INFLUENCE OF VARIOUS *RABI* SEASON INTERCROPS WITH WHEAT ON YIELD ATTRIBUTES

Tarun Sharma[1*], U S Walia[2], Supreet Saajan

Abstract
A field experiment was conducted at Lovely Professional University, Phagwara during Rabi season of 2020-21 & 2021-2022 to identify the effect of intercropping on growth and yield of wheat bed technology & to control Phalaris minor weed for higher overall productivity. There were 14 treatments that were intercropping consisting of wheat weed free & wheat weedy among gobhi sarson, african sarson, lentil, fenugreek, fennel and dill seeds. The grain yield, plant height of wheat varied significantly among different wheat+ Rabi crops. Wheat as sole crop gave significantly higher seed yield than that of all the wheat+ Rabi crops. The sole crop of wheat recorded higher total dry matter production, yield components and yield compared to the intercropping systems. Intercropping of wheat with fennel and dil seed reduce the count of Phalaris minor and increased the wheat grain yield as compared with other intercrops.

Keywords: intercropping, wheat bed technology, productivity

[1*]Ph.D. Scholar, Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara, Punjab,14411, Email: sharmatanu135@gmail.com
[2]Senior Professor, Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara, Punjab,14411

***Corresponding Author:** Tarun sharma
*PhD Scholar, Deptt, Of Agronomy, School of Agriculture, Lovely Professional University, Phagwara, Punjab,14411. E-mail: sharmatanu135@gmail.com

Co-author's full address: Dr. U S Walia
Senior Professor, Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara, Punjab,14411

Co-author's full address: Dr. Supreet Saajan
Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara, Punjab,14411

Research was conducted at agricultural farm of Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara Punjab during Rabi season of 2020-2021 and repeated in 2021-2022.

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INTRODUCTION

Wheat **(*Triticum aestivum* L.)** is one of the most important crops among cereals which is the major source of calories for human diet. Wheat belongs to Poaceae family and is the member of *Triticeae* tribe. Wheat is the primary food for the major portion of the globe. Wheat contributes 20% of the total dietary calories and proteins worldwide. Wheat accounts 53% of the total harvested area and 50% of production (Figueroa *et al*.,2018). It is the important source of dietary nutrients and provides 20% of daily protein and energy. In food-based industries, wheat is the raw material of many food products. The by-products of industrial products of wheat are used as a feed for animals which are rich in nutritious. Wheat is rich in gluten content which helps in making breads and baking products. Wheat requires cool climate for germination and initial growth followed by sunny days for their proper growth and reproductive development. Wheat is grown mainly in Indo-Gangetic plains but can be grown in many parts of India during *Rabi* season. It is one of the options to enhance the economic status of farmers.

India export wheat to different countries like Nepal, Sri Lanka, Bangladesh, Somalia and UAE. In India, wheat is grown in Punjab, U.P., Bihar, Rajasthan, M.P, Haryana, Gujarat and Maharashtra. India ranks first globally in terms of cultivated area. India is the second largest producer of wheat after China. India contributes 13.6% in wheat production globally. The total world's area under wheat cultivation is 218.54 mha during 2021-2022 with the production of 778.6 million metric tons. The total area under cultivation of wheat in the world was highest in India which was 31.36 mha and production is 107.59 mha. (FAO STAT) 2021-2021. The area under wheat cultivation in Punjab is 35.30 lakh ha with production of 171.85 lakh tonnes and average yield of 48.68 q/ha during the anonymous year 2021-22.

Intercropping is the important agronomic practice which decreases the use of synthetic herbicides for the control of weeds. (Banik *et al*., 2006). Intercropping is the growing of two or more crops at the same time on the same piece of land. It is the intensification of both space and time dimensions. The cropping intensity of upland areas is very low due to mono-cropping system. Mono-cropping declines the soil fertility. In these conditions, the stability has been achieved through crop substitution and intercropping. For maintaining the soil fertility, it is very important to grow two or three crops as mixed or intercropping. In intercropping, the main principle is judicious selection of crops. The crop should be short duration and having same ecological requirements as of main crop. It should have minimum competition with main crop. To increase net profit wheat crop should be intercropped with other *Rabi* season crop such as Barley, Mustard, Lentil, linseed, Fennel, and Dilll seed etc.

MATERIALS AND METHODOLOGY

The experimental study was conducted during the *Rabi* season of 2020-2021 and repeated in 2021-2022, at research farm of Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara Punjab. The details of the material used and methodology adopted in these investigations are discussed below:

Experimental treatments details:

TREATMENTS	EXPERIMENTAL DETAILS
T1	Wheat weed free
T2	Wheat weedy
T3	Intercropping of Wheat & Gobhi Sarson (T), Weed free
T4	Intercropping of Wheat & Gobhi Sarson (T), Weedy
T5	Intercropping of Wheat & African Sarson (T), Weed free
T6	Intercropping of Wheat & African Sarson (T), Weedy
T7	Intercropping of Wheat & Lentil, Weed free
T8	Intercropping of Wheat & Lentil, Weedy
T9	Intercropping of Wheat & Fenugreek, Weed free
T10	Intercropping of Wheat & Fenugreek, Weedy
T11	Intercropping of Wheat & Fennel, Weed free
T12	Intercropping of Wheat & Fennel, Weedy
T13	Intercropping of Wheat & Dill seed (soya), Weed free
T14	Intercropping of Wheat & Dill seed (soya), Weedy

*T: stands for transplanted

Statistical analysis

The data was subjected to analysis of variance (ANOVA) following statistical procedures by OPSTAT at level of 95 % significance to check the influence of different variables.

RESULTS & DISCUSSIONS

1. Spike length

Spike length is an important yield contributing character which is associated with the number of grains. In the first year, among the different weed free treatments the maximum spike length was found in the wheat weed free (10.13) followed by intercropping of wheat with fennel weed free treatment (9.83). It was found at par with intercropping of wheat with fennel, dil seed and fenugreek weed free treatment and was significantly higher than all other treatments. the spike length of wheat intercrop with fennel was found at par with wheat intercrop with dil seed and fenugreek and it was significantly higher than all other treatments. From the weed free treatments, the minimum spike length was found in intercropping of wheat with gobhi sarson weed free (8.18). It was found at par with intercropping of wheat with african sarson and lentil. From the weedy treatments, the minimum spike length was found in intercropping of wheat with gobhi sarson weed free treatment (5.85). It was found at par with intercropping of wheat with african sarson and wheat weedy treatment. It was significantly lower than all other treatments.

In the second year, among the different weed free treatments the maximum spike length was found in the wheat weed free (12.15) followed by intercropping of wheat with fennel weed free treatment (10.23). It was significantly higher than all other treatments. The spike length of wheat intercrop with fennel was found at par with wheat intercrop with dil seed and fenugreek and it was significantly higher than all other treatments. From the weed free treatments, the minimum spike length was found in intercropping of wheat with gobhi sarson weed free (8.25). It was statistically at par with intercropping of wheat with african sarson. From the weedy treatments, the minimum spike length was found in intercropping of wheat with gobhi sarson weed free treatment (6.08). It was found at par with intercropping of wheat with african sarson and wheat weedy treatment. It was significantly lower than all other treatments.

In the pooled data, the maximum spike length was found in the wheat weed free (11.14) followed by intercropping of wheat with fennel weed free treatment (10.63). It was significantly higher than all other treatments. The spike length of wheat intercrop with fennel was significantly higher than all other treatments. From the weed free treatments, the minimum spike length was found in intercropping of wheat with Gobhi sarson weed free (8.21). It was statistically at par with intercropping of wheat with African sarson. From the weedy treatments, the minimum spike length was found in intercropping of wheat with Gobhi sarson weed free treatment (5.96). It was statistically at par with intercropping of wheat with African sarson and wheat weedy treatment. It was significantly lower than all other treatments.

The maximum spike length of wheat was found when wheat was sown alone and minimum was found when it was sown with gobhi sarson weedy cropping system. The reduction in the spike length might be due to aggressive nature of gobhi sarson. It competed with wheat for nutrients. This result was in conformity with Naeem *et al*., (2012).

Table 1. Spike length of wheat in bed planted wheat

Treatments	Spike length(cm)		
	2020-21	2021-22	Pool data
wheat weed free	10.13	12.15	11.14
wheat weedy	6.25	6.38	6.31
wheat+ gobi sarson weed free	8.18	8.25	8.21
wheat+ gobi sarson weedy	5.85	6.08	5.96
wheat+African sarson weed free	8.43	8.73	8.58
wheat+ African sarson weedy	6.03	6.35	6.19
wheat+lentil weed free	8.88	9.18	9.03
wheat+lentil weedy	6.83	6.98	6.90
wheat+fennugreek weed free	9.33	9.93	9.63
wheat+fennugreek weedy	6.95	7.08	7.01
wheat+fennel weed free	9.83	10.63	10.23
wheat+fennel weedy	7.23	7.43	7.33
wheat+dil seed weed free	9.45	10.05	9.75
wheat+dil seed weedy	7.09	7.15	7.12
CD	0.89	0.73	0.43

2. Pod length (cm) of intercrops

Pod length is an important yield contributing character which is associated with the number of grains. Increase in the length of pod would increases the yield. During first year (2020-21), the maximum pod length was found in fenugreek weed free (7.09cm) followed by fenugreek weedy (6.10cm). All weed free treatment of different intercrops significantly increased pod length than weedy treatment. The pod length of gobhi sarson weed free was significantly higher than gobhi sarson weedy treatment and infestation of *Phalaris minor* decreased 26.31% pod length in gobhi sarson weedy treatment as compared with gobhi sarson weed free treatment. Similarly *P.minor* infestations had decreased 20.9%, 38.52% and 13.96% pod length of intercrops viz. African sarson, lentil and fenugreek respectively compared to their respective weed free treatments.

During the second year (2021-22), the maximum pod length was found in fenugreek intercropped in wheat under weed free (7.43cm) followed by fenugreek weedy (6.78cm) which were significantly more than all other intercrops. All weed free treatment of different intercrops significantly increased pod length than weedy treatment. The pod length of gobhi sarson weed free was significantly higher than gobhi sarson weedy treatment and infestation of *Phalaris minor* decreased 3.34% pod length in gobhi sarson weedy treatment as compared with gobhi sarson weed free treatment. Similarly *P.minor* infestations had decreased 18.18%, 25.49% and 8.74% pod length of intercrops viz. African sarson, lentil and fenugreek respectively compared to their respective weed free treatments.

On the basis of pooled data (2020-21 and 2021-22), the maximum pod length was found fenugreek weed free (7.26cm) followed by fenugreek weedy (6.44cm) which were significantly more than all other intercrops. All weed free treatment of different intercrops significantly increased pod length than weedy treatment. The pod length of gobhi sarson weed free was significantly higher than gobhi sarson weedy treatment and infestation of *Phalaris minor* decreased 28.96% pod length in gobhi sarson weedy treatment as compared with gobhi sarson weed free treatment. Similarly *P.minor* infestations had decreased 19.12%, 31.85% and 11.29% pod length of intercrops viz. African sarson, lentil and fenugreek respectively compared to their respective weed free treatments. This result was inconformity with Wasaya et al.,(2013).

Table 2: Pod length of intercrops (cm) in bed planted wheat

	Pod length(cm)			
Treatments				
	2020-21	2021-22	Pooled data	Percent decrease over weedy
Wheat+ Gobi sarson weed free	5.13	5.71	5.42	28.96
Wheat+ Gobi sarson weedy	3.78	3.92	3.85	
Wheat+African sarson weed free	4.08	4.18	4.13	19.12
Wheat+ African sarson weedy	3.26	3.42	3.34	
Wheat+Lentil weed free	2.44	2.51	2.48	31.85
Wheat+Lentil weedy	1.5	1.87	1.69	
Wheat+Fennugreek weed free	7.09	7.43	7.26	11.29
Wheat+Fennugreek weedy	6.1	6.78	6.44	
CD 5%	0.1	0.1	0.20	

3. Grain yield

The grain yield is the most important factor for the agricultural product. The data pertaining to the effect of different treatments on yield is given in the table. Weed free treatments showed significantly higher yield than weedy treatment for all crops. Among the different weed free treatments, the higher grain yield was found in the wheat weed free (63.63 kg/ha) in 2020-21 and 65.91 kg/ha in 2021-22. In the first year, the intercropping of medicinal crops weed free treatment (fennel and Dill seeds) was found at par with wheat weed free treatment. The intercropping of wheat with lentil, fenugreek, Gobhi sarson and african sarson weed free treatment were significantly lower than wheat weed free. In the weedy treatments, the lowest grain yield was found in intercropping of wheat with Gobhi sarson weedy (36.04 kg/ha). The treatments with weedy produced significantly less grain yield than wheat weed free treatment. In the first year, the intercropping of wheat with Gobhi sarson weedy was found at par with wheat weedy treatment and wheat with african sarson weedy. The other weedy treatments like Wheat+lentil, wheat+fennel, wheat+fenugreek and wheat+Dill seed were significantly higher than wheat+Gobhi sarson.

In the second year, the highest yield was found in wheat weed free treatment (65.91 kg/ha) followed

by intercropping of wheat with fennel weed free (63.95 kg/ha). The intercropping of wheat with fenugreek, Dill seed and fennel weed free treatment was found at par with wheat weed free treatment. The intercropping of wheat with Gobhi sarson, african sarson and lentil weed free treatment were significantly lower than wheat weed free treatment. The lowest yield was found in intercropping of wheat with Gobhi sarson weedy treatment (34.95 kg/ha) in 2021-22. It was found at par with wheat weedy treatment and wheat+African weedy treatment and other treatments like (wheat+lentil, wheat+fenugreek, wheat+fennel, wheat+Dill seed) were significantly higher than intercropping of wheat with Gobhi sarson weedy treatment. All weedy treatments were significantly lower than weed free treatment.

In the pool table, the highest wheat yield was found in wheat weed free treatment (64.77 kg/ha) followed by intercropping of wheat and fennel weed free (63.02 kg/ha). It was significantly higher than all other treatments. The weed free treatment was found at par with intercropping of wheat with fennel weed free. The lowest yield was found in the treatment intercropping of wheat with Gobhi sarson weedy (35.49 kg/ha). All weed free treatments were significantly higher than all weedy treatments. The treatment intercropping of wheat and Gobhi sarson weedy was found at par with treatment wheat weedy. All other weedy treatments were significantly higher than intercropping of wheat with Gobhi sarson weedy treatment. The intercropping treatments weed free (Gobhi sarson, african sarson, lentil, fenugreek and Dill seed) were significantly lower than wheat with weed free treatment. The *Phalaris minor* decreased the wheat yield differently in different intercrops. The highest reduction in wheat equivalent yield was observed in wheat (44.14%), followed by Gobhi sarson, 36.06% yield was reduced. The lowest percentage decrease was found in lentil crop. Intercropping of wheat with african sarson, fenugreek, fennel and Dill seed weedy treatment also decreased the yield as 32.76%, 25.48%, 25.56%, 23.71% respectively.

Reduction in grain yield may be due to greater inter and intra specific competition of the component crops for different growth factors i.e., moisture, nutrient, space, solar radiation etc. Reduction in grain yield of wheat due to intercropping in linseed (Billare *et al*., 1992) and *Brassica juncea* L. (Singh and Gupta, 1994) has been previously reported. Riaz *et al*. (1993) also reported the reduction in intercropped wheat yield due to suppressive effect of intercrops on the yield of the base crop.

Table: 3. Grain Yield of wheat in bed planted wheat (2020-21 and 2021-22)

	Wheat yield (q/ha)			
TREATMENTS	**2020-21**	**2021-22**	**Pool data**	**Percentage of decrease in yield**
wheat weed free	63.64	65.91	64.78	44.14
wheat weedy	36.31	36.05	36.18	
wheat+ gobi sarson weed free	54.24	56.78	55.51	36.06
wheat+ gobi sarson weedy	36.04	34.95	35.49	
wheat+African sarson weed free	55.83	57.23	56.53	32.76
wheat+ African sarson weedy	38.10	37.93	38.01	
wheat+lentil weed free	56.66	58.36	57.51	21.63
wheat+lentil weedy	44.65	45.49	45.07	
wheat+fennugreek weed free	57.91	59.25	58.58	25.48
wheat+fennugreek weedy	43.39	43.91	43.65	
wheat+fennel weed free	62.09	63.95	63.02	25.56
wheat+fennel weedy	46.33	47.50	46.91	
wheat+Dill seed weed free	59.46	61.23	60.34	23.71
wheat+Dill seed weedy	44.86	47.19	46.03	
CD	**4.061**	**7.20**	**0.91**	

4. Intercrop yield

Intercrop yield records, especially of different intercropping systems, reflect the economic viability of a specific system and hence it was necessary to record yield of each system and production efficiency of a system. In the first year, it had been observed that maximum yield was found in intercropping of wheat with gobhi sarson weed free treatment (7.52q/ha) followed by intercropping of wheat with african sarson weed free treatment (5.79q/ha). The intercropping of wheat with gobhi sarson weed free was significantly higher than all other treatments. All weed free treatments was significantly higher than all weedy treatments. From the mustard crop, the highest yield was found in weed free gobhi sarson weed free which was 23% more than African sarson weed free. From the medicinal crops, the highest yield was found in weed free dil seed which was significantly higher from all medicinal crop

treatments. The second highest yield was found in weed free fennel crop. The intercropping of wheat with dil seed was found at par with intercropping of wheat with lentil weed free. From the weedy treatments, the lowest yield was found in intercropping of wheat with fenugreek weedy treatment. It was found at par with intercropping of wheat with dil seed weedy and significantly lower than all other treatments.

In the second year, the maximum yield was found in intercropping of wheat with gobhi sarson weed free treatment (7.79q/ha) followed by intercropping of wheat with african sarson weed free treatment (6.00q/ha). The intercropping of wheat with gobhi sarson weed free was significantly higher than all other treatments. All weed free treatments was significantly higher than all weedy treatments. From the mustard crop, the highest yield was found in weed free gobhi sarson weed free which was 22.97% more than african sarson weed free. From the medicinal crops, the highest yield was found in weed free dil seed which was found at par with intercropping of wheat with fennel weed free and was significantly higher from all medicinal crop treatments. The second highest yield was found in weed free fennel crop. The intercropping of wheat with lentil was statistically at par with intercropping of wheat with dil seed weed free. From the weedy treatments, the lowest yield was found in intercropping of wheat with fenugreek weedy treatment. It was significantly lower than all other treatments.

In the pooled table, the maximum yield was found in intercropping of wheat with gobhi sarson weed free treatment (7.65q/ha) followed by intercropping of wheat with African sarson weed free treatment (5.90q/ha). The intercropping of wheat with gobhi sarson weed free was significantly higher than all other treatments. All weed free treatments was significantly higher than all weedy treatments. From the mustard crop, the highest yield was found in weed free gobhi sarson weed free which was 22.87% more than African sarson weed free. From the medicinal crops, the highest yield was found in weed free dil seed which was statistically at par with intercropping of wheat with fennel weed free and was significantly higher from all medicinal crop treatments. The second highest yield was found in weed free fennel crop. The intercropping of wheat with lentil was found at par with intercropping of wheat with dil seed and fennel weed free. From the weedy treatments, the lowest yield was found in intercropping of wheat with fenugreek weedy treatment. It was significantly lower than all other treatments.

The maximum intercrop yield was found in intercropping of wheat with gobhi sarson weed free treatment. This might be due to high genetic potential of Gobhi sarson per unit area. The results was inconformity with Wasaya *et al*.,(2013).

Table 4: Yield of different intercrops in bed planted wheat

	Intercrop yield (q/ha)		
Treatments	2020-21	2021-22	Pooled
wheat+ gobi sarson weed free	7.52	7.78	7.65
wheat+ gobi sarson weedy	4.16	4.33	4.25
wheat+African sarson weed free	5.79	6.00	5.89
wheat+ African sarson weedy	4.49	3.81	4.15
wheat+lentil weed free	3.28	3.40	3.34
wheat+lentil weedy	2.48	2.43	2.45
wheat+fennugreek weed free	2.40	2.51	2.45
wheat+fennugreek weedy	1.70	1.74	1.72
wheat+fennel weed free	3.11	3.33	3.22
wheat+fennel weedy	2.12	2.18	2.15
wheat+dil seed weed free	3.34	3.39	3.36
wheat+dil seed weedy	2.03	2.12	2.07
CD	0.65	0.32	0.19

Conclusion

These findings suggested that the wheat as sole crop increased the grain yield of wheat. The growing of wheat with fennel and dil seed also increased the wheat yield. Intercropping led to increase in overall production and net profit. The intercropping of wheat with lentil were shown to be unprofitable, while the other combinations were somewhat lucrative. The findings ultimately point to the prospect of getting a respectable yield and a profitable economic return from intercropping wheat with fennel and dil seed, which could be advantageous for farmers in certain regions.

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