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BIO-ECONOMIC ASSESSMENT OF WHEAT-CANOLA INTERCROPPING SYSTEMS

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Abstract:

Rapid changes in dietary habits and ever-increasing population of Pakistan demand increase in edible oil availability. Stagnant rather decreased domestic oilseeds production further makes the situation miserable. This issue can be addressed through adaptation of good techniques. Canola growing period coincides with wheat and wheat is staple food of Pakistan thus farmers are not ready to sacrifice growing of canola in place of wheat. Intercropping increases crop production per unit area and time with efficient use of resources especially for small land holders. An experiment was conducted at Agronomic Research Area, University of Agriculture, Faisalabad during 2012-13 to assess the feasibility of wheat-canola intercropping. Statistical model Randomized complete block design [RCBD] was used keeping net plot size of 5.0 m × 3.0 m for each treatment. Treatments were comprised of wheat alone, canola alone, wheat + two rows of canola, wheat + four rows of canola. Fisher's analysis of variance technique and least significant difference test [LSD] at 5% probability level were used to analyze the data and comparison of differences among treatments' means respectively. Results of experiment depicted that seed yield of wheat reduced from 4493 in wheat sole to 4163 and 3792 kg ha^{-1} in wheat plus 2 rows of canola and wheat plus 4 rows of canola, respectively while this reduction was compensated by the additional yield 283 and 781 kg ha^{-1} from 2 rows and 4 rows of canola, respectively. All yield contributing parameters such as number of fertile tillers per plot, plant height, spike length, number of spikelet per spike and 1000-grain weight were reduced in intercropping than sole wheat. Canola yield contributing parameters were reduced in intercropping combination. Greater land equivalent ratio [1.25] was observed in four rows of canola. Wheat was dominated crop in intercropping as shown by the aggressivety value and relative crowding coefficient values. Maximum net field benefits [83019] and benefit cost ratio [1.92] was obtained through wheat plus four rows of canola. It was concluded that wheat + 4 rows of canola intercropped in multi-row strips can give better yield advantages and sufficient amount of edible oil for house hold use at farm level under Faisalabad conditions.

Keywords: *Bio-Economic, Assessment, Canola, Intercropping Systems.*

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INTRODUCTION:

In Pakistan, there is severe deficiency in edible oilseed production and it imports a huge quantity of edible oil to fulfill its requirements. Along with ever increasing population pressure, per unit consumption is also rising but domestic production of edible oilseeds is not sufficient to fill the gap between production and demand. All this requires an urgent attention for improving the situation of this vital sector. Overlapping of growing season of potential oilseeds with major field crops is the major constraint in this regard. Canola growing period coincides with wheat and wheat is staple food so farmers are not ready to sacrifice by growing canola in case of wheat. Efforts should be made in order to find out the practically feasible solution of the situation. Intercropping of oilseeds with major crops could be an acceptable approach.

Wheat is an important cereal having production 676 million tons worldwide. 68% of total wheat is produced by only ten countries. In Pakistan, value added in agriculture by wheat is 10.1% and its share in GDP is 2.2%. Area under cultivation is 8.6 million hectares total production is 24.2 million tons in Pakistan [Govt. of Pakistan, 2012-13]. Canola is the world's third largest source of edible oil after soyabean and palm oil [Nowlin, 1991]. Canola oil contains 20-25% protein, 40% oil, 21% linoleic acid and 9% alpha-linolenic acid. In fatty acid composition canola oil is identical to safflower and sunflower. Canola oil is good for human consumption because it contains less quantity of erusic acid which causes many diseases in body. 0.03 Million acres were grown under canola in Pakistan having production of 0.01 million tons of oil [Govt. of Pakistan, 2012-13]. There is need to bring awareness among farmers for increasing local oilseeds production without scarifying wheat crop. The practice of intercropping may decrease the reliance on synthetic herbicides and weed control [Banik *et al*., 2006] because it increases stability, uses for more efficient utilization of available resources that ultimately results in reducing weed pressure and generates beneficial biological interactions between crops [Kadziuliene *et al*., 2009].

REVIEW OF LITERATURE:

Intercropping is considered as an advanced agro-technique for increasing yield of crops per unit land area and time. In this technique two or more crops are grown simultaneously in the same place at the same time. Verma *et al*. [1997] conducted an experiment on intercropping of wheat and indian mustard and concluded that it gives maximum net return, land equivalent ratio and benefit cost ratio. Singh and pal [1994] concluded from wheat and canola intercropping that seed yield is reduced in intercropping as compared with pure stands of both. Sharma *et al*. [1996] observed that in wheat and canola intercropping plant density was affected significantly. Ali *et al*. [2000] conducted an experiment having treatments canola alone, wheat alone, canola + one row of wheat, canola + two rows of wheat and canola + three rows of wheat. The results showed that growth and yield components were influenced significantly. The highest canola seed yield [1217 kg ha^{-1}] was produced in canola + one row of wheat treatment and in canola + one row of wheat planting net income, cost benefit ratio and land equivalent ratio [LER] were also increased at Rs. 22486.98, 2.46 and 1.17, respectively. Tahir *et al*. [2003] studied competition functions for two consecutive years of different intercropping systems i.e. canola, lentil, linseed and wheat gram were compared with sole cropping of canola.

Relative crowding coefficient [RCC] showed that maximum K [4.08] was measured from canola + one row of wheat planting. Aggressivety values [A] -0.03 and 0.06 reflected that wheat was most competitive crop than canola. Similarly, competitive ratio [CR] 0.82 and 0.51 indicated that among intercrops, wheat was proved to be better competitive when grown by mixing with canola. Khan *et al*. [2012] evaluated the wheat-canola intercropping system by growing synthetic and hybrid canola varieties in wheat. Wheat and canola intercropping system with 4 rows of wheat + 2 rows of hybrid canola was economically profitable and more productive than all other inter and sole crops. However, minimum economic returns and cost benefit ratios were observed from sole synthetic canola and its intercrops. Regarding competitive functions, higher values of competitive ratio and crowding coefficient for wheat in all wheat and canola intercropping systems checked the dominant behavior of wheat on its companion intercrops. Khan *et al*. [2005] checked the feasibility under rain-fed condition of intercropping chickpea, lentil and rapeseed in wheat using a randomized complete block design with three replications. Wheat sole crop and intercropped with chickpea, lentil, and rapeseed in different proportions viz. 1:1, 2: 1 and 3: 1. The results showed that spike length, number of grains per spike, plant height and grain yield of wheat varied significantly in different intercropping systems, while the effect on 1000-grain weight was non-significant in all cases. The mean values of these proportions showed that the maximum grain yield of wheat [1687 kg ha^{-1}] was gained with chickpea intercropping, against the minimum with rapeseed intercropping. The chickpea intercropping in 1:1 ratio gave the maximum grain yield [1721 kg ha^{-1}] of wheat while the minimum grain yield of 1213 kg ha^{-1}

was gained from wheat-rapeseed intercropping in 1:1 ratio. Naeem *et al.* [2012] conducted an experiment using broadcast and line sowing methods for wheat-canola intercropping system. From the results, it is observed that all intercropping treatments affected dry weight and weed density significantly over component sole crop of wheat. The treatment of Four rows of wheat + four rows of canola gave the net benefit Rs 93 543 and highest land-equivalent ratios 1.37 followed by two rows of wheat + two rows of canola. In irrigated conditions of Faisalabad wheat-canola intercropping could increase land equivalent ratio > 1 [over-yielding] by decreasing weed density.

MATERIALS AND METHODS:

3.1. Site characteristics

Experiment was conducted on Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan during winter 2012-13 using randomized complete block design [RCBD] with three replications and four treatments viz. wheat alone , canola alone, wheat + 2 rows of canola, wheat + 4 rows of canola. Net plot size was 5 m × 3 m. The climate of the region is semi-arid and subtropical. The experimental area is located at 31º North latitude and 73º East longitude with an altitude of 135 meters above sea level.

3.2. Soil analysis

The soil of the experimental site was analyzed for physico-chemical characteristics. For this purpose composite soil samples were collected from the experimental area from a depth of 15 to 30 cm before sowing of crop. The detail of soil analysis is given in

RESULTS AND DISCUSSION:

4.1. PHYSIOLOGICAL PARAMETERS

4.1.1. Leaf area index [LAI]

Different intercropping systems had a significant effect on LAI at different harvest dates. The LAI increases steadily to its mean maximum value of 1.6, 3.7 and 5.9 in 2013-2014 until 90 days harvest and then declines in all the treatments. The decline of LAI after 90 days towards the end of season was linked with the senescence of leaves. Maximum value of leaf area index [5.98] is obtained from sole wheat crop and the minimum value [5.07] is measured when wheat + 30 cm apart four rows of canola are grown.

This type of LAI curve is generally common in many species such as sugarbeet [Hussain and Field, 1991], chickpea [Hussain *et al.*, 1997], mustard [Scott *et al.*, 1973; Allen and Morgan, 1975; Kjellstrom, 1993; Gammellvind *et al.*, 1996; Kumar *et al.*, 1997] and canola [Nielsen, 1997; Cheema, 1999]. Decline in physiological attributes may perhaps be due to inter-specific competition between component crops.

4.1.2. Leaf area duration [LAD]

Leaf area duration of wheat was significantly [P= 0.002] affected by wheat-canola intercropping in [Table.1.]. Results show varying trends as maximum leaf area duration [145.8 days] was observed in sole wheat while minimum LAD [123 days] was recorded in case of 120 cm spaced 6 rows strips of wheat + four rows of canola.

Singh and Rathi [2003] stated that dry matter accumulation decreases when the leaf area duration of a crop decreases. Decrease in leaf area duration might be because of elevated resource utilization and exhaustive nature of crops.

Table. 1. Mean and SE for leaf area index, leaf area duration and crop growth rate for intercropping of canola and wheat.

	Canola			Wheat		
	Wheat alone	Wheat + 2 rows of canola	Wheat + 4 rows of canola	Wheat alone	Wheat + 2 rows of canola	Wheat + 4 rows of canola
LAI	-	5.62a	4.55b	5.98 a	5.65 b	5.07 c
LAD	-	205a	217a	145.8 a	136.6 b	123 c
CGR	-	9.74a	8.38b	15.8 a	13.2 b	11.6 c

4.1.3. Crop growth rate [CGR]

The crop growth rate of different intercropping systems differs significantly [0.0008]. Significantly higher CGR [15.8 g m^{-2} d^{-1}] was recorded for the wheat crop when 25 cm apart 12 rows of wheat were grown while lowest CGR [11.6 g m^{-2} d^{-1}] was measured when one hundred and twenty centimeter spaced multiple rows strips of wheat plus four rows of canola are grown. Research conducted by Hocking *et al.* [1997] in Australia on brassica and canola showed higher growth rates [10-15 g m^{-2} d^{-1}] during the period

between anthesis and maturity. Allen and Morgan [1975] also reported the similar trend of CGR working in the United Kingdom.

4.1.4. Biological yield [kg ha^{-1}] Wheat

Biological yield is the combination of seed and straw yield of a crop. The total biomass per unit area reflects the overall growth behavior of a crop. It is the function of genetic make-up of crop, nutrient status of soil and the environmental conditions prevailing.

Data regarding biological yield are presented in the table 4.11. Analysis of variance showed that biological yield of wheat was affected by canola intercropping. Maximum biomass of wheat [11088 kg ha^{-1}] was recorded in wheat sole and minimum [9156 kg ha^{-1}] was, when four rows of canola intercropped with wheat. The variation in total biomass under different intercropping treatment was due to competitive behavior of the component crops in each intercropping system.

Reduction in biomass of wheat as a result of intercropping might be due to some competition for different growth factors i.e., moisture, nutrients, space and solar radiations etc. besides intercrops might have some suppressive allopathic effect on growth and yield of the associated wheat. These results are similar with the findings of Anjum [1996] and Ahmad *et al.* [1993] who reported significant reduction in biomass yield of wheat in intercropping. Reduction in biomass yield of base crop due to competitive effect of different intercrops was also reported by Rehman [1984], Tareen *et al*. [1988] and Mandal and Mahapatra [1990].

4.1.5. Grain yield [kg ha^{-1}] Wheat

Grain yield is the function of the cumulative behavior of the yield components, such as number of tillers, number of grains per spike and grain size.

Data regarding grain yield are presented in Table. 2. Intercropping reduced the grain yield of wheat substantially compared with sole cropping of wheat. Sole wheat grown at 25 cm spaced single rows have maximum grain yield [4493 kg ha^{-1}] while the minimum grain yield [3792 kg ha^{-1}] was measured in 120 cm spaced 6 rows strips of wheat plus four rows of canola.

In another study wheat as a sole crop attained the highest yield components viz. plant height, 1000-grain weight, longest spike that resulted in the highest yield. Mandal *et al*., 1986, Goldman [1992]. Ahmad *et al.* [1993] reported significant reduction in wheat yield as a result of intercropping. Reduction in grain yield of wheat due to intercropping of linseed was also reported by Billore *et al*. [1992] and Abo-Shelaia [1990].

Table. 2. Mean and SE for Biomass **[kg ha^{-1}]** and Grain Yield **[kg ha^{-1}]** for intercropping of canola and wheat.

	Canola			Wheat		
	Canola alone	Wheat + 2 rows of canola	Wheat + 4 rows of canola	Wheat alone	Wheat + 2 rows of canola	Wheat + 4 rows of canola
BM	9303 a	1558 c	4026 b	11088 a	10060 b	9156 c
GY	1940 a	283 c	781 b	4493	4163 b	3792 c

4.1.6. Biological yield [kg ha^{-1}] Canola

Data regarding the biological yield of canola are presented in Table 4.20. Analysis of variance showed that biological yield of canola was significantly affected by different intensities of canola intercropping. It is clear from the Table that maximum biomass [9303 kg ha^{-1}] was recorded in sole canola grown at 30 cm spaced single rows and minimum biomass [1558 kg ha^{-1}] was calculated in wheat + 2 rows of canola.

The maximum biological yield was found in sole canola treatment because there is no competition between main crop and component crop. The variation in the biological yield of canola in different intensities of intercropping system was due to dominant effect of the wheat which suppressed the vegetative growth of the canola. Decrease in biological yield of canola in wheat-canola intercropping system is due to competition of both crops for growth resources [Szumigalski & Acker, 2005].

4.1.7. Seed yield [kg ha^{-1}] Canola

Data regarding the final seed yield of canola are presented in Table 4.21. Analysis of variance showed that seed yield of canola differ significantly. Canola sole grown at 30 cm spaced single rows exhibited significantly higher seed yield [1973 kg ha^{-1}] than wheat-canola intercropping. Seed yield of canola was significantly affected by wheat-canola intercropping. Results show varying trends as maximum seed yield [1940 kg ha^{-1}] was observed in sole canola while minimum seed yield [283 kg ha^{-1}]

was recorded in case of 60 cm spaced 6 rows strips of wheat + 2 rows of canola.

This might have happened because of competition between component crops for the light, space, nutrient and water. Reduction in seed yield of mung-bean was observed in mung-bean-sesame intercropping system under different patterns was reported by Deshpande *et al*. [1989], and Rao *et al*. [1993]. Bajwa *et al*. [1992] and Ahmad [1990] reported that Gram, Methra, Lentil and Sarson growing as intercrops, significantly decreased wheat grain yield compared to that of monocropped wheat. Prakash *et al*. [1986] observed that wheat yield was decreased by intercropping with Indian mustard.

4.2. Competitive Functions and Agronomic advantages

4.2.1. Relative crowding Coefficient

Relative crowding Coefficient [RCC] plays an important role in determining the competition effects and advantages of intercropping [Willey, 1979]. In an intercropping system each crop has its own RCC [K]. The component crop with higher "K" value is the dominant one and that with lower "K" is dominated. To determine if there is yield advantage of intercropping, the product of the coefficients of both the component crops is formed that is usually designated as "K". If the product of RCC of two species is equal, less or greater than 1, it means intercropping system has no advantage, disadvantage or advantage, respectively.

In both intercropping combinations, wheat appeared to be highly dominant as it had higher values of 'K" than the intercrops in different intercropping systems [Table 4.3]. It can be inferred that the intercropped wheat utilizes the resources more competitively than canola, which appeared to be dominated. As products [K] of coefficients of the component crops are greater than 1, there were yield advantages in all the intercropping systems. The maximum yield advantage was obtained from wheat + four rows of canola as indicated by the maximum value of K.

Maize-soybean [El-Edward *et al.,* 1985], wheat-Indian mustard [Singh and Gupta, 1993], as well as wheat-methra and wheat-gram [Shahid and Saeed, 1997], have been reported to give yield advantages over the respective monoculture on the basis of RCC.

Table. 3. Mean and SE for Relative crowding Coefficient, Aggressivity value and Land equivalent ratio for intercropping of canola and wheat.

	Wheat + 2 rows of canola			Wheat + 4 rows of canola		
	Wheat Ka	Intercrop K_b	System $K= K_a \times K_b$	Wheat Ka	Intercrop K_b	System $K= K_a \times K_b$
RCC	481.3	0.028	13.3	481.3	0.028	13.3
AV	+0.712	-	-0.712	+0.345	-	-0.345
LER	0.927	0.146	1.07	0.844	0.403	1.25

4.2.2. Aggressivity value

Aggressivity [A] value is an important tool to determine the competitive ability of a crop when grown in association with another crop. An aggressivity value of Zero indicates that component crops are equally competitive. For any other situation, both crops will have the same numerical value but the sign of the dominant species will be positive and that of the dominated negative.

The component crops did not compete equally [Table 4.4]. Regardless to treatments, the positive sign for values of wheat indicates the dominant behaviour of wheat over intercrops of canola which has negative values.

These results be in accord with previous findings, according to which wheat was dominant having positive A values when grown in association with canola [Tahir *et al*., 2003].

4.2.3. Land equivalent ratio

The land equivalent ratio is the relative area of a sole crop required to produce the yield achieved in intercropping. Palaniappan [1988] described that when LER was equal or less than one, it was considered to have no advantage of intercropping over monocropping in terms of production. But LER more than one under intercropping was considered to have agronomic advantage over monoculture.

Data regarding LER of different wheat-canola intercropping systems are presented in Table [4.25] which indicates that LER values are greater than one in all the intercropping treatments and the range of yield advantage over sole cropping was between 7 to

25% with the highest in case of wheat + four rows of canola [25%] followed by wheat + 2 rows of canola [7%]. It means that intercropping has 7-25% yield advantage over the sole crop. Higher LER in intercropping treatments compared with monocropping of wheat was ascribed to better utilization of natural resources [land, CO_2, light] and added fertilizer and water resources. Higher LER in intercropping compared to monocropping of wheat was also reported by Mandal *et al*. [1990], Nazir *et al*. [1996], Tahir *et al.* [2003] and Tusbo *et al*. [2005].

4.3. Quality parameters

4.3.1. Seed protein contents [%]

4.3.1.1.Wheat

Different wheat-based intercropping systems significantly affected the seed protein contents. Data regarding seed protein contents is given in table 4.26. According to results sole wheat grown at 25 cm spaced six rows of wheat have more protein contents [10.6%] which are similar with the protein contents [10.1%] present in wheat plus sixty centimeter spaced two rows of canola. While minimum protein contents [9.77%] are measured in wheat plus 120 cm centimeter spaced four rows of canola.

Decrease in protein contents of wheat-canola intercrops may have been due to the competitive behaviour of these crops. In contradiction to our results, Singh and Rathi [2003] stated that Pairing of rows of mustard had a positive effect on protein contents**.**

4.3.1.2. Canola

Protein content in seeds indicates the quality and dietary value of the seeds. More the proteins, higher will be the dietary value and vice versa.

The data regarding seed protein percentage of canola as affected by different wheat-canola intercropping systems is presented in table 4. Data regarding canola protein percentage shows that protein contents of seed varied significantly. Maximum protein contents [22.04%] was measured when four rows of canola are intercropped with multiple strips of wheat which is similar to protein content with [21.5%] of protein present in wheat + two rows of canola. Lesser protein contents are observed in sole canola crop.

Tahir [2002] reported that canola protein content was affected in canola based intercropping.

Table. 4. Mean and SE for protein [%] and oil [%] for intercropping of canola and wheat.

	Canola			Wheat		
	Canola alone	Wheat + 2 rows of canola	Wheat + 4 rows of canola	Wheat alone	Wheat + 2 rows of canola	Wheat + 4 rows of canola
Oil %	40.4a	39ab	37.2 b			
Protein %	20.96 b	21.5 ab	22.04 a	10.6 a	10.1 ab	9.77 b

4.3.3. Oil contents [%]

A crop rich in oil contents is the ultimate goal of the growers. The data pertaining seed oil contents of canola as affected by intercropping system is presented in table 4.28.

Oil contents *[%]* of canola are affected significantly in wheat-canola intercropping system. More oil content [40.4%] measured in canola sole grown at thirty centimeter apart ten rows which are similar [39%] with 120 cm spaced strips of wheat plus two rows of canola. Minimum oil contents [37.2%] are measured in 60 cm spaced single rows strips of wheat plus four rows of canola.

These findings are similar to the results of Ayisi *et al.* [1997], but are in contradiction to the work of Singh and Gupta [1994], who revealed that intercropping did not affect seed oil contents.

4.4. Economic Analysis

The cost of production was analyzed in order to find out the most economic combination of wheat and canola intercropping system. All input cost and interest on fixed land and running capital were considerd for calculating the cost of production. The efficiency of an intercropping system is determined either by the net income per unit area in a specified period of time, or benefit cost ratio [BCR]. Data regarding economic analysis are presented in Table [4.5]. It is clear from the Table that wheat + 4 row of canola intercropping system gave the highest net income of Rs. 99083.3 per hectare followed by Rs. 89597.5 per hectare recorded in case sole wheat crop. In term of benefit cost ratio [BCR], the highest value of BCR [2.07] was recorded in case of wheat plus four rows of canola.

Jha *et al*. [1991] and Chandra [1992] reported

higher net monetary returns from intercropping over monocropping of rice. In another study Itnal *et al*. [1980] also observed that higher gross returns and net returns in chickpea + safflower intercropping system.

Table 4.5. Effect of wheat-canola intercropping on benefit cost ratio of wheat

Intercropping systems	Grain yield [kg ha^{-1}]		Gross income [Rs. ha^{-1}]	Total fixed cost [Rs.ha^{-1}]	Variable cost [Rs. ha^{-1}]	Total cost [Rs. ha^{-1}]	Net income [Rs. ha^{-1}]	Benefit cost ratio
	Wheat	canola						
Wheat sole	4493	-	177875.5	63668	24610	88278	89597.5	2.015
canola sole	-	1939	145475.0	63668	7000	70668	74807.0	2.059
Wheat + 2 rows of canola	4163	283	153585.7	63668	25650	89318	64267.7	1.719
Wheat + 4 rows of canola	3792	781	191351.3	63668	28600	92268	99083.3	2.074

CONCLUSION:

An experiment was conducted on Agronomic Research Area, University of Agriculture, Faisalabad during 2012-13 to assess the feasibility of wheat-canola intercropping. Randomized complete block design **[**RCBD] was used having net plot size of 5.0 m × 3.0 m for each treatment. Treatments were comprised of wheat alone [25cm apart 12 rows], canola alone [30cm apart 10 rows], wheat + two rows of canola [20cm apart 12 rows+30cm apart 2 rows], wheat + four rows of canola [15cm apart 12 rows+30cm apart 4 rows]. Number of rows of wheat was kept constant in sole and intercropping treatments; only row to row distance was decreased to adjust intercrop lines in between the wheat strips. Varieties of wheat and canola were Miraj-2008 and Punjab sarson, respectively. Sowing was done on December 03-2012 with single row hand drill. Seed rate for wheat and canola was used @ 125 kg ha^{-1} and 5 kg ha^{-1}, respectively. Urea, DAP and SOP fertilizers were applied to provide 110 N, 88 P and 60 K kg ha^{-1}, respectively. All the recommended phosphorus, potassium and 1/2 of nitrogen was applied as basal dose remaining and 1/2 of nitrogen with 1st irrigation. Four irrigations each of 7.5 cm was applied at the wheat stages of tillering, jointing, anthesis and grain filling respectively. Thinning of canola crop was done two time in whole growing period. 1st at six leaf and 2nd at twelve leaf stage of canola. To free the plot from weeds, two hoeing were done manually. Plant protection measures against sucking pests like termites were taken. Both crops [wheat and canola] were harvested at their harvest maturity on 29-04-13 and 03-05-13, respectively. These crops were harvested manually with help of a sickle from ground levels, sun dried and then tied them into separate bundles. Wheat samples were threshed by mini electric thresher and of canola were threshed manually after one week sun drying. Following results were obtained from the study:

- Plant growth characters such as LAI, LAD and CGR of wheat were affected by intercropping than sole component crops.
- Yield and yield components of wheat such as plant height, spike length, 1000 grain weight, grain yield and biological yield were decreased in intercropping.
- Canola yield components were also exaggerated in intercropping than sole treatments.
- Quality traits of both crops like protein contents [%] of wheat and canola, oil contents [%] of canola were lessened in intercropping systems.
- Wheat was more competent in treatment of wheat + 2 rows of canola in term of aggressivity value, relative crowding coefficient and land equivalent ratio.
- Net income and benefit cost ratio were obtained in greater amount from wheat plus four rows of canola.

It is concluded that wheat plus four rows of canola is more feasible and economical intercropping system under agro-ecological conditions of Faisalabad. It gave high net benefits and proved better for resource utilization. Farmers can get reasonable amount of edible oil for their household and contributes a lot to fulfill oil requirement of the country by following

this intercropping technique without sacrificing their major field crops like wheat.

REFERENCES:

1. Ahmad, G. and Z. Qureshi. 2001. Better use of land through intercropping of canola with wheat. Sarhad. J. Agric. 17: 363-366.
2. Ahmad, H.K. 1990. Studies on biological intercrop relationship and water use techniques in wheat, Ph.D. Thesis, Uni. Agric. Faisalabad.
3. Ahmad, R., .M.S. Amjad, M.S. Nazir and T. Mahmood. 1993. Agronomic studies on mash-soybean intercropping system. Pak. J. Agric. Res. 14: 304-308.
4. Abo- Shelaia. 1990. Inter and intra competition when intercropping fababcan and barley. Ann. Agric. Sci. Cairo. 2: 11-278.
5. Akhter, N., M.A. Alim, M.M. Islam, Z. Naher, M. Rahman and A.S.M.I. Hossain. 2004. Evalution of mixed and intercropping of lentil and wheat. J . Agron., 3: 48-51.
6. Ali , Z., M.A. Malik and M.A. Cheema. 2000. Studies on determining a suitable Canola-Wheat intercropping pattern. Int. J. Agric. Biol. 2: 42-44.
7. Allen, E.J. and D.G. Morgan. 1972. A quantitative analysis of the effects of nitrogen on the growth, development and yield of oilseed rape. J. Agric. Sci. 78: 315-324,
8. Allen, E.J. and D.G. Morgan. 1975. A quantitative comparison of the growth, development and yield of different varieties of oilseed rape. J. Agric. Sci. Camb. 85: 359-174.
9. Amar, S., R.L. Agarwal and A. Singh. 1990. Effect of wheat-mustard mixture and nitrogen on yield and economics of wheat. Ind. J. Agron. 35: 326-327.
10. Anjum, M.A. 1996. Agro-management studies on biological fixation of nitrogen in wheat-legume intercropping system. PhD. Thesis, Univ. Agric. Faisalabad, Pakistan.
11. AOAC, 1990. Official Methods of Analysis. Assoc. Off. Analyt. Chemist, 15th Ed. Arlington. Virginia, USA.
12. Ayisi, K.K., D.H. Punam, G.P. Vance, M.P. Russelle and D.L. Allan. 1997. Strip intercropping ard nitrogen effects on seed, oil ald protein yields of cnola ard soyabean. Agron. J. 8l: 23-29.
13. Azizur-Rahman, M. 1999. Comparative performance of intercropping of pulses and oilseeds with rainfed wheat [*Triticum aestivum*] in Bangladesh. Ind. J. Agron. 44: 504-508.
14. Bajwa, A.N., M.S. Nazir and M. Mohsan. 1992. Agronomic studies on some wheat- based intercropping system. Pak. J. Agric. Sci. 64: 364-368.
15. Banik, P., A. Midya, B.K. Sarkar, and S.S. Ghose. 2006. Wheat and chickpea intercropping systems in an additive series experiment: Advantages and weed smothering. Eur. J. Agron. 24: 325-332.
16. Bhatti, I. H., R. Ahmad, A. Jabbar, M.S. Nazir and T. Mahmood. 2006. Competitive behaviour of component crops in differenet sesame legume intercropping systems. Int. J. Agric. Biol. 8: 165–167.
17. Bhatti, I.H., R. Ahmad and M.S. Nazir. 2005. Agronomic traits of sesame as affected by grain legume intercropping and planting patterns. Pak. J. Agric. Sci. 42: 56-60.
18. Billare, S.D., K. Singh and S.B. Nahatkar. 1992. Economic viability to wheat + linseed intercropping system under different fertility levels. Crop Res. 5: 430-433.
19. Billore, S.D., S. Kalyan and B. Mridula. 1992. Competition functions of wheat plus linseed intercropping grown under different fertility levels. Ind. J. Agron. 37: 415-419.
20. Bora, P.C. 1999. Competition studies in intercropping of wheat [*Triticum aestivum* L.], rapeseed [*Brassica compestris* L.] and pea [*Psium sativum* L.]. Ind. J. Agron. 44: 509-513.
21. Bulson, H.A. J., R.W. Snaydon and E.C. Stopes. 1997. Effect of plant density on intercropped wheat and field beans in an organic farming system. J. Agric. Sci. 128: 59-71.
22. Bunker, G.K., B.S. Rana and O.P. Ameta. 2006. Efficacy of some plant products against mustard aphid under different intercropping systems. Pestology. 30: 28-30.
23. Chandra, D., 1992. Evaluation of suitable rice and pigeonpea varieties for intercropping udder upland conditions in Orissa, India. Int. Rice Res. Newsletter, 17: 19.
24. Chatterjee, B.N. and S. Bhattacharya. 1986. Grain Legumes. Oxford and IBH Publ. Co., New Delhi. pp. 344-356.