



RESEARCH ARTICLE

Assessment of natural farming practices on productivity and profitability of a wheat–chickpea intercropping system

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Abstract

Combining intercropping systems with organic amendments has the potential to enhance both crop productivity and soil health. The present study aimed to evaluate the performance of wheat and chickpea under organic amendments like ghanjeevamrit and jeevamrit with and without mulching, to identify economically viable strategies for enhancing productivity. A field experiment was conducted for two years during the winter season (2019–2020 and 2020–2021) at Palampur, Himachal Pradesh, India, which comprises combination of ghanjeevamrit, jeevamrit and mulching. The experiment was conducted in randomised block design (RBD) with 3 replications. The wheat equivalent yield and economics of wheat-chickpea intercropping system were studied under a sub-temperate humid zone. Data showed that application of cow-based organic preparations (ghanjeevamrit- added at rate of 0.5 t ha⁻¹, jeevamrit-1st spray at rate 5 %, 2nd spray 7.5 % and subsequent sprays 10 % jeevamrit in the water with the rate of 200 L acre⁻¹ at 21 days interval) and mulching significantly affected wheat equivalent yield and economic of the intercropping system. Based on pooled data of both years, the wheat equivalent yield of wheat-chickpea cropping system was found significantly higher with application of ghanjeevamrit + jeevamrit + mulching and was statistically at par with application of ghanjeevamrit + jeevamrit and lowest was recorded with control treatment. Similarly, the application of ghanjeevamrit + jeevamrit + mulching resulted in significantly higher gross and net returns, followed by ghanjeevamrit + jeevamrit, whereas the lowest returns were observed with ghanjeevamrit applied alone.

Keywords: biodiversity; economic; ghanjeevamrit; jeevamrit; natural farming

Introduction

The intensification of traditional agricultural systems has resulted in a high reliance on agrochemicals, modern machinery and high-yield varieties, leading to detrimental effects on the environment, such as groundwater contamination and air pollution, which exacerbates the greenhouse effect. These environmental stresses not only affect human health but also degrade soil fertility, water quality and biodiversity, ultimately threatening the long-term sustainability of agricultural production (1). Intercropping has been recognized as a sustainable and resource-efficient farming practice, with research demonstrating that it can provide significant yield advantages over monoculture systems without requiring costly external inputs (2).

Natural farming serves as a viable alternative to organic farming, particularly for small and marginal farmers in India (3). The philosophy behind natural farming is anchored in natural principles, aiming for long-term sustainability to produce healthy food while

also ensuring the well-being of the environment, particularly the land resources. Natural farming encourages a harmonious relationship between indigenous flora and crop plants. Subhash Palekar Natural Farming (SPNF), proposed by Subhash Palekar, has gained significant attention among farmers, policymakers, researchers and the media as a sustainable alternative to chemical-intensive agriculture. This contemporary approach aims to promote long-term sustainability in agricultural practices. While often grouped with organic agriculture, SPNF specifically replaces bulky external inputs like farmyard manure and commercial compost with on-farm microbial formulations, such as Jeevamrit and Beejamrit. These are used alongside cover crops and mulching to activate soil biology rather than simply adding nutrients. The yields from intercropping systems often surpass those from sole cropping systems (4). This advantage is primarily attributed to more efficient utilization of resources such as water, light and nutrients compared to sole cropping systems. Additionally, intercropping enhances

resource-use efficiency, leading to improved nutrient retention (5, 6) and better water-use efficiency (7). When legumes are intercropped with non-legumes, they facilitate biological nitrogen fixation and transfer benefits during the current growing season, while also contributing to the accumulation of residual nutrients in the soil (8, 9). Furthermore, it facilitates more efficient utilisation of soil moisture from deeper layers of the soil. Intercropping can also enhance farm profitability by increasing overall yield and providing risk diversification.

Materials and Methods

The field experiment was conducted during the rabi seasons of 2019–2020 and 2020–2021 at Holta Farm, CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur (32°6' N, 76°33' E; 1290 m mean sea level). The experimental site falls under the sub-temperate high rainfall zone of Himachal Pradesh. The experiment consisted of 8 treatments with 3 replications. The T₁- ghanjeevamrit (soil application 5 q ha⁻¹), T₂- jeevamrit (1st spray at rate 5 %, 2nd spray 7.5 % and subsequent sprays 10 % at 21 days interval), T₃- mulching (10 t ha⁻¹), T₄- ghanjeevamrit + jeevamrit, T₅- ghanjeevamrit + mulching, T₆- jeevamrit + mulching, T₇- ghanjeevamrit + jeevamrit + mulching, T₈ – control (no inputs). The soil in the experimental field was a silty clay loam in texture and was acidic in nature. It had pH 5.08 (1:2.5 soil: water), electrical conductivity 0.096 dS m⁻¹ (1:2 soil: water), organic carbon 0.77 %, available nitrogen 256 kg ha⁻¹, available phosphorus 15.9 kg ha⁻¹ and available potassium 277 kg ha⁻¹.

Wheat grain equivalent yield kg ha⁻¹ were calculated by calculating a wheat equivalent factor, which was equal to the ratio of the price of gram (per kg) to that of wheat (per kg). The Government of India's minimum support prices for wheat and chickpeas were used to assess the economic values for grain/seed and straw yield. Gram yield was multiplied by the wheat equivalent factor to determine the wheat equivalent yield of grams (10).

Wheat grain equivalent yield (kg ha⁻¹) =

$$\frac{\text{Yield of gram (kg ha}^{-1}\text{)} \times \text{Price of gram (₹ kg}^{-1}\text{)}}{\text{Price of Wheat gram (₹ kg}^{-1}\text{)}} \quad (\text{Eqn.1})$$

Economic analysis

The cost of cultivation (₹ ha⁻¹) was calculated by adding all costs involved in each input/operation. The treatment-wise cost of cultivation was calculated. The requirements of labour and mechanical power for different operations were calculated as per the rates approved by the university. Gross returns (₹ ha⁻¹) were worked out by converting the wheat grain yield into monetary terms based on prevailing university prices. Net returns (₹ ha⁻¹) were obtained

Statistical analysis

The data obtained from the randomised block design were subjected to analysis of variance (ANOVA), and the results were interpreted at a significance level of $p \leq 0.05$ (11). The critical difference (CD) was calculated to compare the means of different treatments.

Results

Wheat grain equivalent yield

The 2 years data and pooled data on wheat grain equivalent yield of wheat-chickpea cropping system have been presented in Table 1 and the pooled result also illustrate in Fig. 1, which clearly indicated that application of ghanjeevamrit + jeevamrit + mulching resulted in significantly higher yield (3406, 3699.8 and 3552.9 kg ha⁻¹) as compared to control and was statistically at par with application of ghanjeevamrit + jeevamrit (3157.1, 3341.9 and 3249.4 kg ha⁻¹) during 2019–2020, 2020–2021 and in pooled, respectively. The increase in wheat grain equivalent yield with ghanjeevamrit + jeevamrit + mulching was representing a 59.5% increase over control. The pooled analysis of data clearly revealed that among treatments, T₇ produced significantly higher wheat grain equivalent yield (9.3, 18.9, 25.3 and 35.5 % higher grain equivalent yield) over treatment T₄ (ghanjeevamrit + jeevamrit), T₆ (jeevamrit + mulching), T₅ (ghanjeevamrit + mulching) and T₃ (mulching) respectively.

Economics

To evaluate the economic feasibility of different treatments, cost of cultivation, gross returns, net returns and net returns per rupee invested were calculated and the results have been presented in Table 2.

Cost of cultivation

The pooled data from both years (Table 2) revealed that the highest cost of cultivation (₹46010 ha⁻¹) was incurred under T₇ (ghanjeevamrit + jeevamrit + mulching), followed by T₅ (ghanjeevamrit + mulching) with a cost of ₹43398 ha⁻¹. The least cost (₹29480 ha⁻¹) was incurred in T₈ (control). The higher cost in T₇ can be attributed to the use of multiple inputs like ghanjeevamrit, jeevamrit and mulching in the treatment.

Gross returns

A perusal of the pooled data (Table 2) revealed that the treatment ghanjeevamrit + jeevamrit + mulching (T₇) recorded significantly higher gross returns of ₹81249 ha⁻¹ which was followed by ₹73039 ha⁻¹ in T₄ (ghanjeevamrit + jeevamrit). The significantly lowest ₹51784 ha⁻¹ gross returns were recorded in T₈ (control).

Table 1. Effect of different components of natural farming on wheat grain equivalent yield

Treatment		Wheat grain equivalent yield (kg ha ⁻¹)		Pooled
		2019–20	2020–21	
T ₁	Ghanjeevamrit at 5 q ha ⁻¹ before sowing	2308.8	2494.6	2401.69
T ₂	Jeevamrit (foliar application at 21 days interval)	2451.1	2756.3	2603.70
T ₃	Mulching at 10 t ha ⁻¹	2487.5	2755.9	2621.69
T ₄	Ghanjeevamrit + jeevamrit	3157.1	3341.9	3249.49
T ₅	Ghanjeevamrit + mulching	2687.6	2982.2	2834.91
T ₆	Jeevamrit + mulching	2855.4	3119.3	2987.31
T ₇	Ghanjeevamrit + jeevamrit + mulching	3406.0	3699.8	3552.91
T ₈	Control	2098.8	2354.0	2226.40
SEm±		92.8	110.2	59.7
CD (p = 0.05)		281.4	334.4	181.1

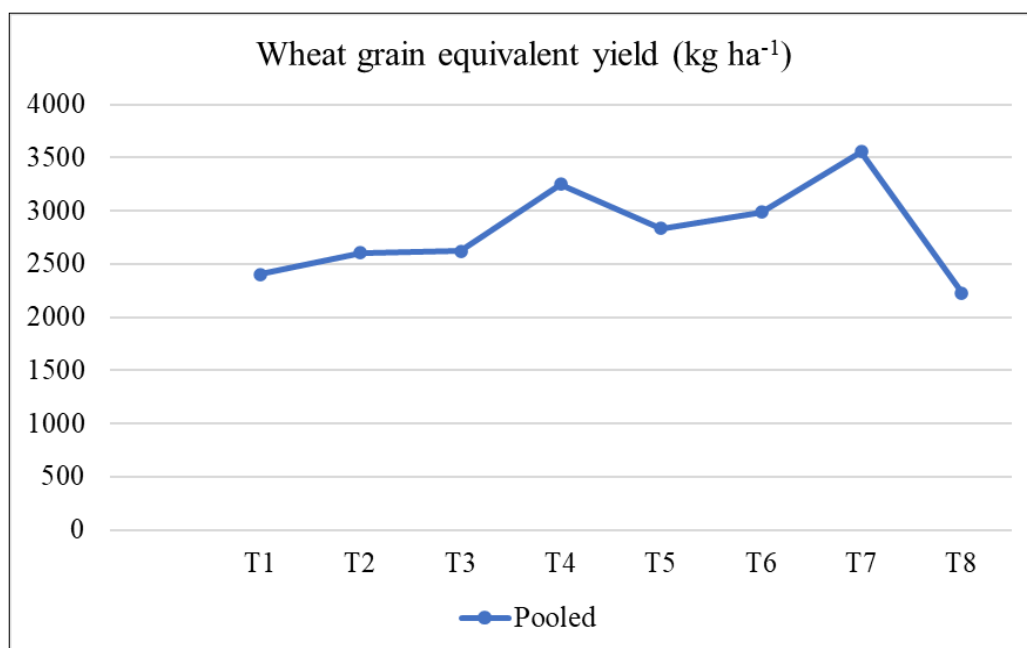


Fig. 1. Effect of different components of natural farming on wheat grain equivalent yield.

Table 2. Effect of different components of natural farming on economics of wheat-chickpea cropping system

Treatment	Cost of cultivation (₹ ha ⁻¹)			Gross returns (₹ ha ⁻¹)			Net returns (₹ ha ⁻¹)			Net returns per rupee invested		
	2019-20	2020-21	pooled	2019-20	2020-21	pooled	2019-20	2020-21	pooled	2019-20	2020-21	pooled
T1	34960	38160	36560	54125	56007	55066	19165	17847	18506	0.55	0.47	0.51
T2	31523	34823	33173	57448	62783	60115	25926	27960	26943	0.82	0.80	0.81
T3	34960	38260	36610	58416	62467	60441	23456	24207	23832	0.67	0.63	0.65
T4	38023	41373	39698	73552	72526	73039	35530	31153	33342	0.93	0.75	0.84
T5	41710	45085	43398	62343	70654	66499	20633	25569	23101	0.49	0.57	0.53
T6	37773	41198	39485	66089	70671	68380	28317	29474	28896	0.75	0.72	0.73
T7	44273	47748	46010	79082	83417	81249	34809	35670	35240	0.79	0.75	0.77
T8	27930	31030	29480	50574	52994	51784	22644	21964	22304	0.81	0.71	0.76
SEm (±)	-	-	-	2057	1579	1010	2057	1578	1010	0.07	0.04	0.02
CD (p = 0.05)	-	-	-	6241	4789	3064	6241	4789	3064	0.20	0.13	0.1

T₁ Ghanjeevamrit at 5 q ha⁻¹ before sowing; T₂: Jeevamrit (foliar application at 21 days interval); T₃: Mulching at 10 t ha⁻¹; T₄: Ghanjeevamrit + jeevamrit; T₅: Ghanjeevamrit + mulching; T₆: Jeevamrit + mulching; T₇: Ghanjeevamrit + jeevamrit + mulching; T₈: Control (no inputs).

Net returns

AA perusal of Table 2 revealed that the application of ghanjeevamrit + jeevamrit + mulching (T₇) recorded significantly higher net returns (₹35240 ha⁻¹), which were at par with T₄ (ghanjeevamrit + jeevamrit) (₹33342 ha⁻¹). Significantly lower net returns (₹18506 ha⁻¹) were recorded in T₁ (ghanjeevamrit), primarily due to relatively lower seed and straw yields.

Net returns per rupee invested

The perusal of data presented in Table 2 revealed that net return per rupee invested was also significantly affected by different treatments. Application of ghanjeevamrit + jeevamrit (T₄) recorded significantly higher net return per rupee invested (0.84) which was statistically at par (0.81) with jeevamrit (T₂). The lowest returns (0.51) were recorded in T₁ (ghanjeevamrit).

Discussion

The higher equivalent yield observed with combined application of natural farming inputs might be because the plants' ability to obtain nutrients like nitrogen has been maximised and the soil's quality has improved in terms of its water-stable aggregates. Due to the organic manures' slow release of nitrogen and slow mineralisation, more nutrients were available to the plants to support their growth and development, which contributed to a greater yield (12, 13).

The application of jeevamrit in combination with different organic manures was found to be more cost-effective at 2000 L ha⁻¹ than its application alone (14). These results were also similar with the previous study (15). 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, as well as increasing the soil's nutrient status. This implies that applying organic amendments with intercropping systems is economically

feasible, improving environmental sustainability as well as production (16). In India, balancing food production with available resources is challenging and effective intercropping is essential for sustainability (17). According to previous study, finger millet-horsegram intercropping improved weed suppression and land use efficiency (18). In low-fertility soils, cereal-legume intercrops such as triticale/pea and barley/pea have been shown to improve grain yield and quality (19). These findings highlight the importance of intercropping in sustainable farming systems.

Conclusion

Wheat grain equivalent yield of wheat-chickpea cropping system was found to be significantly higher compared to the control with the application of ghanjeevamrit + jeevamrit + mulching and it was statistically at par with the application of ghanjeevamrit + jeevamrit. The highest cost of cultivation was recorded under the application of ghanjeevamrit + jeevamrit + mulching (T₇). Application of ghanjeevamrit + jeevamrit + mulching (T₇), recorded significantly higher gross and net returns followed by ghanjeevamrit + jeevamrit (T₄) and the lowest returns were observed in T₁ (ghanjeevamrit alone). However, ghanjeevamrit + jeevamrit (T₄) recorded the highest net return per rupee invested, followed by T₂ (jeevamrit).

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Authors' contributions

RC conceived and designed the experiment, supervised the field trials and contributed to data interpretation. RC and RK conducted the field experiment, recorded observations and managed data collection. KVR and MC assisted in the experimental layout and agronomic management practices. KC, BBR and ARN performed statistical analysis and assisted in data interpretation. RC and RK drafted the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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