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The influence of natural and organic farming techniques on productivity and economics of maize (*Zea mays* L.) based intercropping systems

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Abstract
A field experiment was conducted during kharif 2020 at the Zero Budget Natural Farm (ZBNF), Department of Organic Agriculture & Natural Farming, COA, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, to evaluate the influence of natural and organic farming techniques on the productivity and economics of maize based intercropping systems. The experiment was comprised of thirteen treatments which were tested in randomized block design with three replications. Results of the study revealed that significantly higher grain yield (27.38 q/ha) of maize was recorded under maize + lobia and *jeevamrit* spray at 14 days interval which was found to be statistically at par with maize + soybean and *jeevamrit* spray at 14 days interval (25.99 q/ha). In case of economic analysis, highest gross returns (205252 ₹/ha), net returns (156132 ₹/ha), benefit cost ratio (3.18) and gross returns per rupee invested (4.18) were noted under maize + soybean and *jeevamrit* spray at 14 days interval.

Keywords: Economics, natural farming, organic farming and yield

Introduction

Maize, wheat and rice are the most widely grown cereal crops worldwide, including India and constitute the cornerstone of global food security. Maize (*Zea mays* L.) and wheat (*Triticum aestivum* L.) are the main sources of the world's food energy and contain a significant amount of proteins, vitamins and minerals. Maize is the third-most significant cereal crop in the world and a major source of staple food for a big portion of the global population. In India, it is grown on an area of 9.90 million hectare with a production of 31.65 million tonnes per hectare and productivity of 3.20 tonnes per hectare (Anonymous 2021) [1]. Compared to other cereal crops, it has a higher production potential. Maize is a heavy feeder of plant nutrients and growing of these crops alone over the years will barren the land and cause for decline in productivity. Inclusion of legumes in rotation or raising them in association with these crops have been advocated by various workers to sustain the soil health and due importance was given for achieving higher productivity. The yield advantage of cereals in intercropping system with leguminous crops probably occurred from the difference in timing of utilization of resources by different crops. The productivity of maize based intercropping systems in India has been maintained with the use of high analysis chemical fertilizers. Chemical fertilizers have the capacity to meet the nutrient requirements of these crops in an intensive cropping system but regular use of these fertilizers leads to nutrient imbalance, which has a detrimental effect on both the soil health and crop productivity. Therefore, to ensure food, nutritional, soil and environmental security, conventional production systems need to shift towards eco-friendly agriculture systems that combine low ecological footprint to produce more crops/commodities. Organic farming is one such step towards environment friendly techniques that is taken to ensure sustainable agricultural production. Although, in organic farming, there is a significant need for organic manures such as farm yard manure, green manure, compost, vermi-compost and non-edible cake etc. to meet the nutritional needs of organic crops (Kumar 2015) [5]. Moreover, small and marginal farmers owe a small number of animals so in order to meet the nutritional requirement of the crops, they need to purchase the bulky organic manures from outside sources which further adds the transportation costs in the cost of cultivation. In that case, this practice does not remain economically feasible for small and marginal farmers. Padma Shree Subhash Palekar presented a novel idea called "Zero Budget Natural Farming (ZBNF), "which is low-input, climate-resilient farming thus promotes farmers to use inexpensive, locally obtained inputs rather than synthetic fertilizers and pesticides from industrial sources. He has defined four aspects of ZBNF that are critical *viz.*, *beejamrit* - cow dung and urine-based formulation for microbial coating of seeds. It protects the crop from harmful soil-borne and seed-borne pathogens. The second component is a *jeevamrit*, a fermented microbial culture. It not only provides nutrients, but also serves as a catalyst, promoting earthworm activity and microbiological activity in the soil. The positive effects of *jeevamrit* reported by Palekar (2006) [7]. The third aspect *acchadana* - mulching, is the process of covering the soil surface with an organic material to prevent water evaporation and promote the development of soil humus. The fourth aspect *whapasa* - moisture is the state in which both water and air molecules are present in the soil. He has recommended the application of *jeevamrit* at 21 days interval. Hence, keeping in view the above-mentioned points, the present investigation entitled "The influence of natural and organic farming techniques on the productivity and economics of maize based intercropping systems" was carried out with the aim of increasing the production of the crops per unit area in the present study and different intervals (14, 21 and 28 days) of *jeevamrit* application were tested in different maize based intercropping systems.

Materials and Methods

Field experiment was conducted at CSK HPKV, Palampur (32°09´ N, 76°5´ E), during *kharif* 2020 and 2021. The soil of the experimental site was silty clay loam in texture, acidic in reaction (pH 5.4), high in organic carbon and medium in available nitrogen, phosphorus and potassium. The experiment was laid out in randomized block design comprising of thirteen treatments *viz.*, T_1- Maize + Lobia and *Jeevamrit* spray at 14 days interval, T_2- Maize + Lobia and *Jeevamrit* spray at 21 days interval, T_3- Maize + Lobia and *Jeevamrit* spray at 28 days interval, T_4- Maize + Soybean and *Jeevamrit* spray at 14 days interval, T_5- Maize + Soybean and *Jeevamrit* spray at 21 days interval, T_6- Maize + Soybean and *Jeevamrit* spray at 28 days interval, T_7- Maize sole and *Jeevamrit* spray at 14 days interval, T_8- Maize sole and *Jeevamrit* spray at 21 days interval, T_9- Maize sole and *Jeevamrit* spray at 28 days interval, T_{10}- Maize + Lobia and *Matka khad* spray at 30 days interval, T_{11}- Maize + Soybean and *Matka khad* spray at 30 days interval, T_{12}- Maize sole and *Matka khad* spray at 30 days interval and T_{13}- Maize sole (Absolute control).

Location

Field experiment was conducted at the Zero Budget Natural Farm (ZBNF), Department of Organic Agriculture & Natural Farming, COA, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, during *kharif* 2020 and 2021. The region is endowed with mild summers and cool winters. The mean weekly meteorological observations recorded at the meteorological observatory of the Department of Agronomy, College of Agriculture, CSK HPKV, Palampur during the crop growth period. The meteorological data revealed that maximum mean monthly temperature ranged from 25.0 ºC to 28.9 ºC and minimum from 9.3 ºC to 20.1 ºC. The relative humidity ranged between 51.8 to 92.1% with highest humidity recorded during the month of August.

Crop management

Maize was intercropped with soybean and lobia, respectively. Maize with spacing 60 × 20 cm, soybean and lobia with spacing 60 × 20 cm is recommended for mid hills area for timely sowing. Before sowing of maize, *ghanjeevamrit* (under natural farming plots) and FYM (under organic farming plots) was applied at the time of final field preparation. Seeds were treated with the *beejamrit* and *biofertilizers* as per treatment. *Jeevamrit* was applied at 14, 21 and 28 days interval in natural farming treatments, whereas in organic farming treatments *matka khad* was sprayed at every 30 days interval, respectively. Nutrient analysis of different traditional inputs was carried out as standard procedure. Maximum N, P and K content was recorded under *ghanjeevamrit* (1.25, 0.87 & 0.68%, respectively) followed by *beejamrit* (0.72, 0.14 & 0.23%, respectively) and *jeevemarit* (0.25, 0.13 & 0.15%, respectively).

Results and Discussion

Data on effect of different natural and organic farming practices on the grain yield and cost of cultivation, gross returns, net returns, benefit cost ratio and gross returns per rupee invested have been presented in Table 1 & 2.

Grain yield

Grain yield was significantly affected by different natural and organic farming practices (Table 1). During *kharif* 2020, highest grain yield (27.38 q/ha) was obtained under natural farming practices *i.e.* T_1- maize + lobia and *jeevamrit* spray at 14 days interval and it remained statistically at par with the T_4- maize + soybean and *jeevamrit* spray at 14 days interval (25.99 q/ha) which in turn was statistically at par with organic farming practices *i.e.* T_{10}, T_{11} and T_2 (25.44, 25.50 and 25.44 q/ha), respectively. Maize yield was higher due to the frequent application of *jeevamrit* that might have enhanced the soil microbial activity and population to a greater extent that helped in phosphate solubilization and nitrogen fixation etc. This in turn had a positive effect on growth due to steady and continues supply of nutrients throughout the entire crop growth period, which might have enhanced the maize yield (Patel *et al*. 2021) [8]. Another reason might be that in an intercropping system (maize + lobia and maize + soybean), part of the nitrogen fixed in root nodules of the legume becomes available to non-legume component (maize) and the presence of rhizosphere microflora and mycorrhiza may lead to mobilization and greater availability of nutrients not only to the species concerned, but also to the associated species. Mulching in natural farming plots also helped to conserve soil moisture, control weeds and increase the population of micro flora (El-Beltagi 2022) [3]. Higher yield under organic treatments (T_{10} and T_{11}) might be because of the steady supply of nutrients through FYM, which might have a favourable effect on soil physical, chemical and biological properties and thus facilitating the quick and increased availability of plant nutrients to crop (Avnimelech 1986 and Shwetha *et al*. 2009) [2, 10]. Application of *jeevamrit* at 28 days interval decreased the yield of maize (T_3, T_6 and T_9) in both the seasons. Absolute control (T_{13}) resulted in the lowest yield of maize as compared to natural and organic farming practices during both the seasons. T_1 and T_4 resulted in 46.73% and 39.28% higher yield of maize over absolute control, while it was 36.33% and 36.65% higher yield under organic farming treatments *i.e.* T_{10} and T_{11} over absolute control, respectively.

Economic studies

Cost of cultivation

It was evident from the data presented in Table 2 that T4 (maize + soybean and *jeevamrit* spray at 14 days interval) recorded the highest cost of cultivation (49120 ₹/ha and 52220 ₹/ha) which was followed by T11 (maize + soybean and *matka khad* spray at 30 days interval) and T5 (maize + soybean and *jeevamrit* spray at 21 days interval) during *kharif.*

Gross returns

A perusal of the data revealed that the treatment T4 (maize + soybean and *jeevamrit* spray at 14 days interval) recorded the highest gross returns of 205252 ₹/ha which was followed by maize + soybean and *matka khad* spray at 30 days interval (T_{11}) and maize + soybean and *jeevamrit* spray at 21 days interval (T_5). The lowest gross returns were recorded in T_{13} (absolute control). The variation in the gross returns was mainly because of the difference in grain and stover yields due to the treatments effect (Table 2). Kasbe *et al*. (2009) [12] also found that application of *jeevamrit* with combination of different organic manures was cost effective when used @ 2000 l/ha than when *jeevamrit* was used alone. It was observed that application of *jeevamrit* in combination with other organic manures such as vermicompost is one of the cheapest and most effective organic sources in an integrated approach for high crop yield and profitability.

Net returns

A cursory glance at Table 2 further revealed that T_4 (maize + soybean and *jeevamrit* spray at 14 days interval) recorded the highest net returns (156132 ₹/ha). Treatment T_{11} (maize + soybean and *matka khad* spray at 30 days interval) was found to be the second best treatment followed by T_5. The lowest net returns were recorded under T_9 (maize sole and *jeevamrit* spray at 28 days interval), which was the result of lower grain and stover yields as compared to cost of cultivation. These findings are in line with the results obtained by Kumar (2015) [5].

Benefit cost ratio (B:C)

The perusal of data presented in Table 2 revealed that treatment T_4 (maize + soybean and *jeevamrit* spray at 14 days interval) recorded the highest B:C (3.18) followed by T_5 (maize + soybean and *jeevamrit* spray at 21 days interval) and T_{11} (maize + soybean and *matka khad* spray at 30 days interval), while lowest was under T_9 (maize sole and *jeevamrit* spray at 28 days interval) (0.71). The lowest benefit cost ratio obtained under T_9 might be due to high cost of cultivation as compared to grain and stover yield, which provided lesser profit (Singh *et al*. 2008) [11].

Gross returns per rupee invested

The perusal of data presented in Table 2 revealed that treatment T4 recorded the highest gross returns per rupee invested (4.18) followed by T11, while lowest returns (1.71) were obtained from T9.

Table 1: Effect of natural and organic farming practices on grain yield of different maize based intercropping systems

Treatments	Grain/seed yield (q/ha) (2020)		
	Maize	Soybean	Lobia
T_1 - Maize + Lobia and *jeevamrit* spray at 14 days interval	27.38	-	13.25
T_2 - Maize + Lobia and *jeevamrit* spray at 21 days interval	25.44	-	10.96
T_3 - Maize + Lobia and *jeevamrit* spray at 28 days interval	23.17	-	9.33
T_4 - Maize + Soybean and *jeevamrit* spray at 14 days interval	25.99	17.84	-
T_5 - Maize + Soybean and *jeevamrit* spray at 21 days interval	24.10	16.33	-
T_6 - Maize + Soybean and *jeevamrit* spray at 28 days interval	21.92	15.22	-
T_7 - Maize (sole) and *jeevamrit* spray at 14 days interval	23.77	-	-
T_8 - Maize (sole) and *jeevamrit* spray at 21 days interval	22.92	-	-
T_9 - Maize (sole) and *jeevamrit* spray at 28 days interval	21.20	-	-
T_{10} - Maize + Lobia (Organic package of practices)	25.44	-	11.96
T_{11} - Maize + Soybean (Organic package of practices)	25.50	15.96	-
T_{12} - Maize sole (Organic package of practices)	24.14	-	-
T_{13} - Maize sole (Absolute control)	18.66	-	-
SEm±	0.62	-	-
LSD (P=0.05)	1.81	-	-

Table 2: Effect of natural and organic farming practices on economics of different maize based intercropping systems

Treatments	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C	Gross returns per rupee invested
	2020	2020	2020	2020	2020
T_1	46390	177709	131319	2.83	3.83
T_2	45640	155602	109962	2.41	3.41
T_3	44990	137541	92551	2.06	3.06
T_4	49120	205252	156132	3.18	4.18
T_5	48370	187660	139290	2.88	3.88
T_6	47720	173566	125846	2.64	3.64
T_7	40170	75831	35661	0.89	1.89
T_8	39420	72566	33146	0.84	1.84
T_9	38770	66470	27700	0.71	1.71
T_{10}	46015	162540	116525	2.53	3.53
T_{11}	48835	190040	141205	2.89	3.89
T_{12}	39735	76032	36297	0.91	1.91

T_{13}	18000	51811	33811	1.88	2.88

T_1- Maize + Lobia and jeevamrit spray at 14 days interval, T_2- Maize + Lobia and jeevamrit spray at 21 days interval, T_3- Maize + Lobia and jeevamrit spray at 28 days interval, T_4- Maize + Soybean and jeevamrit spray at 14 days interval, T_5- Maize + Soybean and jeevamrit spray at 21 days interval, T_6- Maize + Soybean and jeevamrit spray at 28 days interval, T_7- Maize sole and jeevamrit spray at 14 days interval, T_8- Maize sole and jeevamrit spray at 21 days interval, T_9 – Maize sole and jeevamrit spray at 28 days interval, T_{10} - Maize + Lobia (Organic package of practices), $T_1$1 – Maize + Soybean (Organic package of practices), T_{12} - Maize sole (Organic package of practices), T_{13} - Maize sole (Absolute control)

Conclusion

Maize intercropped with lobia or soybean along with application of *jeevamrit* at 14 days interval proved to be the best treatment for enhancing crop productivity. However, in terms of economic benefits (gross returns, net returns, benefit cost ratio and gross returns per rupee invested), both the farming practices showed promising outcomes, suggesting that they can be effective agricultural approaches for sustainable and profitable crop production.

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