



Performance of maize (*Zea mays*) + field bean (*Dolichos lablab*) intercropping system under natural, organic and conventional farming practices

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ABSTRACT

The present study was carried out at Zonal Agricultural and Horticultural Research Station, Babbur Farm, Hiriyur, Chitradurga, Karnataka during rainy (*kharif*) season 2019, 2020, 2021 and 2022 to study the productivity and economics of maize (*Zea mays* L.) + field bean (*Dolichos lablab* L.) (4:2) intercropping system under different farming practices. The experiment was laid out in randomized complete block design (RCBD) with four farming practices as treatments, viz. T₁, Natural farming (NF); T₂, Organic farming (OF); T₃, Recommended package of practices (RPP) and; T₄, Farmer practices (FP) with five replications. Results revealed that the recommended package of practices (RPP) recorded a significantly higher maize grain yield (6045 kg/ha), seed yield of field bean (538 kg/ha), maize equivalent yield (9625 kg/ha). Cost of cultivation in different farming practices indicated the lowest labour cost incurred in organic farming (₹25405/ha) and material cost in natural farming (₹14576/ha) as compared to other farming practices. Among the farming practices, lowest cost of cultivation was observed under natural farming (₹45436/ha) as compared to other farming practices. The gross returns (₹166471/ha) and net returns (₹109428/ha) were again significantly higher in RPP over other farming practices.

Keywords: Equivalent yield, Intercrop, Jeevamrutha, Panchagavya

The green revolution resulted in massive food production to meet demands of ever bulging population in India after independence. This relied heavily on fertilizers and agrochemicals for crop nutrients and pest control and boosting food grain production. However, their imbalanced, excessive use led to soil, water, and environmental pollution and health risks. In the 20th century, organic farming arose as an alternative agricultural system, promoting food self-reliance, rural development and natural ecosystem conservation. The green revolution led to farming debt from costly cultivation. To counter conventional agriculture's drawbacks and enable technology for poorer farmers, adopting natural farming is key (Palekar 2006). Natural farming aims to enhance India's food self-sufficiency by aligning with nature and reducing reliance on external inputs and credit. This holistic approach reduces commercial costs and decreases farmers' dependency on markets by avoiding external inputs (Smith *et al.* 2020). It is seen as a way of overcoming the inability of many poor farmers to access improved seed and manufactured agrochemicals (Palekar 2006).

Maize (*Zea mays* L.) is an important cereal crop in tropical regions, covering 9.86 million hectares in India and producing 31.51 million tonnes with a productivity of 3195 t/ha (Anonymous 2021). It is a staple food in Africa and the Indian subcontinent. The vertical diversification through intercropping can boost maize production. This intercropping strategy offers mutual benefits, including differential nutrient and moisture demands, soil enrichment, and insurance against crop failure in abnormal weather conditions. In maize, incorporating short-duration, high-value intercrops boosts economic security and overall productivity. Diversification optimizes resources, cuts costs and enriches soil quality in intensive farming (Singh *et al.* 2021). Although natural farming is practiced by small-scale peasants in various parts of India, the scientific community has been reluctant to accept it due to the lack of sufficient proof of concepts. Keeping these points in view, the field experiment was undertaken to study the effect of different farming practices on the productivity and economics of maize + field bean (*Dolichos lablab* L.) (4:2) intercropping system.

MATERIALS AND METHODS

Experimental site and soil characteristics: The present study was carried out at Zonal Agricultural and Horticultural

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Research Station, Babbur farm, Hiriyyur, Chitradurga district, Karnataka situated in the Central Dry Zone of Karnataka (Zone 4) (13°95'92''N, 76°61'37''E and 606.1 m amsl). The monthly mean annual rainfall of the experimental site was 615.8 mm (2004–2018). During the crop growing season, the per cent deviation in rainfall was 21.89, -3.77, 35.38 and 42.78% during 2019, 2020, 2021 and 2022, respectively as compared to the mean normal annual rainfall of the experimental site (615.8 mm). Sufficient rainfall was received for all cropping seasons except during the year 2020. The soil of the experimental site was medium black clay in texture having a slightly alkaline pH (8.46) with normal electrical conductivity (0.31 dS/m). The soil had low organic carbon content (0.44%), low in available nitrogen (225 kg/ha), medium in available P₂O₅ (31.47 kg/ha) and high in available K₂O (355 kg/ha).

Design of experiment and treatment details: The experiment was laid out in randomized complete block design (RCBD) with four farming practices as treatments, viz. T₁, Natural farming (Seed treatment with beejamrutha + soil application of jeevamrutha @500 litre/ha at 15 days interval + foliar application of jeevamrutha @10% at 30 days interval + ghanajeevamrutha @1000 kg/ha in two equal splits + mulching of previous crop residue + plant protection with natural pesticides/fungicides like neemstra, agniastra, brahmastra, shuntiastra, dashparni and sour butter milk); T₂, Organic farming (FYM @7.5 t/ha + nutrient application through equivalent to recommended nitrogen through FYM and vermicompost 50% each + seed treatment with *Azospirillum* and PSB + foliar application of panchagavya @3% at flowering followed by 15 days interval); T₃, Recommended package of practices (FYM @7.5 t/ha + 100:50:25 kg NPK/ha + seed treatment with *Azospirillum* and PSB) and; T₄, Farmer practices (FYM @5 t/ha + 82:92:0 kg of NPK/ha), treatments were replicated five times.

Agronomic management and data recording: Furrows were opened 60 cm apart. Maize seeds of cultivar Kaveri-244 and field bean seed of cultivar Hebbal Avare-4 were sown at plant to plant spacing of 20 cm at the ratio of 4:2 after every four rows of maize followed by two rows of field bean. Maize and field beans were harvested at physiological maturity. The maize cob and field bean pods were separated from the plant and were threshed by machine from a net plot then converted in kg/ha. Intercrop yields were computed as maize equivalent yields. Maize equivalent yield (MEY) is a simple expression in intercropping to compare the economics of intercrops by converting grain/seed/economic part etc. in terms of gross returns/net returns for valid comparison. The economics was worked out from prevailing market prices of inputs and outputs for different treatments.

Statistical analysis: The data recorded during the investigation were compiled and analysed for statistical significance as per the analysis of variance for the randomized complete block design (RCBD). Fisher's method of analysis of variance (ANOVA) as described by Gomez and Gomez (1984) was adopted for the purpose. Standard error

of mean and coefficient of variability have been worked out for a set of observations under each character at P=0.05 to interpret the significance. The pooled analysis for a series of experiments was done by using online statistical package OPSTAT (Sheoran *et al.* 1998).

RESULTS AND DISCUSSION

Yield attributes and grain yield of maize: The yield attributes and yields of maize showed significant difference due different farming practices as well as over the years (Table 1). Pooled combined analysis of data indicated that during first year (2019) recorded significantly higher yield attributes, viz. number of kernels per cob (419.8) and test weight (30.48 g) as compared to rest of the years. Higher yield attributes resulted in significantly higher maize grain yield (5112 kg/ha), stover yield (7450 kg/ha) and harvest index (40.52%) than rest of the years. Among the farming practices, recommended package of practices (RPP) recorded significantly higher yield attributes, viz. cob length (17.89 cm), number of rows per cob (14.75), number of kernels per cob (4491.5) and test weight (33.81 g) of maize as compared to other farming practices. The higher yield attributes resulted in significant maize grain yield (6045 kg/ha), stover yield (7645 kg/ha) and harvest index (42.65%) as compared to other farming practices. Whereas, natural farming practices recorded significantly lower yield attributes, viz. cob length (13.98 cm), number of rows per cob (12.15), number of kernels per cob (264.1), test weight (23.73 g) and maize grain yield (3530 kg/ha), stover yield (6037 kg/ha) and harvest index (36.80%) as compared to other farming practices (Table 1). The reduction in grain yield was observed under natural farming to the tune of 41.61% as compared to RPP. The higher maize grain yield was recorded under recommended package of practices mainly due to higher yield attributes, viz. cob length, number of rows per cob, number of kernels per cob and test weight as compared to other farming practices (Table 1). It was mainly due to better nutrient management and their availability under recommended package of practices where all the nutrients (100:50:50 N:P₂O₅:K₂O kg/ha, respectively) are provided in correct proportion in readily available form along with FYM (7.5 t/ha) which led to better crop nutrient uptake as and when it demands leading to increase growth and yield parameters. The reduction in grain yield to the tune of 41.61% was observed in natural farming and 31.53% under organic farming when compared to RPP. In organic farming, the application of carbonic substrate through organic manures coupled with soil application of jeevamrutha which was congenial for microbial growth lead to better mineralization of organic matter and further increased the availability of essential nutrients coupled with foliar nutrition with panchagavya leading to better growth and yield attributes of maize compared to natural farming (Vinay *et al.* 2020a, Sushma 2022). Similar observations were made by Behera and Chandrashekara (2023) in irrigated wheat. In organic farming, there is a need for bulky organic manures like

FYM, vermicompost and other organic materials for the fulfilment of the nutritional requirement of the crops. It is a slow process of building soil health and hence, crop yields are likely to reduce during the initial few years. In natural farming no manures were applied, but microbial inoculum in the form of jeevamrutha or ghanjeevamrutha are applied in the field which promotes the multiplication of earthworms and microbes in the soil (Shivanand Goudra *et al.* 2022, Saharan *et al.* 2023). The lower yield observed in natural farming was due to the fact that external application of fertilizer as well as organic manures were avoided which led to insufficient nutrient supply from soil to maize crop which is nutrient demanding crop throughout its growth stages (Shivanand Goudra *et al.* 2023). Hence, undernourished crops resulted in poor growth and yield attributes finally reducing maize yield. Similar observations were made by Vinay *et al.* (2020b) in maize, who reported that the organic farming practices yielding better than natural farming is attributed due to the application of bulky organic manures which is congenial for microbial proliferation and result in nutrient transformations as revealed from improved enzyme activity in the soil.

Grain yield, haulm yield and harvest index of field bean: The grain yield and haulm yield of field beans significantly influenced over the years (Table 1). The first year (2019) recorded significantly higher grain yield (489 kg/ha) and haulm yield (1255 kg/ha) of field beans than the rest of the year. The pooled combined analysis of data of grain yield, haulm yield and harvest index of field beans influenced significantly due to different farming practices (Table 1). Among the farming practices tested, the recommended package of practices recorded significantly higher grain

yield (538 kg/ha), haulm yield (1289 kg/ha) and harvest index (29.43%) of field beans as compared to other farming practices. Natural farming recorded a significantly lower grain yield (390 kg/ha) and haulm yield (1157 kg/ha) and harvest index (26.47%) than other farming practices. The reduction in field bean seed yield under natural farming was 22.43% when compared to RPP. The reduction in grain yield was to the tune of 22.43% in natural farming and 7.90% under organic farming when compared to RPP.

Maize equivalent yield of maize + field bean (4:2) intercropping: The maize equivalent yield significantly influenced over the years (Fig 1). The first year (2019) recorded significantly more maize equivalent yield (8694 kg/ha) than the rest of the year. The different farming practices significantly influenced the maize equivalent yield (MEY) of maize + field bean (4:2) intercropping (Fig 1). The pooled data indicated that the recommended package of practices recorded significantly higher maize equivalent yield (9625 kg/ha) as compared to other farming practices. Significantly lower maize equivalent yield (6317 kg/ha) was observed under natural farming than other farming practices. The reduction in maize equivalent yield under natural farming was 34.38% as compared to RPP. The higher maize equivalent yield observed under the recommended package of practices was due to higher maize grain yield (6045 kg/ha) and seed yield of field bean (538 kg/ha) as compared to other farming practices (Table 1). The greater MEY was mainly due to maximum maize and field bean yield under recommended package of practices as compared to other farming practices due to better nutrient and pest management practices. Similar observations were made by Shivanand Goudra *et al.* (2023) in seasonal sugarcane

Table 1 Yield attributes of maize and field bean as influenced by different farming practices

Treatment	Maize yield attributes							Field bean yield attributes		
	Cob length (cm)	No. of rows per cob	No. of grains per cob	Test weight (g)	Grain yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)	Grain yield (kg/ha)	Haulm yield (kg/ha)	Harvest index (%)
<i>Year (Y)</i>										
2019	16.19	13.80	419.8	30.48	5112	7450	40.52	489	1255	28.01
2020	15.76	13.71	405.3	30.03	4794	7067	40.03	473	1217	27.96
2021	15.80	13.40	366.8	27.77	4606	6894	39.68	470	1188	28.28
2022	15.64	13.43	374.6	28.32	4432	6777	39.17	451	1199	27.24
CD (P=0.05)	NS	NS	15.12	0.74	173	260	0.66	18.0	46.7	NS
<i>Farming practices (F)</i>										
T ₁	13.98	12.15	264.1	23.73	3530	6037	36.80	417	1157	26.47
T ₂	15.19	13.43	370.3	27.13	4139	6380	39.34	453	1192	27.53
T ₃	17.89	14.75	491.5	33.81	6045	8125	42.65	538	1289	29.43
T ₄	16.35	14.00	440.7	31.93	5229	7645	40.61	476	1220	28.07
CD (P=0.05)	0.35	0.59	26.90	2.41	375	443	0.35	15.5	50.3	0.96
<i>Interaction</i>										
Y × F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Treatment details are given in Materials and Methods. NS, non-significant.

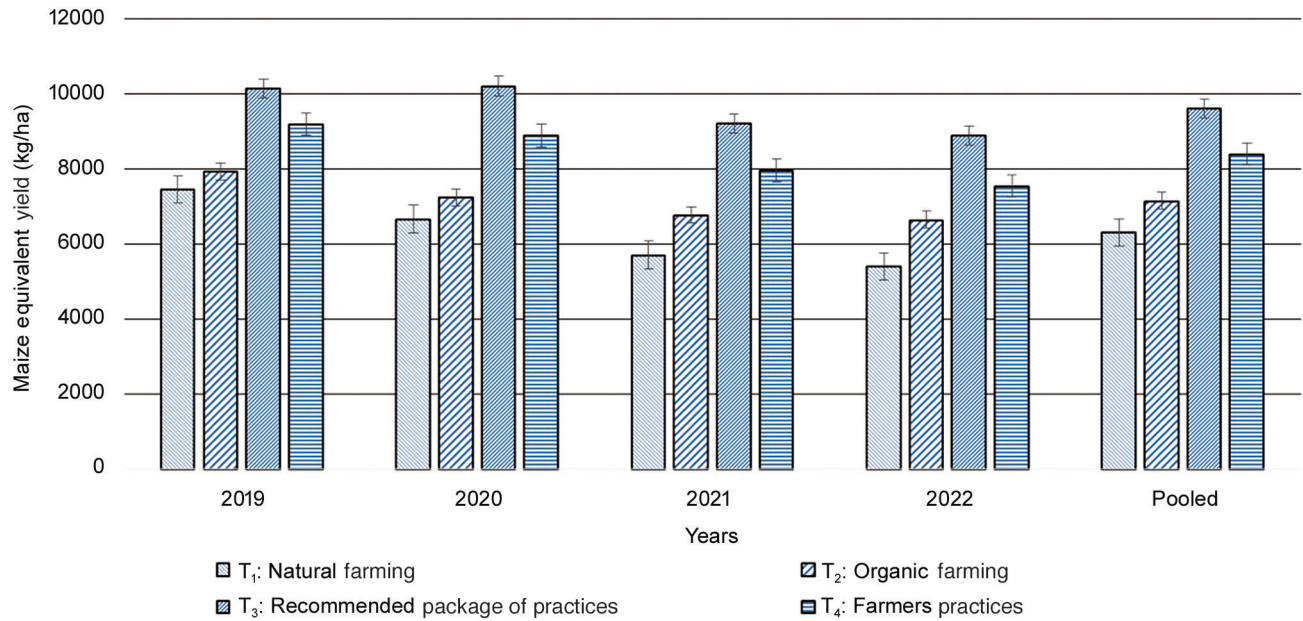


Fig 1 Maize equivalent yield (MEY) as influenced by different farming practices.

Table 2a Economics of maize without premium price as influenced by different farming practices

Treatment	Without premium price											
	2019				2020				2021			
	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
T ₁	44398	118198	73800	2.66	44071	105764	61693	2.40	45613	109176	63563	2.39
T ₂	72979	125538	52559	1.72	72874	114499	41624	1.57	75042	129195	54153	1.72
T ₃	54572	160238	105666	2.94	56142	161121	104980	2.87	57549	175153	117604	3.04
T ₄	51575	145518	93943	2.82	52343	140635	88292	2.69	54284	151772	97487	2.80
SEm±	-	4099	2409	0.07	-	3547	2108	0.06	-	4290	2540	0.07
CD (P=0.05)	-	12631	7424	0.22	-	10929	6496	0.20	-	13220	7828	0.22

Treatment details are given in Materials and Methods.

Table 2b Economics of maize without premium price as influenced by different farming practices

Treatment	Without premium price							
	2022				Pooled			
	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
T ₁	47663	103425	55763	2.17	45436	109141	63705	2.41
T ₂	77196	126791	49595	1.64	74523	124006	49483	1.66
T ₃	59911	169373	109462	2.83	57043	166471	109428	2.92
T ₄	56576	144043	87467	2.55	53695	145492	91797	2.71
SEm±	-	3722	2155	0.06	-	3704	2214	0.06
CD (P=0.05)	-	11467	6642	0.19	-	11413	6823	0.20

Note: Market price for Maize: ₹1530/q (2019), ₹1530/q (2020), ₹1850/q (2021), ₹1870/q (2022); Field bean grain: ₹10500/q (2019), ₹10500/q (2020), ₹11000/q (2021), ₹11200/q (2022). Treatment details are given in Materials and Methods.

Table 3 Economics of maize with premium price as influenced by different farming practices

Treatment	With premium price														
	2019			2020			2021			2022			Pooled		
	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
T ₁ *	141046	96648	3.18	126184	82113	2.86	130324	84710	2.86	123445	75783	2.59	130250	84813	2.87
T ₂ *	149838	76859	2.05	136672	63798	1.88	154286	79244	2.06	151403	74207	1.96	148050	73527	1.99
T ₃	160238	105666	2.94	161121	104980	2.87	175153	117604	3.04	169373	109462	2.83	166471	109428	2.92
T ₄	145518	93943	2.82	140635	88292	2.69	151772	97487	2.80	144043	87467	2.55	145492	91797	2.71
SEm±	4390	2655	0.08	3718	2220	0.07	4577	2777	0.08	3919	2296	0.06	3896	2350	0.07
CD (P=0.05)	13526	8180	0.24	11455	6842	0.20	14104	8557	0.23	12075	7075	0.20	12003	7243	0.21

Note: *Premium price for Maize: ₹1836/q (2019), ₹1836/q (2020), ₹2220/q (2021), ₹2244/q (2022); Field bean grain: ₹12600/q (2019), ₹12600/q (2020), ₹13200/q (2021), ₹13440/q (2022). Treatment details are given in Materials and Methods.

based intercropping systems. Lower yield of maize and field bean led to reduction in maize equivalent yield to the tune of 34.38% in natural farming and 11.72% under organic farming practices when compared to RPP.

Economics of maize + field bean (4:2) intercropping:

The study of economics is an important parameter to know the feasibility and viability of any developed technology. The present study was focussed to know the cost of cultivation in different practices. The cost of cultivation of maize + field bean (4:1) intercropping for consecutive four year indicated that the organic farming practices registered maximum cost of cultivation (₹74523/ha) as compared to recommended package of practices (₹57043/ha) and least under natural farming (₹45436/ha) which was about 25.54% lesser than RPP (Table 2a and 2b). About 20.34% cost of cultivation was saved under natural farming than the recommended package of practices. Natural farming was the one where least cost was invested on materials required for farming as compared to other practices (Behera and Chandrashekar 2023, Shivanand Goudra *et al.* 2023). It is evident from the experiment that higher cost of production per unit maize equivalent yield was observed under organic farming (₹1042/q) as compared to other practices (Sushma 2022).

The study of economic components were made in two categories, i.e. when the produce sold under normal market price and another one when produce of organic and natural farming were sold with premium price of 20% on existing market price. Under first category, i.e. farm produce sold to normal price without considering premium price, in this situation recommended package of practices recorded significantly higher gross returns (₹166471/ha), net returns (₹109428/ha) and B:C ratio (2.91) as compared to other farming practices. Significantly lower gross returns (₹109141/ha) and net returns (₹49483/ha) was recorded under natural farming and organic farming practices, respectively than other farming practices (Table 2a and 2b). Even considering premium prices for produce under organic and natural farming practices they fail to attend higher returns than RPP due to lower yield levels in both the crops. But an increase in B:C ratio was observed under natural farming than farmer practices as well as organic farming practices (Table 3). It was mainly due to the premium price of 20% coupled with lower cost of cultivation under natural farming practice as compared to organic and farmer practices (Shivanand Goudra *et al.* 2023).

From this study, it can be concluded that the recommended package of practices resulted in consistently higher grain yield, maize equivalent yield and net returns in maize + field bean (4:2) intercropping. Looking into the cost of cultivation, lower cost of cultivation was registered under natural farming as compared to other farming practices, about 20.34% cost of cultivation was saved under natural farming over the recommended package of practices. It is evident that higher cost of production per unit maize equivalent yield was observed under organic farming and least under recommended package of practices. If premium price was provided to natural farming products there is a

consistent increase in benefit:cost ratio.

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