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Assessing the effect of conventional and natural farming practices on yield and economics of wheat based intercropping systems

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Abstract
A field experiment was conducted during *rabi* 2019-20 and 2020-21 at the Bhadiarkhar farm, Department of Agronomy, COA, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur to study the influence of natural and conventional farming practices on yield and profitability of wheat based intercropping systems. The experiment constituted of ten treatments in randomized block design with three replications. Results indicated that significantly highest wheat grain equivalent yield (3853 kg/ha) was recorded in wheat + gram (1:1) under conventional farming practices, while, significantly higher gross return (106392 ₹/ha) and net return (69889 ₹/ha) were recorded in sole wheat applied with conventional farming treatments. However, wheat + gram (1:1) under conventional farming practices reported highest benefit cost ratio (1.94) along with highest gross return per rupee invested (2.94) which were statistically similar to sole wheat.

Keywords: Conventional farming, intercropping, natural farming, yield

Introduction
Wheat (*Triticum aestivum* L.) is one of the most important cereal crops and ranks first in respect of nutritional value globally, covering an area of 220.10 million hectares along and with the total production of 763.26 million tonnes (USDA, 2019) [10]. It is consumed as staple food by more than one third of population all over the world. In several developing nations, wheat accounts for more than 50% of the daily caloric intake (Cakmak, 2008) [1]. Wheat is an important staple crop in India and is crucial to the nation's food security with a production of 107.18 million tonnes, covering an area of 29.9 million hectares in the year 2018-19. Wheat accounts for 35% share in the total food grain production and occupies nearly 23.3% of the total area under field crops in India (MoA&FW, 2019) [7].

In order to feed the ever-increasing population, country's wheat production needs to surpass the target of 140 million tonnes by 2050 (ICAR-IIWBR, 2015) [3]. Hence, it is evident that sustainability of wheat production is essential to ensure nutritional security of India. Keeping in the view of this, boosting the crop productivity per unit area of cultivated land has gained attention among the most promising techniques to meet this increasing demand of food grains. Among several attempts undertaken to maximize the production and/or land use, crop diversification by intercropping of legumes and/or oilseed crops with wheat has appeared as an appealing technique. Intercropping is the chief element of multiple cropping system (Zhang and Li, 2003); compared to monoculture, it provides several benefits through the efficient use of resources such as solar energy, water and nutrients. (Nasri *et al*., 2014) [8].

Most wheat ecologies have witnessed yield plateauing recently, and even in the most productive region of North India, yield has begun to decline. One of the primary reasons for such a yield variation is inefficient nutrient management. (Majumdar *et al*., 2012) [6]. Due to its heavy nutrient consumption, wheat withdraws a substantial quantity of plant nutrients from the soil. If this depletion is not replenished, it will lead to a decrease in the crop's production. Nowadays, the fundamental principle including replenishing of soil nutrient reserves at the rates they are depleted appears to be lacking in the crop production systems.

As far as the soil resources quality, pollution of the environment, and cost of production are concerned, increasing nutrient mining and imbalanced usage of fertilizers are negatively affecting the soil fertility status. In some circumstances, yields are stalling or failing to attain their potential status, implying that input use efficiency is declining simultaneously with rise in the production costs which necessitates the adoption of alternative nutrient management

techniques. Keeping the aforementioned things in mind, the present investigation was carried out to compare the productivity of wheat and associated intercrops under conventional and natural farming practices.

Materials and Methods

Field experiment was conducted at CSK HPKV, Palampur (32°6´ N, 76°3´ E), during *rabi* 2019-20 and 2020-21. The soil of the experimental area was acidic in reaction (pH 5.5), silty clay loam (texture), having medium organic carbon and available potassium content, low available nitrogen and high available phosphorus content, before the commencement of the experiment. The experiment was laid out in randomized block design constituting ten treatments *viz*., T_1- wheat, T_2- wheat + gram, T_3- wheat + lentil, T_4- wheat + linseed and T_5- wheat + mustard under conventional farming practices, whereas, T_6- wheat, T_7- wheat + gram, T_8- wheat + lentil, T_9- wheat + linseed and T_{10}- wheat + mustard under natural farming). T_1 to T_5 were applied with recommended dose of fertilizers (N:P:K 120:60:30) and T_6 to T_{10} comprised of basal application of sieved FYM @ 250 kg/ha and *ghanjeevamrit* @ 250 kg/ha along with periodic spray of 10 per cent *jeevamrit* at 21 – 30 days interval.

Location

Field experiment was carried out at the Bhadiarkhar experimental farm, COA, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, during *rabi* 2019-20 and 2020-21. The experimental farm is located at an altitude of 1290 m in the Palam Valley of Himachal Pradesh. This region is graced with severe winters and mild summers.

Crop management

Wheat was intercropped with respective intercrops *i.e.* gram, lentil, linseed and mustard (except sole wheat in T_1 and T_6) in replacement series (1:1) at 20 cm spacing. *Ghanjeevamrit* and FYM were applied to natural farming plots during final preparation of the fields. Seed treatment was done with the *beejamrit*, and application of *jeevamrit* was scheduled at 21-30 days interval in treatments subjected to natural farming practices, whereas, recommended dose of NPK (120:60:30) was applied to the conventional farming plots. Analysis of nutrient content of different natural farming inputs was conducted as per standard procedure. It was found that maximum content of N, P and K was recorded under *ghanjeevamrit* (0.20, 0.10 & 0.18%, respectively) which was followed by *beejamrit* (0.17, 0.02 & 0.09%, respectively) as well as *jeevamrit* (0.15, 0.04 & 0.07%, respectively).

Results and Discussion

Data pertaining to the operation wise cost of different treatments, influence of different conventional and natural farming methods on the wheat grain equivalent yield and cost of cultivation, gross return, net return, benefit cost ratio and gross return per rupee invested has been depicted in Table 1, 2 & 3.

Wheat grain equivalent yield

Wheat grain equivalent yield was significantly influenced by different conventional and natural farming techniques (Table 2). During *rabi* 2020, the highest wheat grain equivalent yield (38.53 q/ha) was recorded under conventional farming practices *i.e.* T_2- wheat + gram (1:1) and remained statistically at par with T_1- wheat (38.14 q/ha) which was followed by T_3 and T_5 (33.84 and 33.24 q/ha), respectively.

Highest wheat grain equivalent yield in T_2 (wheat + gram) was the result of application of fertilizers at recommended doses which boosted the supply of nutrients in the soil (Laghari *et al.* 2010) [4], leading to enhanced grain yield of both main crop and intercrop, respectively. Further, incorporation of legume (gram) aided in nitrogen fixation, thereby, improved the fertility status of the soil. As an intercrop, gram, due to its short plant stature and lower nutrition requirement inflicted less competition to the main crop *i.e.* wheat. As market price of gram was higher than other intercrops, it resulted in higher wheat grain equivalent yield as compared to the other intercropping systems.

Intercropping systems applied with natural farming inputs reported lower wheat grain equivalent yield because of lower NPK content of natural farming inputs (*jeevamrit* and *ghanjeevamrit*) compared to RDF, resulting in the inability of the soil to meet up the nutrient requirement of the crop in absence of applied fertilizers. However, among treatments under natural farming practices, wheat + gram intercropping recorded higher wheat grain equivalent yield than other treatments, cause by the nitrogen fixing ability of gram as well as short plant height of gram imposing less competition for space, light and nutrients. T_9 (wheat + linseed) recorded lowest wheat grain equivalent yield, which is attributable to lower yields of linseed and wheat as intercrops under1:1 replacement series.

Economic studies

Cost of cultivation

A perusal of data presented in Table 3 showed that T_1 (wheat under conventional farming practices) recorded the highest cost of cultivation (36503 ₹/ha), followed by T_5 *i.e.* wheat + mustard (33413 ₹/ha) and T_2 – wheat + gram (32702 ₹/ha) during *rabi* 2019-20.

Gross returns

A close perusal of the data revealed that T_1 (wheat) recorded the highest gross returns of 106392 ₹/ha, followed by wheat + gram (T_2) and wheat + mustard (T_5) under conventional farming practices. The lowest gross returns were recorded in T_9 (wheat + linseed) subjected to natural farming practices. This contrast in the gross returns was primarily due to the dissimilarity in grain and straw yields as a result of treatments effect (Table 3).

Application of fertilizers to sole wheat significantly enhanced the grain and straw yield of wheat. Intercropping systems comprised of 1:1 row replacement arrangement which reduced the plant population of wheat. Grain and straw yield of intercrops were lower than main crop due to less dry matter accumulation in short statured crops. Shirpurkar *et al.* (2010) [10] also suggested that application of fertilizers recorded higher gross returns by enhancing the grain and straw yield of the respective crops. It was observed that application of recommended dose of fertilizers resulted in higher crop yield and profitability as compared to application of *ghanjeevamrit* and *jeevamrit*. (Lin *et al*., 2022) [5].

Net returns

Data presented in Table 3 concluded that T_1 (wheat supplied with RDF) recorded the highest net returns (69889 ₹/ha). Treatment T_2 (wheat + gram applied with RDF) remained as

second best treatment and it followed by T_5 (wheat + mustard) which appeared to be statistically similar to T_3 (wheat + lentil). The lowest net returns reported under T_9 (wheat + linseed supplied with natural farming inputs) were due to lower grain and straw yields of wheat and linseed compared to cost of cultivation. Similar results were recorded by Rather and Sharma (2009) [9].

Benefit cost ratio (B:C)

A cursory glance at data presented in Table 3 revealed that treatment T_2 (wheat + gram under conventional farming practices) recorded the highest B:C (1.94) and was found to be statistically similar to sole wheat (T_1). These outcomes are in line with the findings reported by Desai *et al.* (2015) [2]. The lowest benefit cost ratio was obtained under T_9 (wheat + linseed) in natural farming owing to higher cost of cultivation compared to lower grain and straw yield, which delivered lesser profit (Singh *et al*. 2008).

Gross returns per rupee invested

The perusal of data presented in Table 3 further showed that treatment T_2 (wheat + gram) resulted in the highest gross returns per rupee invested (2.94) and behaved statistically similar to T_1 (wheat), whereas, lowest returns (1.59) were reported in T_9.

Table 1: Operation wise cost of different treatments

Sr no.	Operations	Conventional Farming					Natural Farming				
		T_1- Wheat	T_2- Wheat+ Gram	T_3- Wheat+ Lentil	T_4- Wheat+ Linseed	T_5- Wheat+ Mustard	T_6- Wheat	T_7- Wheat+ Gram	T_8- Wheat+ Lentil	T^9- Wheat+ Linseed	T_{10}- Wheat+ Mustard
1.	Field Preparation	5650.00	5650	5650	5650	5650	5650	5650	5650	5650	5650
2.	Seed treatment	-	-	-	-	-	35	24.50	22.75	24.50	18.55
3.	Sowing	8750.00	7150	6860	6550	6260	8750	7150	6860	6550	6262
4.	Manure & Fertilizers	7502.90	7227.9	7227.9	7227.9	7227.9	3900	3900	3900	3900	3900
5.	Plant protection	-	-	-	-	-	300	300	300	300	300
6.	Mulching	-	-	-	-	-	1375	1375	1375	1375	1375
7.	Weed management	4400.00	3300	3575	3300	3575	2475	2200	2475	2475	2475
8.	Irrigation	1375.00	1375	1375	1375	1375	1375	1375	1375	1375	1375
9.	Harvesting	4125.00	3575	3025	2750	4125	2200	1650	1650	1375	1925
10.	Threshing and winnowing	4700.00	4425	4425	4925	5200	4150	3875	3875	3100	3875
Total		36502.9	32702.9	32137.9	31777.9	33412.9	30210	27499.5	27482.7	26124.5	27155.5

Table 2: Effect of conventional and natural farming practices on wheat grain equivalent yield under different wheat based intercropping systems

Treatments	Wheat grain equivalent yield (q/ha) (2019-20)
T_1 – wheat	38.14
T_2 – wheat + Gram	38.53
T_3 - wheat + Lentil	33.84
T_4 - wheat + Linseed	25.39
T_5 - wheat + Mustard	33.24
T_6 – wheat	25.15
T_7 - wheat + Gram	27.20
T_8 - wheat + Lentil	23.13
T_9 - wheat + Linseed	14.70
T_{10} - wheat + Mustard	21.25
SEm±	0.46
LSD (P=0.05)	1.36

(T_1 to T_5: RDF (120:60:30); T_6 to T_{10}: FYM @ 250 kg/ha + *ghanjeevamrit* @ 250 kg/ha + *jeevaamrit* @ 10%)

Table 3: Influence of conventional and natural farming treatments on economics of different wheat based intercropping systems

Treatments	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C	Gross returns per rupee invested
	2019-20	2019-20	2019-20	2019-20	2019-20
T_1 – wheat	36503	106392	69889	1.91	2.91
T_2 – wheat + gram	32702	96168	63466	1.94	2.94
T_3 - wheat + lentil	32138	87548	55410	1.72	2.72
T_4 - wheat + linseed	31778	73555	41777	1.31	2.31
T_5 - wheat + mustard	33413	89083	55670	1.67	2.66
T_6 – wheat	30210	74120	43910	1.45	2.45
T_7 - wheat + gram	27499	68039	40540	1.47	2.47
T_8 - wheat + lentil	27483	61184	33701	1.23	2.22
T_9 - wheat + linseed	26124	41654	15530	0.59	1.59
T_{10} - wheat + mustard	27155	57125	29970	1.1	2.1

(T_1 to T_5: RDF (120:60:30); T_6 to T_{10}: FYM @ 250 kg/ha + *ghanjeevamrit* @ 250 kg/ha + *jeevaamrit* @ 10%)

Conclusion

Among different treatments consisting of wheat and intercrops under conventional and natural farming, significantly higher wheat grain equivalent yield was reported

by wheat + gram under conventional farming. Similarly, economic analysis (gross returns, net returns, B:C and gross returns per rupee invested), revealed that conventional farming practices exhibited positive outcomes, indicating that adoption of natural farming practices might not show promising results during initial years as a significant time period is required to boost up the population of soil microbiome, which in turn, would accelerate the mineralization of nutrients in soil, thereby, enhancing the nutrient availability to the crops.

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