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Investigating Yield Dynamics and Economic Benefits of Maize-Wheat Based Cropping System under mid hill conditions of Himachal Pradesh, India

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ABSTRACT

A two-year field experiment was carried out during 2020-2021 and 2021-2022 to find out the impact of natural and organic farming techniques on the productivity and profitability of the maize-wheat based cropping system. The experiment was conducted in randomized block design, replicated thrice and 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), T_{11}- Maize + Soybean - Wheat + Lentil (Organic), T_{12}- Maize sole - Wheat sole (Organic) and T_{13}- Maize sole - Wheat sole (Absolute control). The findings indicated that adopting organic farming techniques led to significantly higher maize equivalent yield of the system and there was an increment in the system equivalent yield of T_4 by 118.96%, 131.84%, 143.66% and 126.94% in the 1st year of experimentation and 112.43%, 137.98%, 157.66% and 114.42% system in the 2nd year of experimentation over sole treatments (T_7, T_8, T_9 and T_{12}, respectively). Similarly, organic farming practices also proved to be better in terms of various economic indicators, including gross returns, net returns and benefit cost ratio as well as profitability of the system.

Key words: *Economics, Equivalent yield, Jeevamrit, Matka khad, Natural farming and organic farming*

Introduction

Cereals play an important role in providing nutrition and are usually consumed as raw grains or as ingredients in various foods. They're not only essential for human consumption but also serve as animal

([2]Assistant Professor, [3]Principal Scientist) feed, contributing to products like meat, dairy and poultry. Additionally, they utilized industrially in the manufacturing of variety of substances, such as glucose, adhesives, oils and alcohols. Wheat stands out as the second most significant crops after rice among cereals. 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 and constitute the cornerstone of global food security (Pal and Molnar 2021).

Chemical fertilizers have traditionally been used to maintain the productivity of maize and wheat. However, their regular use has caused nutritional imbalances in the soil, which has had a detrimental effect on soil health and crop growth. To address this, a shift towards eco-friendly agricultural practices is necessary for food, soil and environmental security. These approaches release nutrients in accordance with the crop's requirement. Organic farming, a sustainable approach, is gaining popularity due to increasing health awareness among consumers. As customers become more concerned with their health and are even willing to pay higher prices for the safe food, the demand for food grown organically is increasing. India is ranked first in the world in terms of the total number of producers and fifth in terms of the amount of organic agricultural land (FIBL & IFOAM year book 2021). The total area under organic farming in India is 2.6 million acres (Anonymous, 2021). Soils from organically managed farms had higher number and more diverse populations of beneficial organisms than soils from conventionally managed farms. According to Stolze et al. (2000), organic farming boosted both microbial biomass and activity by 20-30% and 30-100%, respectively. Nonetheless, organic farming requires significant inputs including FYM, green manure, compost and vermicompost to meet the nutritional needs of crops. This poses a challenge for small and marginal farmers who own only a few animals. To meet crop nutritional demands, they frequently have to purchase these bulky organic manures from external sources, adding transportation costs to their cultivation expenses. In such situations, this practice becomes economically unviable for them. "Padma Shree Subhash Palekar" presented a novel idea called "Zero Budget Natural Farming (ZBNF)" which is a low-input, credit-free farming, utilizing locally available inputs. This approach reduces the cost of production and enhances yield.

The four primary components of ZBNF are: *beejamrit* for coating seeds with a cow dung and cow urine mixture, *jeevamrit* for providing nutrients and enhancing soil activity. The positive effects of *jeevamrit* reported by Palekar (2006); Vasanthkumar (2006) and Devakumar *et al.* (2008) have been attributed to higher microbial load and growth hormones, which may have increased soil biomass, maintaining the availability and uptake of applied as well as native soil nutrients, resulting in higher crop growth and production. *Acchadan*a for mulching to retain soil moisture and *whapasa* for maintaining optimal soil moisture level. In order to preserve soil fertility in cropping systems with high levels of production, intercropping with legumes has also been emphasized as a crucial practice of natural farming. Thus, the philosophy of natural farming is to nurture the growth of these beneficial microbes without using external manure and synthetic pesticides. Additionally, legumes enrich the soil by fixing the atmospheric nitrogen (Li *et al.,* 2012). So, cereal + legume intercropping system, besides increasing productivity and profitability also improves soil health and conserves soil moisture. To some extent natural farming is already being practiced in states like Himachal Pradesh, Uttarakhand etc. where accessibility to farm inputs is difficult due to topographical limitations. In addition, agriculture is the primary source of income for small and marginal farmers in Himachal Pradesh for their livelihood. Therefore, there is a need to promote research and extension activities in order to take natural farming steps ahead.

Materials and Methods

The research study was carried out at the Zero Budget Natural Farm (ZBNF), Department of Organic Agriculture & Natural Farming, COA, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during 2 years (from *kharif* 2020 to *rabi* 2021-22). Intercropping of maize with soybean (*Glycin max* L.) and lobia (*Vigna unguiculata* L.) in one seeding ratios 1:1 and wheat with gram (*Cicer arietinum* L.) and lentil (*Lens culinaris* L.) in 4:1 ratio was compared with sole planting of maize and wheat. Maize variety Bajaura Makka, soybean variety Harit Soya and lobia variety Him Lobia-I with spacing 60 × 20 and wheat variety HPW 368 with spacing 22.5 × 5 cm, gram variety Himachal Chana - I and lentil variety Vipasha with spacing 30 × 15 cm is recommended for mid hills area for timely sowing. Prior to the sowing, *ghanjeevamrit* was applied in natural farming plots and FYM in organic farming plots at the time of final field preparation. Seeds were treated with the *beejamrit* and *biofertilizers* in accordance with the respective treatment protocols. *Jeevamrit* was sprayed at 14, 21 and 28 days interval in natural farming plots, conversely in organic farming plots *matka khad* was applied at every 30 days interval, respectively. Standard procedures were followed for nutrient analysis of various traditional inputs. Notably, the highest content of nitrogen (N), phosphorus (P) and potassium (K) was observed in *ghanjeevamrit* (1.25, 0.87 & 0.68%, respectively) followed by *beejamrit* (0.72, 0.14 & 0.23%, respectively) and *jeevamrit* (0.25, 0.13 & 0.15 %), respectively.

Crop Management

Details of Observations Recorded

System studies

The crops in sequence were studied as a cropping system and subjected to maize grain equivalent yield. On the transformed yield basis, gross returns, net returns, profitability and benefit-cost ratio were calculated for both the years of experiment.

Maize equivalent yield of system

It was calculated according to the standard procedure (Lal and Ray, 1976).

Gross returns

The transformed grain/seed and straw/stover yield (maize equivalent yield) of wheat was multiplied with their respective market prices. By summing up the returns from grain/seed and straw/stover yields, the gross returns (₹/ha) were calculated treatment-wise for the cropping system.

Net returns

Net returns were obtained by subtraction of total cost of cultivation for a year from gross returns.

Profitability

Net returns were divided with duration of the cropping system. It depicts the returns per day for the system (₹/ha/day) and calculated as:

$$\text{Profitability} = \frac{\text{Net returns (₹/ha)}}{\text{Duration of cropping system (days)}}$$

Benefit-cost ratio

B: C was obtained by dividing net returns with cost of cultivation obtained during the system.

$$\text{B:C} = \frac{\text{Net returns (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

Statistical analysis

To test whether significant differences resulted from the Randomized block design, the data were analyzed using analysis of variance (ANOVA) as per the procedure given by Gomez and Gomez (1984) and conclusions were drawn at 5% level of probability. 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

System studies

Maize grain equivalent yield of system (MEY)

Maize equivalent yield of system was significantly affected by natural and organic farming practices during both the years (Table 1). Significantly higher maize equivalent yield (90.30 q/ha in 1st year and 82.53 q/ha in 2nd year) of the system was recorded with treatment T_4 (maize + soybean - wheat + lentil and *jeevamrit* spray at 14 days interval) and it was statistically at par with T_{11} (maize + soybean - wheat + lentil and *matka khad* spray at 30 days interval) during 2nd year. The lowest maize equivalent yield of the system was recorded under absolute control during both the years, respectively. Higher maize and wheat equivalent yield under intercropping system was attributed to yield advantages achieved in intercropping system (Hugar and Palled, 2008). The difference in equivalent yield was mainly as a consequence of differences in the yield of maize and wheat, additional component crop yield and price of individual component crops. The use of leguminous intercrops (lobia, soybean, gram and lentil) in association with cereals (maize and wheat) could have been responsible for the higher equivalent yield. 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 cereals and legumes may have been reduced due to different growth habits, thus en-

Table 1. Effect of treatments on maize equivalent yield (MEY) and economics for maize-wheat based cropping system

Treatments	MEY of system (q/ha)		Gross returns (₹/ha)		Net returns (₹/ha)		Profitability (₹/ha/day)		B:C	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
T_1	77.45	71.16	221113	201713	130197	104697	431.1	342.1	1.43	1.08
T_2	68.95	58.11	197271	168656	108055	73440	357.8	240.0	1.21	0.77
T_3	62.44	51.66	180490	149604	92574	55788	306.5	182.3	1.05	0.59
T_4	90.30	82.53	249101	231759	156061	132551	516.8	433.2	1.68	1.34
T_5	84.63	71.51	232242	203741	140834	106333	466.3	347.5	1.54	1.09
T_6	80.00	59.52	220573	171515	130465	75507	432.0	246.8	1.45	0.79
T_7	41.24	38.85	137377	130183	54327	41583	179.9	135.9	0.65	0.47
T_8	38.95	34.68	129055	114224	47705	27424	158.0	89.6	0.59	0.32
T_9	37.06	32.03	122349	107057	42299	21657	140.1	70.8	0.53	0.25
T_{10}	74.00	71.56	209588	203959	119258	107629	394.9	351.7	1.32	1.12
T_{11}	85.69	81.83	236175	228980	143583	130388	475.4	426.1	1.55	1.32
T_{12}	39.79	38.49	131177	129745	48517	41635	160.7	136.1	0.59	0.47
T_{13}	28.95	21.14	81407	61688	40957	14888	135.6	48.7	1.01	0.32
SEm±	1.25	1.27								
LSD (P=0.05)	3.64	3.71								

hancing the growth and productivity of all the crops involved in the intercropping system.

In context of maize-wheat cropping system, among different treatments higher maize equivalent yield of the system was observed in treatments T_4 and T_{11}, where lentil and soybean were intercropped, could be attributed to the influence of market prices and the individual crop yields. Soybean and lentil gave higher economic yield and this accompanied with better market price resulted in higher MEY of the system. Maize and wheat itself gave higher economic yield with the inclusion of soybean and lentil (legumes) as an intercrop as well as the preceding crop maize + soybean and this accompanied with better market value resulted in higher onion-equivalent yield compared with other cropping systems.

Economic studies

The data presented in Table 1 indicated that gross returns & net returns (249101 /ha in 1st year and 231759 /ha in 2nd year & 156061 /ha in 1st year and 132551 /ha in 2nd year) were higher under T_4 (maize + soybean - wheat + lentil and *jeevamrit* spray at 14 days interval) followed by T_{11} (236175 /ha in 1st year and 228980 /ha in 2nd year, 143583 /ha in 1st year and 130388 /ha in 2nd year) in both the years of study. The lowest net returns were obtained from T_{13} (40957 /ha in 1st year and 14888 /ha in 2nd year). In context of B:C ratio, treatment T_4 provided higher B:C (1.68 and 1.34) followed by T_{11} (1.55 and 1.32) in first and second year of the experiment respectively, while lowest B:C was obtained from T_9 (0.53 in 1st year and 0.25 in 2nd year), which was the result of lower grain/seed and stover/straw yields as compared to cost of cultivation which provided lesser profit (Singh *et al.*, 2008).

The treatments T_4 and T_{11} resulted in higher gross returns, net returns and benefit-cost ratio, which can be attributed to the increased yields and economic values of the intercrops associated with these treatments. The variation in the gross returns and net returns were mainly because of the difference in grain/seed and stover/straw yields due to the treatments effect. Similarly, Kumar (2015) also found that applying FYM @12 t/ha resulted in the highest gross returns, net returns and benefit-cost ratio. In context of the profitability, treatment T_4 had higher profitability (516.8 /ha/day and 433.2 /ha/day during 1st and 2nd year, respectively) followed by T_{11} (475.4 /ha/day in 1st year and 426.1 /ha/day in 2nd year). The lowest profitability was recorded under T_{13} (135.6 /ha/day and 48.7 /ha/day in 1st year and 2nd year, respectively).

Conclusion

The present study indicates that the natural and organic farming practices significantly improved the crop yield in a maize-wheat cropping system. According to the study's results, farmers should involve legumes in intercropping systems to enrich the soil with organic matter. Maize and wheat intercropped with legumes (soybean and lentil) along with application of *jeevamrit* at 14 days interval and *matka khad* at 30 days interval gave better results for achieving higher equivalent yield and economic profitability. These practices yielded promising results, indicating their potential effectiveness as viable approaches for sustainable crop production.

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Conflict of Interest - None

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