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Optimizing Productivity and Economics of Maize + Legumes Intercropping: A Study on the Impact of Natural and Organic Farming Practices

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ABSTRACT

Background: Excessive use of chemical fertilizers in a cropping system adversely affects the soil health and crop productivity. To ensure food security, nutritional balance and environmental sustainability, a shift towards eco-friendly organic farming based agricultural systems was imperative. But it also poses challenges for small farmers who owe a small number of animals and they need to purchase bulk organic manures. Zero Budget Natural Farming (ZBNF) emerges as an alternate and advocate for low-input, climate-resilient practices which include *beejamrit, jeevamrit, achhadana* and *whapasa*. With the aim of increasing the production of the crops per unit area in the present study, different intervals (14, 21 and 28 days) of *jeevamrit* under natural farming plots and *matka khad* (30 days interval) under organic farming plots were tested in different maize based intercropping systems.

Methods: A field experiment was conducted during *kharif* 2020 and 2021 at the Zero Budget Natural Farm (ZBNF), Department of Organic Agriculture and Natural Farming, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The experiment was comprised of thirteen treatments which were tested in randomized block design with three replications.

Result: Among different treatments significantly higher values of yield attributes and yield of maize were recorded under maize + lobia and *jeevamrit* spray at 14 days interval during *kharif* 2020 and maize + soybean and *jeevamrit* spray at 14 days interval during *kharif* 2021. In case of economics, higher gross returns, net returns and benefit cost ratio were recorded under maize + soybean and *jeevamrit* spray at 14 days interval during *kharif* 2020, whereas during *kharif* 2021, maize + soybean and *matka khad* spray at 30 days interval resulted in the highest returns.

Key words: Economics, Natural farming, Organic farming, Yield.

INTRODUCTION

Maize (*Zea mays* L.) is a major source of world's food energy and contains a significant amount of proteins, vitamins and minerals. 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 (Gebru, 2015). 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 lead 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.

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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). 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 add 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 (Palekar, 2006). The core idea of natural farming is to encourage the growth of beneficial microbes without relying on external fertilizers or synthetic pesticides. Legumes, in this context, are valuable because they capture atmospheric nitrogen, enriching the soil (Raveena *et al*., 2024). He has recommended four aspects of ZBNF that are critical *viz., beejamrit*, *jeevamrit*, *acchadana* and *whapasa*. He has recommended the application of *jeevamrit* at 21 days interval. Hence, keeping in view the above-mentioned points and *jeevamrit* application duration, 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– Wheat + gram and *jeevamrit* spray at 14 days interval, T_2- Maize + lobia- Wheat + gram and *jeevamrit* spray at 21 days interval, T_3- Maize + lobia - Wheat + gram and *jeevamrit* spray at 28 days interval, T_4- Maize + soybean - Wheat + lentil and *jeevamrit* spray at 14 days interval, T_5- Maize + soybean - Wheat + lentil and *jeevamrit* spray at 21 days interval, T_6- Maize + soybean - Wheat + lentil and *jeevamrit* spray at 28 days interval, T_7- Maize sole -Wheat sole and *jeevamrit* spray at 14 days interval, T_8-Maize sole -Wheat sole and *Jeevamrit* spray at 21 days interval, T_9-Maize sole-Wheat sole and *jeevamrit* spray at 28 days interval, T_{10}-Maize+lobia-Wheat+gram (Organic package of practices), T_{11}-Maize + soybean - Wheat + lentil (Organic package of practices), T_{12}- Maize sole - Wheat sole (Organic package of practices) and T_{13}- Maize sole - Wheat sole (Absolute control).

Crop management

Maize was intercropped with soybean and lobia, respectively. Maize with spacing 60 × 20 cm, soybean and lobia with spacing 45 × 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. Conversely, in the organic farming treatments, *matka khad* was sprayed at every 30 days interval, respectively. Standard procedures were employed to conduct nutrient analysis of different traditional inputs. Maximum N, P and K content was recorded under *ghanjeevamrit* (1.25, 0.87 and 0.68%, respectively) followed by *beejamrit* (0.72, 0.14 and 0.23%, respectively) and *jeevemarit* (0.25, 0.13 and 0.15 %, respectively).

Observations recorded

Maize

Data on number of plants/m^2 at maturity, number of cobs/plant, cob length, cob diameter, cob girth, number of grains/cob, test weight (1000-seed weight, grain yield, biological yield (Verma *et al*., 2015) and maize grain equivalent yield was recorded (MGEY) (Lal and Ray, 1976).

$$\text{MGEY} = \text{Yield of maize (q/ha)} + \frac{\text{Yield of intercrop(q/ha)} \times \text{Price of intercrop(₹/q)}}{\text{Price of maize crop(₹/q)}}$$

Soybean and Lobia

Data on yield attributes *i.e.* plant population at maturity, number of branches per plant, number of pods per plant, number of seeds per pod and test weight as well as yield of soybean and lobia were recorded (Shilpa *et al.,* 2023).

Economics

Gross returns, net returns and B:C ratio were calculated treatment wise (Shilpa *et al.,* 2023).

Statistical analysis

The data generated from field and laboratory analysis were subjected to statistical analysis using the technique of analysis of variance for randomized block design for the interpretation of results as described by Gomez and Gomez (1984). The treatment differences were compared at 5 per cent level of significance (P=0.05). Each case was subjected to a standard error of mean calculation. When the 'F' value from the analysis of variance tables was significant, a minimum significant difference was calculated.

RESULTS AND DISCUSSION

Yield attributes

Different treatments didn't have a significant effect on number of cobs per plant and test weight of maize (Table 1) during both the seasons (*Kharif* 2020 and 2021). In case of cob length, cob diameter and cob girth, treatment T_1 (maize + lobia and *jeevamrit* spray at 14 days interval)

resulted in the highest yield attributes (16.1 cm, 3.87 cm and 15.61 cm) of maize during *kharif* 2020. However during *kharif* 2021, treatment T_4 (maize + soybean and *jeevamrit* spray at 14 days interval) recorded the highest cob length, diameter and girth (15.9 cm, 3.64 and 14.70 cm), while number of grains per cob were found to be maximum (180.1) under T_1 (maize + lobia and *jeevamrit* spray at 14 days interval) during *kharif* 2020. However during *kharif* 2021, significantly higher number of grains per cob (171.8) were recorded under treatment T_4 (maize + soybean and *jeevamrit* spray at 14 days interval) (Mridula, 2021). Absolute control (T_{13}) resulted in lesser cob length, cob diameter, cob girth and number of grains per cob (133.9 in *Kharif* 2020 and 110.5 in *Kharif* 2021) during both the seasons, which might be due to the limited availability of nutrients resulting from the absence of external nutrient sources (either organic or natural). Maize yield attributing characters were significantly improved in treatments where *jeevamrit* was applied at 14 day intervals (T_4 and T_1) and *ghanjeevamrit* was added at the time of sowing, which contain small quantities of macro and micro-nutrients as well as growth promoting substances and beneficial microbes (Yadav and Mowade, 2004; Joshi, 2012), which in turn increased the mineralization and solubilization of nutrients in soil, leading to better nutrient availability throughout the cropping season and promoting crop growth and development (Avnimelech, 1986). Mulching was also used to maintain adequate moisture and temperature, which are crucial for balanced metabolic activities of plants and improved soil physical properties, promoting the quick and increased availability of plant nutrients.

Yield

Grain yield was significantly affected by natural and organic farming practices during both the years (Table 2). During *kharif* 2020, highest grain yield (27.38 q/ha) was obtained under natural farming practices i.e. maize + lobia and *jeevamrit* spray at 14 days interval (T_1) and it remained statistically at par with the maize + soybean and *jeevamrit* spray at 14 days interval (T_4) (25.99 q/ha). However, during *kharif* 2021, significantly higher yield (24.20 q/ha) was obtained in T_4 (maize + soybean and *jeevamrit* spray at 14 days interval) and it was found to be statistically at par with the treatments T_5 (maize + soybean and *jeevamrit* spray at 21 days interval) and T_{11} (maize + soybean and *matka khad* spray at 30 days interval) (22.88 q/ha and 22.69 q/ha). Whereas, application of *jeevamrit* at 28 days interval decreased the yield of maize (T_3, T_6 and T_9) in both the seasons, while absolute control (T_{13}) resulted in the lowest yield of maize as compared to natural and organic farming practices during both the seasons.

The yield of any crop is determined by the assimilatory surface of the plant system, which is influenced by various factors such as plant height, leaf area index and number of leaves. These factors directly affect the distribution of dry matter in different plant parts, ultimately impacting the yield attributes and total yield of the crop. In the present study, maximum grain yield was observed in natural farming treatments T_1 and T_4, which could be attributed to the cumulative effect of *ghanjeevamrit* at the time of sowing and *jeevamrit* spray in standing crop and these treatments might have enhanced the microbial activity, leading to increased organic carbon content of soil, which acted as a source of carbon and energy for the microbes. This resulted in the quick buildup of heterotrophic microflora and fauna, leading to better availability of nutrients throughout the crop season and ultimately, positive influence on the growth and yield characters of maize (Thakur, 2022 and Mridula, 2021). Additionally, mulching in natural farming plots played a critical role in conserving soil moisture,

Table 1: Effect of treatments on yield attributes of maize crop.

Treatments	Plant population at maturity (plants/m^2)		No. of cobs/plant		Cob length (cm)		Cob diameter (cm)		No. of grains/cob		Cob girth (cm)		Test weight (g)	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
T_1	8.40	8.27	1.00	1.00	16.1	14.7	3.87	3.31	180.1	158.3	15.61	13.64	201.3	198.2
T_2	8.20	8.00	1.00	1.00	14.8	13.8	3.38	3.29	165.5	152.2	14.79	13.40	199.9	197.8
T_3	8.13	8.00	1.00	1.00	14.2	13.5	3.27	3.17	152.6	137.5	13.17	13.05	195.5	195.5
T_4	8.33	8.33	1.00	1.00	15.7	15.9	3.70	3.64	177.2	171.8	15.22	14.70	200.3	200.5
T_5	8.00	8.00	1.00	1.00	14.4	15.8	3.31	3.60	162.9	162.2	13.90	14.46	199.9	199.1
T_6	8.07	8.07	1.00	1.00	13.8	13.7	3.19	3.25	150.4	144.6	13.20	13.39	195.1	195.7
T_7	8.13	8.13	1.00	1.00	14.5	14.3	3.30	3.23	156.5	154.3	13.55	13.51	199.3	197.5
T_8	8.07	8.07	1.00	1.00	14.2	13.4	3.18	3.21	154.7	143.3	13.43	13.12	196.7	195.7
T_9	8.13	8.00	1.00	1.00	13.6	13.1	3.16	3.10	151.4	130.5	13.03	12.69	194.6	194.5
T_{10}	8.33	8.20	1.00	1.00	15.0	14.3	3.66	3.59	164.2	157.1	15.03	13.35	200.2	199.3
T_{11}	8.20	8.13	1.00	1.00	15.4	15.7	3.71	3.61	165.3	169.2	14.89	14.38	196.9	197.6
T_{12}	8.07	8.10	1.00	1.00	14.5	13.5	3.34	3.22	157.3	153.9	13.83	12.83	198.8	195.8
T_{13}	8.00	7.60	0.93	0.93	12.4	12.1	2.88	2.82	133.9	110.5	12.25	12.06	194.2	193.9
SEm±	0.15	0.19	0.02	0.02	0.43	0.41	0.10	0.10	4.75	4.4	0.27	0.33	2.7	2.8
LSD (P=0.05)	NS	NS	NS	NS	1.25	1.19	0.29	0.30	13.57	12.9	0.80	0.96	NS	NS

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

Treatments	Yield (q/ha) 2020		Yield (q/ha) 2021	
	Grain	MEY	Grain	MEY
T_1 - Maize + lobia and *jeevamrit* spray at 14 days interval	27.38	59.06	21.82	46.57
T_2 - Maize + lobia and *jeevamrit* spray at 21 days interval	25.44	51.65	20.36	37.98
T_3 - Maize + lobia and *jeevamrit* spray at 28 days interval	23.17	45.48	18.47	34.80
T_4 - Maize + soybean and *jeevamrit* spray at 14 days interval	25.99	72.53	24.20	56.52
T_5 - Maize + soybean and *jeevamrit* spray at 21 days interval	24.10	66.69	22.88	50.19
T_6 - Maize + soybean and *jeevamrit* spray at 28 days interval	21.92	61.62	20.15	40.08
T_7 - Maize (sole) and *jeevamrit* spray at 14 days interval	23.77	23.77	21.17	21.17
T_8 - Maize (sole) and *jeevamrit* spray at 21 days interval	22.92	22.92	20.27	20.27
T_9 - Maize (sole) and *jeevamrit* spray at 28 days interval	21.20	21.20	17.78	17.78
T_{10} - Maize + lobia (Organic package of practices)	25.44	54.04	20.33	46.22
T_{11} - Maize + soybean (Organic package of practices)	25.50	67.13	22.69	54.82
T_{12} - Maize sole (Organic package of practices)	24.14	24.14	20.16	20.16
T_{13} - Maize sole (Absolute control)	18.66	18.66	12.36	12.36
SEm±	0.62	1.03	0.54	1.12
LSD (P=0.05)	1.81	2.99	1.57	3.26

controlling weeds and increasing the population of microflora (El-Beltagi *et al.,* 2022).

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). However, there was a decrement in the grain yield of maize in second year of experimentation (2021) by 20.31% and 6.89% and 20.08% and 11.02% under T_{10} and T_4 and T_{10} and T_{11}, respectively as compared to first year. The lower yield observed during the *kharif* 2021 season can be attributed to the excessive rainfall and high temperatures on maize growth and productivity. High rainfall in the Himalayan region can have detrimental effects on maize yield, particularly in cooler areas with poorly drained soils (Li *et al.,* 2019). Maize is a warm season crop that requires an optimal amount and distribution of rainfall throughout its growing season, making rainfall a critical factor for maize yield. Research has shown that there is a threshold for the amount of rainfall that is beneficial for maize production. While an increase in rainfall can enhance yield up to a certain limit, beyond that point, the additional gain in maize production begins to diminish. Studies by Li *et al.,* (2019); Cudjoe *et al.* (2021) and Dwamena *et al.* (2022) have highlighted the detrimental effects of above-normal rainfall on crop yield, including direct physical damage and processes associated with excessive soil water such as waterlogging and flooding, particularly under poor drainage conditions. Excessive waterlogging caused oxygen deficiency in the soil, leading to poor root growth and limited nutrient uptake by maize plants which leads to reduced photosynthetic activity and ultimately decreased yield. In case of maize grain equivalent yield in the year 2020, it was significantly higher (72.53 q/ha) under T_4 (maize + soybean and *jeevamrit* spray at 14 days interval) followed by T_{11} (maize + soybean and *matka khad* spray at 30 days interval) and T_5 (maize + soybean and *jeevamrit* spray at 21 days interval) (67.13 q/ha and 66.69 q/ha), respectively. Whereas in the year 2021, again T_4 resulted in the highest maize grain equivalent yield (56.52 q/ha) and it was found to be statistically at par with T_{11} (54.82 q/ha). Higher maize equivalent yield under intercropping system was attributed to yield advantages achieved in intercropping system (Hugar and Palled, 2008). The difference in MEY was mainly as a consequence of differences in the yield of maize, additional component crop yield and price of individual component crops. The use of leguminous intercrops (lobia and soybean) in association with maize could have been responsible for the higher MEY. Leguminous crops are capable of thriving under shade and they have the ability to fix atmospheric nitrogen in the soil, which may have contributed to the increased yield. Furthermore, nutrient competition between maize and intercrops (soybean or lobia) may have been reduced due to different growth habits, thus enhancing the growth and productivity of all the crops involved in the intercropping system. T_3 (maize + lobia + *jeevamrit* spray at 28 days interval) resulted in the lowest maize grain equivalent yield in both the years (2020 and 2021).

Intercrop studies

Yield attributes and yield

Lobia

Treatment T_1 (maize + lobia and *jeevamrit* spray at 14 days interval) resulted in the highest yield attributing characters (number of branches per plant, number of pods per plant and number of seeds per pod and test weight) of lobia in both the years. In case of plant population at maturity, T_1 during *kharif* 2020 and T_{10} during *kharif* 2021 recorded higher plant population of lobia (Table 3 to 4). Whereas, highest yield (seed and straw) was obtained under treatment maize + lobia and *jeevamrit* spray at 14 days interval in both the years.

Soybean

The treatment maize + soybean and *jeevamrit* spray at 14 days interval resulted in higher yield attributes (plant population per square meter, number of branches per plant, number of pods per plant and number of seeds per pod) and yield (seed and straw) of soybean during *kharif* 2020 (Patil and Udmale, 2016; Yadav and Mowade, 2004). Whereas, during *kharif* 2021, higher values of yield parameters and yield were observed under organic farming treatment maize + soybean and *matka khad* spray at 30 days interval (Table 5 and Table 6).

The favorable yield attributes of lobia and soybean observed in natural farming plots might be due to mulching which maintained optimal soil moisture and temperature regime, which is critical for the balanced metabolic activities of the plants and resulted in the enhancement of growth characters of lobia and soybean. Moreover under organic farming plots, the increased organic matter content improved soil structure, leading to better distribution of water and nutrients in the soil profile as well as facilitated greater cycling of available nutrients, ultimately enhancing the growth and yield parameters of soybean and lobia (Farooqui *et al.*, 2009). Legumes (Soybean, Lobia), in particular, can serve as effective live mulches due to their ability to suppress weed growth and enhance soil fertility through nitrogen fixation as well as reduce erosion and increase soil moisture retention, ultimately leading to better crop growth and yield. The yield of soybean and lobia decreased

Table 3: Effect of treatments on yield attributes of lobia crop.

Treatments	Plant population at maturity(plants/m^2)		Test weight (g)		No. of pods /plant		No. of branches /plant		No. of seeds /pod	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
T_1 - Maize + lobia and *jeevamrit* spray at 14 days interval	9.45 ±0.97	9.28 ±1.19	80.78 ±0.15	80.36 ±0.19	22.38 ±2.04	20.39 ±2.22	11.07 ±1.64	10.53 ±0.75	11.53 ±0.28	10.53 ±0.34
T_2 - Maize + lobia and *jeevamrit* spray at 21 days interval	9.21 ±0.55	9.16 ±2.94	80.45 ±0.33	79.47 ±0.45	19.65 ±1.18	16.87 ±1.01	9.73 ±1.50	9.30 ±1.53	9.81 ±0.31	9.30 ±0.45
T_3 - Maize + lobia and *jeevamrit* spray at 28 days interval	9.35 ±1.04	8.93 ±3.80	79.56 ±0.24	78.16 ±0.31	17.87 ±2.22	15.43 ±2.59	9.12 ±2.32	8.54 ±1.79	9.25 ±0.41	8.54 ±0.41
T_{10} - Maize + lobia (Organic package of practices)	9.40 ±0.56	9.37 ±2.11	80.31 ±0.18	80.12 ±0.35	21.70 ±1.76	19.24 ±2.15	10.62 ±1.76	9.88 ±0.62	10.32 ±0.24	9.88 ±0.12

*Mean±SD.

Table 4: Effect of treatments on seed yield and straw yield of lobia crop.

Treatments	Seed yield (q/ha)		Straw yield (q/ha)	
	2020	2021	2020	2021
T_1- Maize + lobia and *jeevamrit* spray at 14 days interval	13.25±0.20	10.35±0.23	28.56±0.31	22.31±0.14
T_2- Maize + lobia and *jeevamrit* spray at 21 days interval	10.96±0.26	7.37±0.24	23.62±0.38	15.89±0.22
T_3- Maize + lobia and *jeevamrit* spray at 28 days interval	9.33±0.31	6.83±0.30	20.11±0.41	14.72±0.29
T_{10}- Maize + lobia (Organic package of practices)	11.96±0.12	9.84±0.21	26.78±0.27	21.51±0.21

*Mean±SD.

Table 5: Effect of treatments on yield attributes of soybean crop.

Treatments	Plant population at maturity (plants/m^2)		Test weight (g)		No. of pods /plant		No. of branches /plant		No. of seeds /pod	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
T_4- Maize + soybean and *jeevamrit* spray at days 14 interval	14 9.27 ±0.56	9.24 ±1.36	129.11 ±0.45	128.30 ±0.49	61.15 ±1.45	51.75 ±1.93	8.45 ±0.71	7.12 ±0.42	3.27 ±0.20	2.73 ±0.16
T_5- Maize + soybean and *jeevamrit* spray at 21 days interval	9.16 ±0.87	8.82 ±1.71	128.70 ±0.70	127.20 ±0.37	57.47 ±1.76	47.58 ±2.85	7.26 ±0.87	6.63 ±0.89	3.20 ±0.27	2.65 ±0.14
T_6- Maize + soybean and *jeevamrit* spray at 28 days interval	8.82 ±1.18	8.65 ±1.32	128.50 ±0.72	127.10 ±0.44	55.78 ±2.84	40.40 ±3.23	6.79 ±1.44	5.66 ±1.21	3.12 ±0.19	2.42 ±0.18
T_{11} - Maize + soybean (Organic package of practices)	9.20 ±0.67	9.28 ±0.56	129.20 ±0.35	128.50 ±0.51	59.32 ±1.98	54.14 ±2.41	7.52 ±0.45	7.41 ±0.45	3.15 ±0.25	2.87 ±0.20

*Mean±SD.

Table 6: Effect of treatments on seed yield and straw yield of soybean crop.

Treatments	Seed yield (q/ha)		Straw yield (q/ha)	
	2020	2021	2020	2021
T_4- Maize+soybean and *jeevamrit* spray at 14 days interval	17.84±0.15	12.39±0.16	31.17±0.20	21.54±0.29
T_5- Maize+soybean and *jeevamrit* spray at 21 days interval	16.33±0.41	10.47±0.24	28.39±0.60	18.20±0.33
T_6- Maize+soybean and *jeevamrit* spray at 28 days interval	15.22±0.54	7.64±0.46	26.46±0.66	15.28±0.44
T_{11}- Maize+soybean (Organic package of practices)	15.96±0.22	13.22±0.21	27.75±0.41	22.98±0.38

*Mean±SD.

in the second season as compared to the first season, which might be attributed to the adverse effects of excessive rainfall on crop growth and productivity by creating an oxygen-deficient environment in the root zone, causing a buildup of carbon dioxide, which negatively affected the crops. The lack of oxygen may disrupt the symbiotic relationship between soybean plants and the *Bradyrhizobia* bacteria, which are responsible for nitrogen fixation within nodules on the root system (Pampana *et al.,* 2016).

Economic studies

Economic studies such as cost of cultivation, gross returns, net returns, benefit cost ratio and profitability have been presented in Table 7. T_4 (maize + soybean and *jeevamrit* spray at 14 days interval) recorded the highest cost of cultivation (49120 ₹/ha and 52220 ₹/ha) during *kharif* 2020 and 2021, respectively, whereas in case of gross returns, net returns and benefit cost ratio, T_4 (maize + soybean and *jeevamrit* spray at 14 days interval) was found to be the besttreatment (205252 ₹ /ha, 156132 ₹/ha and 3.18) during *kharif* 2020 (190040 ₹/ha, 141205 ₹/ha, 2.89 and 187660 ₹ /ha, 139390 ₹/ha, 2.88). T_{11} was the best economical treatment (163707 ₹/ha, 111822 ₹/ha and 1.73) during second year (*Kharif* 2021). The variation in the gross returns and net returns was mainly because of the difference in grain and stover yields due to the treatments effect (Table 2). Kasbe *et al.*, (2009) 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 vermi-compost is one of the cheapest and most effective organic sources in an integrated approach for high crop yield and profitability. However, lowest net returns (27700 ₹/ha and 12446 ₹/ha) were recorded under T_9 (maize sole and *jeevamrit* spray at 28 days interval) in 2020 and under T_{13} (absolute control) in 2021, which was the result of lower grain and stover yields as compared to cost of cultivation (Kumar, 2015). Lowest lowest benefit cost ratio was obtained under T_9 (maize sole and *jeevamrit* spray at 28 days interval) during both the years (0.71 and 0.37), might be due to high cost of cultivation as compared to grain and stover yield, which provided lesser profit (Singh *et al.*, 2008).

Table 7: Effect of natural and organic farming practices on economics of different maize based intercropping systems.

Treatments	Gross returns (₹/ha)		Net returns (₹/ha)		B:C	
	2020	2021	2020	2021	2020	2021
T_1	177709	141678	131319	92188	2.83	1.86
T_2	155602	118483	109962	69793	2.41	1.43
T_3	137541	107681	92551	59691	2.06	1.24
T_4	205252	162722	156132	110502	3.18	2.12
T_5	187660	145566	139290	94146	2.88	1.83
T_6	173566	117925	125846	67205	2.64	1.33
T_7	75831	67871	35661	25001	0.89	0.58
T_8	72566	62705	33146	20635	0.84	0.49
T_9	66470	56844	27700	15474	0.71	0.37
T_{10}	162540	133967	116525	84902	2.53	1.73
T_{11}	190040	163707	141205	111822	2.89	2.16
T_{12}	76032	65073	36297	22688	0.91	0.54
T_{13}	51811	34646	33811	12446	1.88	0.56

CONCLUSION

In present scenario, where there is destruction in soil and plant health, it is important to adopt a sustainable cropping system which should be environmental friendly and economically sound. In the present study, emphasis was given on the use of organic nutrient sources and it was concluded that maize intercropped with lobia or soybean along with application of *jeevamrit* at 14 days interval proved to be the best treatment for enhancing the crop productivity. However, in terms of economic benefits (gross returns, net returns and benefit: cost), both the farming practices showed promising outcomes, suggesting that they can be effective agricultural approaches for sustainable and economical crop production.

Conflict of interest

The authors declare no competing interest.

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