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Productivity and economic feasibility of vegetable-based cropping system under organic and natural farming conditions in Indo-Gangetic plains of India

Manisha Thakur*, C.S. Aulakh, and A.S. Sidhu

School of Organic Farming, Punjab Agricultural University, Ludhiana-141004, Punjab, India

ABSTRACT

Organic and natural farming are considered alternatives to modern agriculture for sustaining soil and environmental health and producing better quality agricultural produce free from pesticide residues. The consumer concern for the same is more for vegetables and fruits as they are generally consumed raw and have higher purchase frequency. Field experiments were conducted in northwest India in 2018 and 2019 to evaluate the performance of the pea-okra radish cropping system under organic and natural farming practices with paddy straw mulch and no-mulch conditions. The treatments consisted of farmyard manure (FYM) to supply recommended nitrogen to the crops, natural farming practices-250 kg FYM/ha + on-farm preparations (NF), FYM + NF and FYM + vermicompost (VC). The FYM, FYM + NF and FYM + VC were at par with each other but were significantly superior to NF and unfertilized control regarding economic yields of all the crops. The economic yields of pea, okra, and radish were 40.11, 46.48 and 25.99 per cent higher with FYM than NF. Paddy straw mulch gave significantly higher economic yields (11.10, 12.56 and 19.28 per cent in pea, okra and radish) than no-mulch. Though the economic yields were higher with FYM + NF, the benefit-cost ratios for all the crops were higher with FYM alone due to the higher cost of production in other treatments.

Key words: Cropping system, Farmyard manure, Mulch, Natural farming, Organic farming

INTRODUCTION

India has the distinction of growing many vegetables worldwide due to its diverse agro-climatic conditions, making it possible to grow vegetable crops year-round. Vegetables fetch higher prices in the market than cereals, can be cultivated quickly, produce higher yields, and play a significant role in accomplishing nutritional security (Rishitha *et al.*, 17). Vegetables, a rich source of vitamins, minerals, dietary fibres and biochemical constituents, are one of the cornerstones of human nutrition. In India, the total vegetable production is 191.76 mt from the 10.35 mha area, with an average productivity of 18.52 t/ha (NHB, 13). According to the National Institute of Nutrition (NIN) expert group report 2020, a healthy daily diet needs to include nearly 100 g of green leafy vegetables, 200 g of other vegetables, and 100 g of roots and tubers. More than 80 per cent of Indians do not meet this recommendation, and we can meet only around 1/9th of this requirement. Malnutrition and poverty are major concerns in developing countries, which can be reduced only by consuming safe vegetables.

The safe production of vegetables with better quality produce has attained constant attention among common people (Das *et al.*, 4). Safe food has become synonymous with organic farming, which has received more attention, resulting in the expansion of organic agriculture. These markets' expansion makes it feasible for vegetable growers to sell their vegetables or other products at more significant price premiums. Organic farming is one of the influential sectors as it prohibits the use of pesticides, fungicides and herbicides; the use of different crop rotations saturated with leguminous crops follows the optimum use of natural resources such as water and soil with negligible effect on the natural ecosystem (Kostadinova and Popov, 10). The intensive cropping system without non-leguminous crops and high fertilizer-responsive crops often leads to non-sustainability in crop yield. It poses a severe threat to the health of the soil. Thus, alternative practices, such as crop rotation with leguminous crops, intercropping, cover cropping, etc., must be adopted to make agriculture more enduring and sustainable. In organic farming, leguminous crops are an essential component of the cropping system. The pea (*Pisum sativum* L.) is a widely cultivated member of the Leguminaceae family due to its lower nitrogen requirement and more significant yield potential under organic and natural farming, leaving a valuable home for the superseding crops (Wysokinski and Lozak, 20). Okra (*Abelmoschus esculentus* L. Moench), believed to have originated

*Corresponding author: mshthakur4@pau.edu

in tropical Africa, is a popular vegetable crop that can be grown in tropical and sub-tropical parts of the world for its nutritional value (Ola *et al.*, 14).

Further, radish (*Raphanus sativus* L.) is widely cultivated among root vegetables in temperate and tropical regions. Its young, fresh, tender tuberous roots are a good source of ascorbic acid (Vitamin C) and are mostly consumed as raw food as a salad or cooked (Singh, 19). Diversity in crop rotations and cropping systems affects soil microbial communities by producing different root exudates (Garbeva *et al.*, 6). Exploiting different vegetable crops in a cropping system provides other substrates to soil microorganisms, further enhancing residue decomposition (Lupwayi *et al.*, 11). Thus, pea-okra-radish qualifies to be a suitable cropping system for organic vegetable farming in the Indo-Gangetic plains of India. This study assessed vegetable-based cropping systems' productivity and economic feasibility under organic and natural farming conditions.

MATERIALS AND METHODS

Field experiments were carried out at the Integrated Farming System Research Farm of the School of Organic Farming, Punjab Agricultural University, Ludhiana, situated at 30°54′N, 75°48′E and an altitude of 247 m above mean sea level from November 2018 to March 2020, a period that covered six full growing seasons of vegetables. The crops received rainfall 18.17 mm monthly and 1327.7 mm from November 2018 to March 2020. The mean weekly minimum and maximum temperature ranged between 4.9° C & 42.7°C during 3rd week of 2019 and 6th week of 2020, respectively (Figure 1). The experiments comprise five nutritional treatment combinations with three replications in a split-plot design. Farmyard manure, vermicompost and natural farming treatments were applied each season at the beginning of each crop season according to the treatments viz., T1: Farmyard manure (FYM) to supply recommended nitrogen (N)/ha, i.e.,@ 5 tonnes/ha, 9 tonnes/ha and 6.25 tonnes/ha to pea, okra and radish respectively, T2: Natural farming* (NF): Seed treatment with bijamrit + basal application of ghanjeevamrit @ 250 kg/ha + FYM @ 250 kg/ha + jeevamrit + mulching + pesticides/fungicides prepared from locally available organic material, T3: T1 + T2, T4: FYM (75 %) + vermicompost (25 %), T5: Unfertilized control and sub-plots consisted of S1: no mulch and S2: paddy straw mulch @10 tonnes/ha, 9 tonnes/ha and 8 tonnes/ha to pea, okra and radish respectively. Crops were grown according to organic agricultural practices with no agrochemicals (herbicides, fungicides, and pesticides). Bird perches were also used to reduce damage from insect pests. Need-based biopesticides were used as a prophylactic measure against diseases and insect pests, viz., Pseudomonas fluorescence, Trichoderma sp. and neem extract, respectively. The significance of the results and the data were subjected to statistical analysis to draw valid conclusions, and all the comparisons were made at a 5% significance level (Cochran and Cox, 3).

RESULTS AND DISCUSSION

The growth and yield parameters of the crops showed different manifestations under organic and natural farming management (Table 1) (Figure 2).

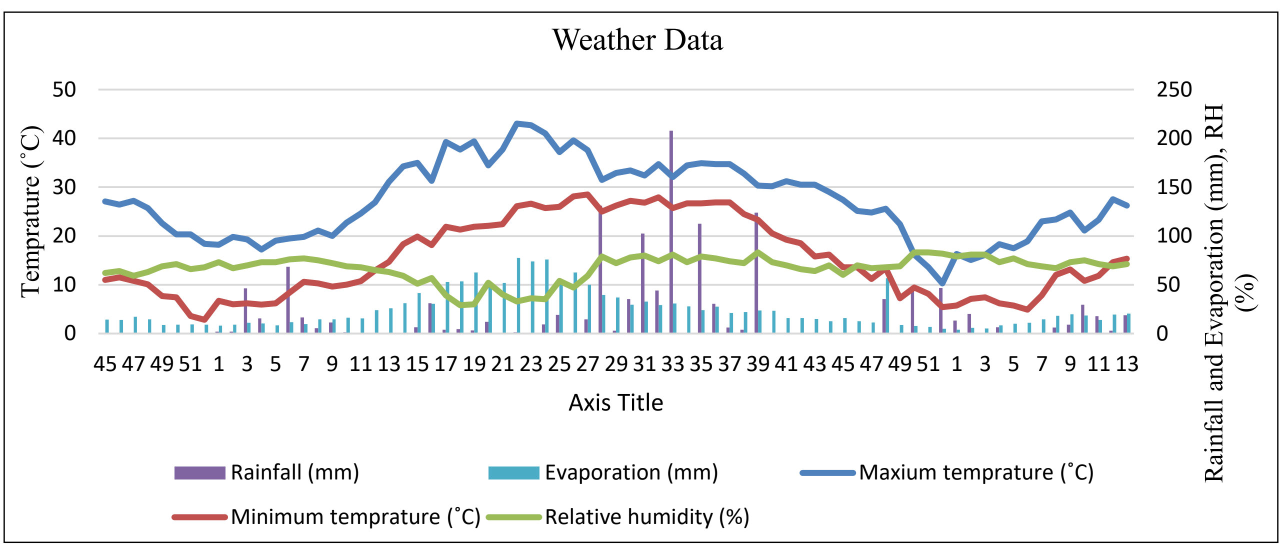

Fig. 1. Mean monthly temperature (maximum and minimum), relative humidity (maximum and minimum) and rainfall recorded from November 2018- March 2020.

Table 1. Productivity of vegetable based cropping system under organic and natural farming conditions (Two year pooled analysis).

Treatment	Pea		Okra		Radish		
	Plant height (cm)	Yield (t/ha)	Plant height (cm)	Yield (t/ha)	Plant height (cm)	Root weight (g)	Yield (t/ha)
Main Plots (Nutrient management)							
T_1: FYM to supply recommended N	82.36	13.00	77.66	8.86	34.59	201.75	53.21
T_2: Natural farming (NF)*	74.97	7.79	56.30	4.69	25.24	148.97	39.38
T_3: FYM + NF	84.22	13.44	79.62	9.41	37.21	210.30	55.13
T_4: FYM (75%) + VC (25%)	83.12	13.13	78.49	9.13	35.75	206.56	54.06
T_5: Unfertilized control	72.65	7.40	55.85	4.49	21.66	134.36	35.50
CD (p=0.05)	3.55	2.35	2.52	1.45	3.29	49.20	12.45
Sub Plots (Weed management)							
S_1: No mulch	76.30	10.30	62.57	6.81	28.88	160.82	42.39
S_2: Paddy straw mulch	81.02	11.59	66.61	7.79	32.03	200.25	52.52
CD (p=0.05)	2.30	1.01	1.75	0.8	2.26	29.42	2.35

Natural Farming*: Seed treatment with *bijamrit* + basal application of *ghanjeevamrit* @ 250 kg/ha + FYM @ 250 kg/ha + *jeevamrit* + mulching + pesticides/fungicides prepared from locally available organic material

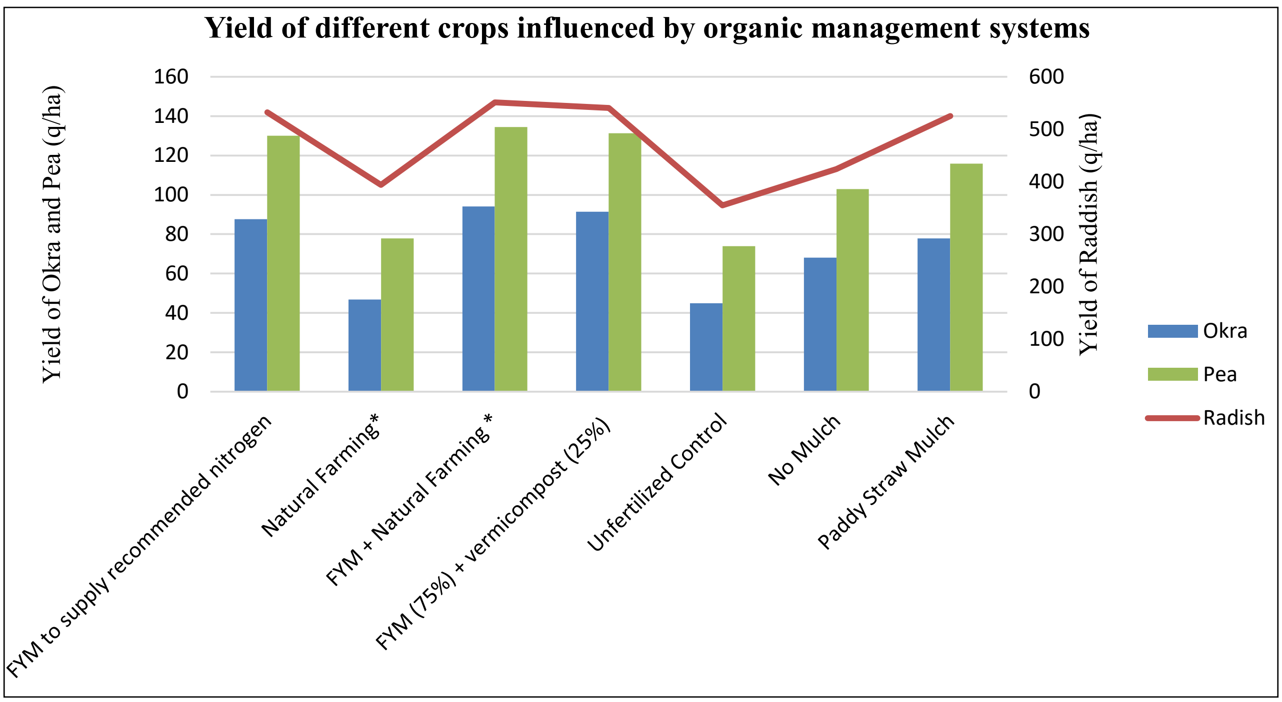

Fig. 2. Productivity of vegetable based cropping system under organic and natural farming conditions.

In the Pea crop, the integration of T3 (FYM + NF) had the maximum average plant height (84.22 cm), which was statistically at par with T4 (FYM + VC) and T1 (FYM alone). The maximum average fresh pod yield was obtained with T3 (FYM + NF) and the minimum with T2 (NF) and unfertilized control (T5). Integration of FYM + NF (T1 + T2) gave the highest fresh pod yield (13.44 t/ha), which was statistically at par with T4 (FYM + VC) and T1 (FYM). In subplots, paddy straw mulch (S2) gave a significantly higher yield (11.59t/ha) than no mulch (S1) treatment (10.30 t/ha) (Table 1). Inadequate availability of essential nutrients often leads to poor crop performance. The results highlighted the edge of manured plots over the less manured and unfertilized ones regarding growth parameters and economic yields (Jannoura *et al.*, 9). Lupwayi and Kennedy (12) stated that peas have a relatively low soil nitrogen requirement as legume crops. Including legumes in the cropping system reduces insect-pest and disease cycles, enhancing the diversity and activity of microbial populations. As a result, soil health improved. In organic farming conditions, pea crops have also shown superior growth and yield traits (Pandey *et al.*, 15; Gopinath and Mina, 7). Without any nitrogen fertilizer application, the pea crop's maximum nitrogen (65-75 per cent) is derived from biological nitrogen fixation (Wysokinski and Lozak, 20). The maximum mean plant height of okra was observed in T3 (FYM + NF) (79.62 cm), which was statistically at par with T4 (FYM + VC) and T1 (FYM alone). However, the maximum mean fresh fruit yield was obtained with FYM + NF (T3) (9.41 t/ha), which was statistically at par with FYM + VC (T4) and FYM (T1). The paddy straw mulch (S2) gave a significantly higher yield (7.79t/ha) than the no-mulch (S1) treatment in subplots. Significant enhancement of fruit production in okra with organic manures is related to the adequate availability of nutrients, resulting in improved vegetative growth (due to synthesis and translocation of photosynthesis from the sources to the sink) and significantly enhanced number and weight of fresh pod yield and yield attributes.

Adekiya, (2), has earlier reported improvement in growth attributes of okra with soil application of organic manures. The plant height of radish was significantly influenced by organic and organic + NF treatments over the NF and unfertilized control. The highest average plant height was recorded with T3 (FYM + NF) (37.21 cm), which was statistically at par with T4 (FYM + VC) and T1 (FYM alone). The highest root weight (210.30 g) and root yield 55.13 t/ha were recorded with FYM + NF (T3), which was statistically at par with FYM + VC (T4), FYM (T1) and the minimum with NF (T2) and unfertilized control (T1) (Table 1). In subplots, the S2 treatment (paddy straw mulch) gave a significantly higher yield (52.52t/ha) than the S1 (no mulch) treatment. Similar findings have been reported in radish by Rajwade and Bhadur (16), and Adekiya *et al.* (1) have also reported that organic manures improved the growth and yield of radish. As a result, mulching with paddy straw also has shown more economic yield than no mulch treatments in all three crops because it maintains soil temperature, facilitates retention of soil moisture, improves soil health by adding nutrients to the soil and, which results in enhanced vegetative growth and yield attributes of crops (De Silva and Cook, 5). Further use of paddy straw mulch reduced irrigation frequency and increased water use efficiency to 66-80 per cent (Greb *et al.*, 8).

The treatments have significantly affected gross income, net income and benefit-cost ratio (B:C ratio). In all the treatments, FYM + VC cost was higher (Rs/ha-213789/-) except for unfertilized control (Rs/ha-136029/-). In the pea-okra-radish cropping system, due to the higher cost of vermicompost. Maximum gross income Rs. 482312 ha-1, Rs.578775 ha-1 and net income Rs. 279354 ha-1, Rs. 375817 ha-1 with 25, 50 per cent premium respectively was found with the application of FYM + NF treatment but higher B: C ratio, i.e.,1.47, 1.97 with 25, 50 per cent premium respectively was obtained with FYM treatment due to higher cost involved in preparation and field application of NF inputs (beejamrit, jeevamrit and

Table 2. Economic feasibility of vegetable based cropping system under organic and natural farming conditions.

Treatments	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)		Net returns (Rs/ha)		B:C ratio	
		With 25% premium	With 50% premium	With 25% premium	With 50% premium	With 25% premium	With 50% premium
Main Plots (Nutrient management)							
T_1: FYM to supply recommended N	185945	459812	551775	273867	365830	1.47	1.97
T_2: Natural farming (NF)*	154800	283700	340440	128900	185640	0.83	1.20
T_3: FYM + NF	202958	482312	578775	279354	375817	1.38	1.85
T_4: FYM (75%) + VC (25%)	213789	470549	564660	256760	350871	1.20	1.64
T_5: Unfertilized control	136029	265400	318480	129371	182451	0.95	1.34
Sub Plots (Weed management)							
S_1: No mulch	174397	362343	434812	187946	260415	1.08	1.49
S_2: Paddy straw mulch	160521	422080	506497	261559	345976	1.63	2.16

Natural Farming*: Seed treatment with *bijamrit* + basal application of *ghanjeevamrit* @ 250 kg/ha + FYM @ 250 kg/ha + *jeevamrit* + mulching + pesticides/fungicides prepared from locally available organic material ghanjeevamrit). The minimum gross income with 25 and 50 per cent premium (Rs. 265400 ha-1 and Rs. 318480 ha-1) was obtained under unfertilized control treatment while minimum net income (Rs. 128900 ha-1 and Rs. 185640 ha-1) and B:C ratio (0.83 and 1.20) were reported under NF treatment due to inferior yield, results into lesser net income and more cost involved in preparation and field application of NF inputs (beejamrit, jeevamrit and ghanjeevamrit). From overall cropping system economics based on the benefit-cost ratio, the maximum returns were obtained with FYM in main plots and paddy straw mulch treatment in subplots with 25 and 50 per cent premiums (Table 2). Russo and Taylor (18) suggested that if a price premium is given to organically raised crops, then the cost of production could be reduced.

AUTHORS' CONTRIBUTION

Conceptualization of research and designing of the experiments (CSA and MT); Performing field experiments and collection of data (MT); Analysis of data and manuscript writing (MT & ASS).

DECLARATION

The author declares no conflict of interest.

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