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Effect of lentil intercropping on growth, yield and quality of wheat (*Triticum aestivum*)

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Abstract
The field experiment was conducted on sandy loam soil, low organic carbon, available N, available P and high in available K during the *Rabi* season of 2016-2017 at Research farm of khalsa College, Amritsar. The experiment was laid out in Randomised Block Design with 10 treatments $T_{1:}$ Sole wheat, T_2: Sole lentil, T_3: Sole wheat on 67.5 cm beds, T_4 Sole lentil on 67.5 cm beds, T_5: Sole wheat on 67.5 cm beds (AFI), T_6: Sole lentil on 67.5 cm beds (AFI), T_7: wheat + lentil in 2:1 on 67.5 cm beds, T_8: wheat + lentil in 2:1 on 67.5 cm beds (AFI), T_9: wheat + lentil in 2:2 on 90 cm beds, T_{10} wheat + lentil in 2:2 on 90 cm beds (AFI) with three replications. Maximum plant height, LAI, Dry matter accumulation, Grain yield, Straw yield, N-content were recorded in 2:1 row ratio of wheat + lentil on 67.5 cm beds (T_7) which were significantly superior over sole wheat and intercropped on flat and beds (T_1, T_5, T_8 and T_{10}) and at par with sole and intercropped on beds (T_3 and T_9).

Keywords: Wheat, Lentil, Intercropping, Bed planting, Row ratio.

Introduction

Intercropping with pulse crop viz lentil may enhance the productivity of unit area as compare to sole wheat crop. Intercropping with leguminous crops also helps to reduce the fertilizer requirement as compare to sole crop, because it improves the fertility of the soil through the addition of the nitrogen by fixation and increase the availability of nutrients in the soil rhizosphere.

The less production of pulses have been aggravated the problem of malnutrition in humans and thus there is an urgent need for muting their increasing demand by manipulating the production technologies appropriately. This could be achieved by increasing the area under these crops or by increasing their per unit productivity. The area under pulses does not seem likely to expand, as the land has become limiting factor due to rapid industrialization and urbanization. The solution, therefore, lies n the second option i.e in boosting up the productivity of the existing area, which can be achieved through many ways, of which intercropping is the most important one. Intercropping offers an opportunity for efficient utilization of light, water, land and other inputs.

Intercropping with specific crop species is more productivity, profitable and secured than sole cropping. Intercropping of pulses with wheat, mustard, cotton and sugarcane etc is commonly practiced in some parts of India. But due to lack of systematic research and adequate technologies in this area considerable advantages cannot be achieved from intercropping systems.

The way in which crop plants are arranged in field is usually referred to as planting configuration. Unjustified plant configuration leads to unevenness in competition for resource utilization. The productivity of intercropping system, depend to a large extent, on the nature and extent to plant competition. At community level, plant competition can be modified and yield density relationship can be altered by manipulating plant configuration or spatial arrangement. Bed planting in wheat cropping systems is a technique for improving resource use efficiency and increasing the yield. In this system the land is prepared conventionally at raised bed and furrows are prepared manually or using a raised bed planting machine. Crops are planted in rows on top of the raised beds and irrigated water is applied in the furrows between the raised bed. Planting helps in decreasing water consumption, increase WUE (water use efficiency) and has higher yield than flat planting in winter wheat (Zhang *et al.* 2007). Bed planting has advantages viz., weed control with intercultivation reduced lodging, more light penetration in crop canopy and reduced seed rate. Bed planting facilities in controlling the pests and diseases, handling nutrients, reducing tillage and managing crop residues.

So the use of these less expensive and environment friendly techniques help to reduce problem, such as planting geometry, bed planting, legume intercropping etc. So, experiment was planned to study the Effect of intercropping on growth, yield and quality of wheat and lentil

Materials and Methods

The field experiment was conducted at students' research farm, Khalsa College, Amritsar during *rabi* season of 2016-2017. The experiment was planned to study the wheat intercropped with legumes through different agronomic modifications. The experiment was laid out in randomized complete block design with 10 treatments viz., T_1 (flat sowing of wheat), T_2 (flat sowing of lentil), T_3 (Wheat planting on 67.5 cm beds), T_4 (lentil planting on 67.5 cm beds), T_5 (Wheat planting on 67.5 cm beds with AFI), T_6 (lentil planting on 67.5 cm beds with AFI), T_7 (Wheat + lentil in 2:1 on 67.5 cm beds), T_8 (Wheat + lentil in 2:1 on 67.5 cm beds with AFI), T_9 (Wheat + lentil 2:2 on 90 cm beds), T_{10} (Wheat + lentil in 2:2 on 90 cm beds with AFI) replicated three times. After giving primary tillage, heavy pre sowing irrigation (rauni) was given. When field reached proper moisture (water) condition the field was ploughed twice with cultivars followed by planking to prepare fine seed bed. Beds are prepared with the help of bed planter of standard size of 67.5 cm and 90.0 cm. The seed of all the crops having 90 percent germination ability was used for sowing of wheat on flat and beds the seed rate of 100 kg ha^{-1} and 75 kg ha^{-1} respectively, and for lentil crop seed rate of 30 kg ha^{-1} were used as per recommendation of PAU, Ludhiana. The sowing was done on 06 November 2017 on raised beds with manually operated pora method. The recommended row spacing of wheat i.e. 22.5 cm was used during sowing. Full dose of phosphorous (62.5 kg ha^{-1}) was applied at the time of sowing to all plots and nitrogen (125 kg ha^{-1}) was applied in two splits. Nitrogen was given in the form of Urea and phosphorous in the form of SSP. In lentil dose of phosphorous (40 kg ha^{-1}) and nitrogen (12.5 kg ha^{-1}) both was applied at the time of sowing. The crop was harvested manually with sickle on 14 April after maturity and the produce was tied in bundles with tag from each plot and left for one week for sun drying. After drying each bundle weighed to record biological yield (q ha^{-1}). Then threshing was done with tractor operated thresher.

Results and Discussion

Growth

The data in table 1 showed that bed planted wheat has significantly higher growth characters like dry matter, plant height, LAI than flat sown wheat. Growth parameters i.e. plant height, dry matter accumulations were significantly better in 2:1 row ratio of wheat + lentil intercropped on 67.5 cm beds (T_7). It was followed by 2:2 row ratio of wheat + lentil intercropped on 90 cm beds (T_9). Least plant height and dry matter accumulation were observed in controlled flat planted wheat (T_1). The data in table 1showed that bed planted wheat has significantly higher growth parameters than flat sown wheat. It may be attributed due to proper distribution of plants which produced more height of plants, number of tillers and LAI.

Crop growth indices like leaf area index (LAI) and crop growth rate (CGR) increased up to 90 days of the crop age. Higher LAI and CGR was observed in 2:1 row ratio of wheat + lentil intercropped on 67.5 cm beds (T_7) than all other treatments. The maximum CGR (Table 3) was recorded in 2:1 row ratio of wheat + lentil on 67.5 cm beds treatment (T_7) at 30, 60, 90, 120 DAS and harvest stage of crop growth.

The improvement in CGR of wheat on bed with legume intercropping was may be due to better environment, nutrient availability, interception, absorption and utilization of solar radiation. Dhillon *et al.* (2005) [3] also showed similar results.

Yield attributing characters

Number of grains per ear is an important index of grain yield. Data in table 1 revealed that the methods of sowing significantly influenced the number of grains per ear. It showed that bed planted wheat has maximum number of grains per ear than flat planted wheat. The higher number of grains per ear was recorded in 2:1 row ratio of wheat + lentil on 67.5 cm beds treatment (T_7) Which was significantly higher than treatment ($T_{,}$ $T_{5,}$ T_8 and T_{10}) and at par with treatment (T_3 and T_9).Higher number of grains in 2:1 row ratio of wheat + lentil on 67.5 cm beds may be due to proper distribution of plants and long ear with number of grains per ear in this treatment because better light interception in canopy for photosynthesis. These results are accordance with Dhillon *et al.* (2005) [3]. 1000 grain weight data presented in table 3 showed that test weight did not influence significantly due to bed planting and legume intercropping. There observed that slightly difference in 1000 seed weight of bed planted wheat over flat planted wheat but it could not reached up to level of significance.

Grain Yield (q ha^{-1})

The grain yield being an economic component of crop is the important crop parameters and it reflects the resultant effect on all growth parameters and yield attributes which are affected by various inputs and is valid criteria for compairing the efficiency of different treatments. The data with respect to grain yield is presented in table 2 which showed that bed planted, legume intercropped treatments produced significant higher grain yield than flat planted wheat. Further revealed that highest grain yield was recorded in 2:1 row ratio of wheat + lentil on 67.5 cm beds treatment (T_7) which was followed by treatment (T_3 and T_9) and significantly more number of tillers in treatment ($T_{1,}$ $T_{5,}$ T_8 and T_{10}).

Control treatment was lowest grain yield (51.72 q ha^{-1}) than all other treatments. The percent increase in grain yield due to different treatments over T_1 were 13.90, 13.62, 10.17, 7.57, 7.02, 2.94 in order T_7, T_9, T_3, T_8, T_5, T_{10}. Treatment were legume intercropping is not performed, produce less yield because of non availability of nitrogen where as it become available in legume intercropped treatments. Higher grain yield recorded in 2:1 row ratio of wheat + lentil on 675 cm beds due to better growth parameters that is leaf area index, dry matter accumulation, plant height and crop growth rate etc and better yield parameters that is effective tillers from, grain per ear and 1000 grain weight.

Straw yield (q ha^{-1})

Straw yield is an important parameter of biological yield to evaluate its productivity index for judging the ultimate performance of wheat crop. And it has economic value as it is fed to the cattle's. Wheat straw makes a major contribution to the efficiency of various treatments tested in an experiment the data in table 2 presented that bed planted and legume intercropped treatments have maximum straw yield than flat planted wheat. It is cleared from data that higher straw yield was recorded in yield was recorded in 2:1 row ratio of wheat + lentil on 67.5 cm beds treatment (T_7) which was followed by treatment (T_3 and T_9) and significantly more number of tillers in treatment (T_1, T_5, T_8 and T_{10}).

Control treatment (T_1) produce minimum 67.36 q ha^{-1}straw yield than all other treatments. The percent increase in straw yield due to different treatments over T_1 were 13.64, 10.18, 9.41, 7.58, 7.05, 2.98 and order T_7, T_9, T_3, T_8, T_5, T_{10}. Highest straw yield in bed planted and legume intercropped treatment was due to fact that legume crop provide nitrogen and better utilization of nitrogen in bed planting, which results in higher vegetative growth of plants and improved growth of plants, growth parameters and yield attributes and hence increased biomass. Similar results were found by Singh (1992) [5].

Intercrop Lentil

Growth parameters i.e. plant height, leaf area index, dry matter accumulations and yield were significantly better in bed planting, paired lentil than flat and intercropped treatments. The data in table 4 treatment (T_4) sole lentil on 67.5cm bed produce that highest growth parameters which was significantly differ than wheat intercropped with lentil and at par of treatment (T_6) sole wheat on 67.5 cm bed (AFI).

The data embodied in table 5 revealed that the differences in seed and stover yield of grain was non significant due to different treatments. However, the highest seed and stover yield (11.05 q ha^{-1} and 14.47 q ha^{-1}) was recorded in sole wheat sown on 67.5 cm beds treatment (T_4) because there is less competition by weeds for resources and higher light interception due to position advantage of plants on raised bed system. Treatment (T_4) sole lentil on 67.5 cm beds which remained at par with treatments (T_2 and T_6). Whereas, T_4 was significantly better than all intercropped treatments (T_7, T_8, T_9 and T_{10}).

Land equivalent ratio (LER)

The data regarding the land equivalent ratio (LER), presented in table 5 revealed that wheat + lentil system differed significantly in LER. Compared with sole cropping, all the intercropping systems resulted in significantly higher LER indicating the yield advantage in intercropping. Intercropping system of wheat + lentil 2:2 on 90 cm beds recorded maximum LER value (1.46), which was statically at par with wheat + lentil 2:1 on 67.5 cm beds and was significantly higher than all the other treatments.

Quality Parameters of Wheat

Nitrogen content of wheat grain and straw (%)

Nitrogen content of wheat grain is an indication of potential yield response to applied nitrogen. The data presented in table 7 showed that nitrogen content in grain and straw of wheat did not vary significantly due to different methods of sowing. Although bed planting have higher nitrogen content (1.69%) than flat planting (1.62%) and yet it could not reach the statistical level of significance. N content of wheat grain was improved with raised seedbed compared with conventional flat seedbed. Similar results were obtained by Mascagni *et al.* (1991) [4].

Protein content (%)

The protein content is a very important quality parameter of wheat. This ultimately depends on the uptake of nitrogen by the crop. The data regarding protein content (table 6) of grain was not significantly influenced by i.e. bed planting, flat plating. The maximum protein content 10.60% recorded with bed planting method of sowing which was at par with treatment T_9 planting (10.56) methods of sowing. Maximum protein content was recorded when wheat planted on bed as more nitrogen available to the crop as protein content depends upon the nitrogen content. Similar results were obtained by Aulakh *et al.* (2000) [2].

Hectoliter weight (g lit^{-1})

Hectoliter weight is also important quality parameter of wheat. It is the mass of wheat grains in gram per liter. The data recorded for the hectoliter weight have been presented in table 6. Data showed that the different agronomic practices affects the hectoliter weight but not get reached at statistical level of significance. The maximum hectoliter weight (899.1 g lit-1) recorded from 2:1 row ratio wheat + chickpea intercrop on 67.5 cm beds treatments (T_7) was 0.38 per cent higher over the controlled flat planting (T_1).

Table 1: Effect of different intercropping treatments on growth and yield attributing character of wheat (*Triticum aestivum*).

Treatments	Plant height (cm)	LAI	Dry matter accumulation (q ha^{-1})	No. of grains per ear	1000- grain weight
T_1 Sole wheat	91.19	3.28	110.07	46.1	37.0
T_3 Sole wheat on 67.5 cm beds	99.18	3.46	121.60	50.8	37.6
T_5 Sole wheat on 67.5 cm beds (AFI)	94.65	3.35	114.18	49.3	37.3
T_7 Wheat + lentil 2:1 on 67.5 cm beds	101.38	3.51	123.37	52.8	37.9
T_8 Wheat + lentil 2:1 on 67.5 cm beds (AFI)	96.63	3.40	115.46	51.3	37.5
T_9 Wheat + lentil 2:2 on 90 cm beds	100.09	3.49	122.87	51.9	37.7
T_{10} Wheat +lentil 2:2 on 90 cm beds (AFI)	92.72	3.32	111.51	48.6	37.2
CD (p = 0.05)	4.87	0.15	6.51	NS	NS

Table 2: Effect of different intercropping treatments on crop growth rate (q ha^{-1} day^{-1}) of wheat (*Triticum aestivum*).

Treatments	Crop growth rate (q ha^{-1} day^{-1})				
	0-30	30-60	60-90	90-120	120-at harvest
T_1 Sole wheat	0.11	0.44	1.23	0.61	0.11
T_3 Sole wheat on 67.5 cm beds	0.16	0.52	1.32	0.69	0.21
T_5 Sole wheat on 67.5 cm beds (AFI)	0.14	0.50	1.29	0.65	0.17
T_7 Wheat + lentil 2:1 on 67.5 cm beds	0.18	0.54	1.36	0.71	0.24
T_8 Wheat + lentil 2:1 on 67.5 cm beds (AFI)	0.15	0.51	1.31	0.67	0.18
T_9 wheat + lentil 2:2 on 90 cm beds	0.17	0.53	1.35	0.70	0.22
T_{10} Wheat + lentil 2:2 on 90 cm beds (AFI)	0.13	0.49	1.27	0.62	0.19

Table 3: Effect of different intercropping treatments on yield of wheat (*Triticum aestivum*).

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
T_1 Sole wheat	45.52	67.36	38.69
T_3 Sole wheat on 67.5 cm beds	49.81	73.70	40.43
T_5 Sole wheat on 67.5 cm beds (AFI)	48.72	72.11	39.99
T_7 Wheat + lentil 2:1 on 67.5 cm beds	51.72	76.55	40.51
T_8 Wheat + lentil 2:1 on 67.5 cm beds (AFI)	48.97	72.47	40.02
T_9 Wheat + lentil 2:2 on 90 cm beds	50.15	74.22	40.46
T_{10} Wheat + lentil 2:2 on 90 cm beds (AFI)	46.86	69.37	39.26
CD (p = 0.05)	2.40	4.28	NS

Table 4: Effect of different treatments on growth and yield of Lentil.

Treatments	Plant height	LAI	Dry matter Accumulation	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})
T_2 Sole lentil	34.2	1.16	19.76	9.87	12.92
T_4 Sole lentil on 67.5 cm beds	38.5	1.20	23.48	11.05	14.47
T_6 Sole lentil on 67.5 cm beds (AFI)	37.7	1.18	21.06	10.95	14.16
T_7 Wheat + lentil 2:1 on 67.5 cm beds	31.6	1.08	3.97	2.27	2.81
T_8 Wheat + lentil 2:1 on 67.5 cm beds (AFI)	27.9	1.06	3.06	2.03	2.41
T_9 Wheat + lentil 2:2 on 90 cm beds	32.9	1.14	5.74	3.58	4.58
T_{10} Wheat + lentil 2:2 on 90 cm beds (AFI)	32.5	1.11	4.32	3.24	4.08
CD (p = 0.05)	3.50	0.08	1.03	0.96	1.71

Table 5: Effect of different treatments on land equivalent ratio

Symbol	Treatments	LER
T_1	Sole wheat	1
T_2	Sole lentil	1
T_3	Sole Wheat on 67.5 cm beds	1
T_4	Sole lentil on 67.5 cm beds	1
T_5	Sole wheat on 67.5 cm beds (AFI)	1
T_6	Sole lentil on 67.5 cm beds (AFI)	1
T_7	Wheat + lentil in 2:1 on 67.5 cm beds	1.35
T_8	Wheat + lentil in 2:1 on 67.5 cm beds (AFI)	1.27
T_9	Wheat + lentil in 2:2 on 90 cm beds	1.46
T_{10}	Wheat + lentil in 2:2 on 90 cm beds (AFI)	1.34

Table 6: Effect of different treatments on protein content (%) and hectoliter weight (g lit^{-1}) of wheat (*Triticum aestivum*)

Treatments	Protein content (%)	Hectolitre weight (g lit^{-1})
T_1 Sole wheat	10.18	860.5
T_3 Sole wheat on 67.5 cm beds	10.43	862.7
T_5 Sole wheat on 67.5 cm beds (AFI)	10.31	862.2
T_7 Wheat + lentil 2:1 on 67.5 cm beds	10.56	863.5
T_8 Wheat + lentil 2:1 on 67.5 cm beds (AFI)	10.37	862.5
T_9 Wheat +lentil 2:2 on 90 cm beds	10.50	863.1
T_{10} Wheat +lentil 2:2 on 90 cm beds (AFI)	10.25	861.4
CD (p = 0.05)	NS	NS

Table 7: Effect of different treatments on nitrogen content (%) of grain and straw (%) of wheat (*Triticum aestivum*)

Treatments	Nitrogen content of grain (%)	Nitrogen content of straw (%)
T_1 Sole wheat	1.63	0.42
T_3 Sole wheat on 67.5 cm beds	1.67	0.54
T_5 Sole wheat on 67.5 cm beds (AFI)	1.65	0.50
T_7 Wheat + lentil 2:1 on 67.5 cm beds	1.69	0.56
T_8 Wheat + lentil 2:1 on 67.5 cm beds (AFI)	1.66	0.52
T_9 Wheat + lentil 2:2 on 90 cm beds	1.68	0.55
T_{10} Wheat + lentil 2:2 on 90 cm beds (AFI)	1.64	0.48
CD (p = 0.05)	NS	NS

Conclusion
Results of the present field lead to the conclusion that agronomic practices like 2:1 row ratio of wheat + lentil intercrop on 67.5 cm beds (T_7) found significantly higher than treatment (T_1,T_5, T_8 and T_{10}) and at par with treatment (T_3 and T_9). But benefit cost ratio (B:C) and land equivalent ratio (LER) was higher in treatment (T_9) followed by treatment (T_7).

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