al.*, 1990; Mandal and Sinha, 2004) have shown that the combined application of FYM, vermicompost, and poultry manure positively influences seed setting and development in rapeseed by improving source-sink relationships and photosynthate partitioning, ultimately leading to higher yields in rape and mustard. Higher growth, yield attributes, and seed, stover, and biological yield of mustard have also been reported with the use of FYM 6 t/ha + vermicompost 2 t/ha + biofertilizers, or by applying 100% N through FYM + vermicompost + neem cake (Kumar *et al.*, 2018), and by supplying 100% RDF (N) through 50% FYM + 50% vermicompost (Murali *et al.*, 2018).

The higher yields can also be attributed to the total nutrient supply in terms of N, P₂O₅, and K₂O provided by the combined organic sources in the treatments vermicompost 2.5 t/ha + poultry manure 2.5 t/ha + mustard oil cake 1 t/ha (59.59-32.71-31.98: N, P₂O₅, and K₂O kg/ha) and FYM 5 t/ha + poultry manure 2.5 t/ha + mustard oil cake 1 t/ha (47.94-25.59-25.60: N, P₂O₅, and K₂O kg/ha), which were considerably higher, particularly in nitrogen, compared to other treatments and the control. This indicates that the crop received the most favourable nutrient status in the soil, along with higher soil moisture content, ensuring optimal vegetative and reproductive growth and development. This optimal nutrient availability likely resulted in better crop growth and ultimately higher seed and stover yields. These findings align closely with

those reported by Tomar *et al.*, (1996).

Furthermore, the oil content and oil yield of rapeseed were significantly higher with organic nutrient treatments compared to the control. Although the oil content of rapeseed did not vary widely among the different organic nutrient sources, significantly higher oil yields were recorded under the treatment vermicompost 2.5 t/ha + poultry manure 2.5 t/ha + mustard oil cake 1 t/ha (528.0 kg/ha), followed by FYM 5 t/ha + poultry manure 2.5 t/ha + mustard oil cake 1 t/ha (502.4 kg/ha), outperforming the other treatments and the control. The higher seed yields associated with these treatments likely contributed directly to the higher oil yields. Previous reports (De and Sinha, 2012) have indicated that organic sources such as FYM, vermicompost, neem cake, mustard oil cake, and poultry manure contain essential elements like sulfur, boron, and zinc in significant amounts, which likely promote oil synthesis by providing the necessary energy from ATP (adenosine triphosphate). Consequently, significantly higher oil contents and oil yields were observed in these treatments, consistent with the findings of Tomar *et al.*, (1996) and Singh and Singh (2006).

Conclusion

The application of vermicompost 2.5 t/ha + poultry manure 2.5 t/ha + mustard oil cake 1 t/ha, which supplies approximately 60-33-32 kg/ha of N-P, O... -K, O, or FYM 5 t/ha + poultry manure 2.5 t/ha + mustard oil cake 1 t/ha, providing around 48-38-26 kg/ha of N-P, O... -K, O, is optimal for achieving higher growth, yield attributes, and seed and oil yields in organically grown rapeseed. These combinations of organic nutrients not only enhance the vegetative and reproductive growth of the crop but also contribute to a more favorable nutrient

balance in the soil, ensuring sustained availability of essential nutrients throughout the growing season. This sustained nutrient availability leads to improved plant vigor, increased numbers of siliquae per plant, more seeds per siliqua, and ultimately higher seed and stover yields. The enhanced crop performance, in turn, results in significantly higher oil yields, which is a crucial factor in the overall profitability of rapeseed cultivation. This makes the use of these organic nutrient combinations not only beneficial for soil health and crop productivity but also a financially viable option for farmers practicing organic farming. The balance of nutrients provided by these treatments ensures that the crop's nutrient demands are met effectively, leading to optimal growth and maximizing the potential of the organic farming system.

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