



Competitive ability of different barley based intercropping systems

Muhammad Abu Bakar^{1*}, Riaz Ahmad¹, Abdul Jabbar², Muhammad Abid³, Iqbal Husain¹

¹Department of Agronomy, University of Agriculture, Faisalabad, Pakistan

²Department of Agronomy, (PARS) University of Agriculture, Faisalabad, Pakistan

³Soil and water Conservation Department, Soon Valley, Khushab, Pakistan

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Abstract

The competition function of different component crops under barley-based intercropping system with different geometric arrangements was investigated in sandy-clay loam soil at University of Agriculture, Faisalabad for two consecutive years. The geometric arrangements were comprised 40 cm spaced single row, 60 cm spaced double row strips and 100 cm spaced four row strips, while the intercropping system were barley alone, barley + chickpea, barley+ lentil, barley + berseem, barley + linseed, barley + fennel, barley + garden cress (Haloan) and barley + garlic. The main crop barley was sown with different associated cultures and it appeared to be a dominant crop as indicated by its positive sign of aggressiveness, higher values of relative crowding coefficient and competitive ratio. This concluded that barley utilized the available resources more efficiently than respective intercrops.

*Corresponding Author: Muhammad Abu Bakar ✉ abubakaruaf@yahoo.com

Introduction

The population of the under developed countries like Pakistan is increasing day by day but the food production remains stagnant due to low crop productivity and limited resources. So, there is need for increasing production of food grains, oil seeds and pulses because huge amount of foreign exchange is spent on the import of these commodities. The area under barley and other rabi crops cannot be increased due to competition with wheat. Thus, we need to develop new crop management techniques like intercropping for improving production per unit area and efficient use of resources.

Small farmers in many countries are getting low production due to limited resources. Woodhead *et al.*, (1994) reported that only in South Asia 12 million hectare area is under double cropping. Ghosh, (2004) stated that intercropping is a possible way of increasing the productivity on small farms as it provides security against potential losses of monoculture. It is simple and inexpensive planting method which has an advantage over sole cropping (Awal *et al.*, 2006). Barros *et al.*, (2004) stated that uniform adjustment of the crop spacing in the field is one of the most important factors for yield and quality of crops.

Thus intercropping is a major form of multiple cropping systems where a variety of intercrop combination exist. Intercropping is an advance agro-technique and is considered to be an effective and potential mean of increasing crop production per unit area particularly for farmers with small holdings. It helps to solve the different problems as, low productivity per unit area and ensure the sustainability of the production system (Nazir *et al.*, 1997; Ahmad and Saeed, 1998). Intercropping becomes very important due to maximum utilization of resources by the crops and improved consistency from season to season. When a legume is grown in association with another crop (intercropping) commonly a cereal, the nitrogen utilization of the associated crop may be improved by direct nitrogen transfer from legume to cereal (Giller and Wilson. 1991. Xiao *et al.*, 2004).

Pulses with their adjustability to different cropping systems and their capability to fix nitrogen, may offer chances to sustain productivity (Jeyabal and Kuppaswamy, 2001). Therefore, productivity is enhanced by the introduction of a legume in a cropping system (Maingjet *et al.*, 2001).

Barley (*Hordeum vulgare* L.) ranks second position in winter cereals after wheat in Pakistan. During 2011-12, it was grown on 75 thousand hectares and the total production stood at 70 thousand tones which is 1.4% less than the previous year 2010-11 (Anonymous, 2011). The less area under cultivation of barley due to the competition with wheat (*Triticum aestivum* L.) is the main reason of low production in the country. So, the best way to increase the production of barley is to grow it in association with legumes and oilseeds because of their ever increasing use in the daily human diet.

However, conventional planting geometry does not permit convenient intercropping. There is dire need to search a new pattern of plantation that can give barley yields compatible with that of the conventional plantation and also facilitates intercropping. The competitive behaviour of component crops across different barley-based intercropping systems were determined in terms of aggressivity (A), relative crowding coefficient (RCC) and competitive ratio (CR). Keeping in view the importance of intercropping present study was, therefore, undertaken to determine the competition function of some barley-based intercropping systems under agro-climatic conditions of Faisalabad, Pakistan.

Materials and methods

Experimental site and design

The present study was conducted at agronomic research area, University of Agriculture, Faisalabad, during 2009-10 and 2010-11 in sandy clay loam soil to assess the competition functions of barley-based intercropping system. Before sowing, the soil samples were taken from 0-15 cm and 15-30 cm depth for physico-chemical analysis. The soil of experimental site was sandy clay loam, having pH 7.85, electrical

conductivity 1.14 dS m⁻¹, organic matter 0.76%, total nitrogen 0.041%, available phosphorus 6.90 ppm and exchangeable potassium 137 ppm. The intercropping systems comprised barley alone, barley + chick pea, barley + lentil, barley + berseem, barley + linseed, barley + fennel, barley + garden cress (haloon) and barley + garlic, while the geometric arrangements involved 40 cm spaced single rows, 60 cm spaced double row strips and 100 cm spaced four row strips. Replicated three times the experiment was laid out in randomized complete block design (RCBD) with split plot arrangement randomizing the geometric arrangements in main plots and intercropping systems in sub-plots. The net plot size was kept 3.2 m × 7 m.

Crop Husbandry

Uniform seed bed was prepared for all component crops in all experimental units. For seedbed preparation, pre-soaking irrigation of four acre inches was applied, and after the arrival of soil at workable soil moisture, the seedbed was prepared by cultivating three times with the help of tractor mounted cultivator. Barley and its associated cultures were sown in this seedbed soil on 4th November 2009 and 6th November 2010 with single row hand drill in both years. Pure stand of all crops was also maintained in this experiment. Fertilizer was applied as the requirement of main crop (barley) at the rate of 100: 75: 75 kg NPK ha⁻¹ in the form of Urea, Diammonium Phosphate and Sulphate of Potash. A basal dose of fertilizer 50-75-75 kg NPK ha⁻¹ was applied at sowing time while the remaining half nitrogen (50 kg ha⁻¹) was applied at the time of first irrigation. Three irrigations of 7.5 cm depth were applied during the entire growth period of crop. The first irrigation was applied 30 days after the germination, while 2nd irrigation was given 70 days after germination and 3rd irrigation was applied at earing stage. All crops were harvested manually at maturity. Observations on relevant parameters were recorded at harvest by using standard procedures.

Competition functions

The competitive functions of different component crops in barley-based intercropping system was

determined in terms of aggressivity (A), relative crowding coefficient (K) and competitive ratio (CR) which were determined by using the following formulae:

Aggressivity value was derived from the following formula proposed by McGilchrist (1965).

$$A_{ab} = \frac{Y_{ab}}{Y_{aa} \times Z_{ab}} - \frac{Y_{ba}}{Y_{bb} \times Z_{ba}}$$

Where

A_{ab} = Aggressivity value for the component crop "a". Y_{aa} pure stand yield of crop "a".

Y_{ab} intercrop yield of crop "a". Y_{bb} pure stand yield of crop "b". Y_{ba} intercrop yield of crop "b". Z_{ab} are sown proportions of crop "a" in an intercropping system. Z_{ba} are sown proportions of crop "b" in an intercropping system.

Relative crowding coefficient (K) was calculated by the following formula which was proposed by Dewit (1960):

$$K_{ab} = \frac{Y_{ab}}{Y_{aa} - Y_{ab}} \times \frac{Z_{ba}}{Z_{ab}}$$

K_{ab} = Relative crowding coefficient for the component crop "a".

Competitive ratio (CR) was calculated by the formula proposed by Willey *et al.* (1980).

$$CR_a = \frac{Y_{ab}}{Y_{aa} \times Z_{ab}} \div \frac{Y_{ba}}{Y_{bb} \times Z_{ba}}$$

CR_a = Competitive ratio value for the component crop "a". All the other abbreviations have been described above in this section.

Results and discussion

Aggressivity (A): Aggressivity value is an important tool for determining the competitive ability of crops when they were grown in association with each other. If the aggressivity value is zero, then it indicates that the components crops are equally competitive. In any other conditions, if the crops have the same numerical value, then the dominant specie are signed positive and the dominated specie are signed with negative. The aggressivity values of the component crops which are shown in the Table 1 revealed that associated crops did not equally compete with maincrop (barley). Aggressivity value was the minimum for barley + garlic at 40 cm spaced

single rows (-0.19), (-0.11) and (0.03) at 60 cm spaced double row strips and 100 cm spaced four row strips, respectively which indicates the most competitive crop with barley, while the lentil, chick pea and berseem showed less competition with barley. Sarkar *et al.*,

(2001), Bhatti *et al.*, (2006) and Sarkar and Chakraborty (2000) also reported similar type of results in different legume and non-legume intercropping systems.

Table 1. Aggressivity of barley based intercropping system as influenced by geometric arrangements.

Intercropping system	40cm spaced single rows (P ₁)		60cm spaced double row strips (P ₂)		100cm spaced four row strips (P ₃)		System (P ₁ +P ₂ +P ₃)/3	
	barley	intercrop	barley	intercrop	barley	intercrop	barley	intercrop
Barley+Chick pea	0.22	-0.22	0.11	-0.11	0.04	-0.04	0.12	-0.12
Barley+Lentil	0.30	-0.30	0.17	-0.17	0.04	-0.04	0.17	-0.17
Barley+Berseem	0.33	-0.33	0.19	-0.19	0.08	-0.08	0.20	-0.20
Barley+Linseed	0.31	-0.31	0.18	-0.18	0.06	-0.06	0.18	-0.18
Barley+Fennel	0.36	-0.36	0.16	-0.16	0.07	-0.07	0.19	-0.19
Barley+Garden cress	0.41	-0.41	0.18	-0.18	0.07	-0.07	0.22	-0.22
Barley+Garlic	0.19	-19.00	0.11	-0.11	0.03	-0.03	0.11	-0.11

Relative crowding Coefficient (RCC)

For determining the yield advantages of intercropping system, the product of both component crops is formed which is designated by 'K', if the product of component crops is equal then the intercropping system has no yield advantages and if 'K' value is greater or less than one, then it shows yield advantages and disadvantages, respectively. In all the intercropping systems comprised in this experiment, barley appeared to be extremely dominant as it had greater value of 'K' than the intercrops in all the intercropping systems (Table 2). As the product of the coefficient of associated crops was higher than one, therefore, all the intercropping systems had yield benefits or advantages. In case of intercropping

systems, the supreme yield advantage was recorded from barley + lentil as it showed the maximum value of 'K'. Among the geometric arrangements, the yield advantages increased in 100 cm spaced four row strips over 60 cm spaced double row strips or 40 cm spaced single rows as specified by the k values (66.662, 38.350 and 6.112) for barley-lentil intercropping systems, respectively (Table II). Similar results were observed by Bhatti (2005) in sesame-munbean intercropping system and in another study Sarkar and Chakraborty (2000) noted the highest RCC value of product of coefficient when sesame was intercropped with chick pea.

Table 2. Relative crowding coefficient (RCC) of barley based intercropping system as influenced by geometric arrangements.

Intercropping system	40cm spaced single rows		60cm spaced double row strips		100cm spaced four row strips				
	barley	intercrop system	barley	intercrop system	barley	intercrop system			
Barley+Chick pea	4.739	1.539	7.294	15.627	2.598	40.593	13.736	3.780	51.917
Barley+Lentil	5.185	1.179	6.112	23.950	1.601	38.350	17.324	3.848	66.662
Barley+Berseem	3.422	0.806	2.757	7.704	1.032	7.952	8.291	1.307	10.834
Barley+Linseed	3.744	0.929	3.477	10.503	1.195	12.552	10.162	2.100	21.340
Barley+Fennel	3.061	0.657	2.010	5.528	1.139	6.299	6.628	1.526	10.115
Barley+Garden cress	3.218	0.538	1.730	6.398	1.029	6.584	7.139	1.506	10.754
Barley+Garlic	4.423	1.651	7.300	13.574	2.565	34.824	11.887	3.764	44.740

Competitive ratio (CR)

The competitive function of an intercropping system is also determined by competitive ratio (CR), which tells us the degree with which one crop competes with the other.

Higher CR values for barley over the other associated cultures showed that in all the three planting patterns barley was more competitive than other intercrops (Table 3). The competitive ratio (CR) was maximum (0.78) for

berseem in 40 cm spaced single rows which proved that berseem was best competitor with barley in 40 cm spaced single rows geometric arrangement while 60 cm spaced double row strips intercropped chick pea showed the highest value (0.80) of CR and proved best competitor to barley than other intercrop. In case of 100 cm spaced four row strips berseem showed maximum competition (0.93) with barley rather than other intercrops. As for as intercropping systems Barley + berseem proved the best competitor (0.83) than other intercropping systems. It is evident from the competitive ratio (CR) value that

except berseem the other crops like lentil, chick pea, linseed, fennel, garden cress (haloon) and garlic are the most appropriate crops for intercropping in barley. These results are in line with the findings of Bhatti (2005) and El-Edward *et al.*, (1985). An uncertain competitive ratio was also reported by Sarkar and Chakraborty (2000) when sesame was intercropped with mungbean in 1:1 ratio. It is obvious from the data relating to A, RCC and CR that barley was dominant crop in each intercropping system.

Table 3. Competitive ratio (CR) of barley based intercropping system as influenced by geometric arrangements.

Intercropping system	40cm spaced single rows (P_1)		60cm spaced double row strips (P_2)		100cm spaced four row strips (P_3)		System ($(P_1+P_2+P_3)/3$)	
	barley	intercrop	barley	intercrop	barley	intercrop	barley	intercrop
Barley+Chick pea	1.30	0.77	1.25	0.80	1.15	0.87	1.23	0.81
Barley+Lentil	1.31	0.76	1.38	0.73	1.13	0.89	1.27	0.79
Barley+Berseem	1.28	0.78	1.28	0.78	1.08	0.93	1.21	0.83
Barley+Linseed	2.00	0.50	2.09	0.48	1.62	0.62	1.90	0.53
Barley+Fennel	1.94	0.52	1.58	0.63	1.43	0.70	1.65	0.62
Barley+Garden cress	2.31	0.43	1.73	0.58	1.47	0.68	1.84	0.56
Barley+Garlic	1.79	0.56	1.57	0.64	1.41	0.71	1.59	0.63

Conclusion

It is concluded that barley appeared to be dominant crop as indicated by its higher values of RCC, CR and positive sign of aggressivity. Barley grown in association with component crops like chick pea, lentil, berseem, linseed, fennel, garden cress and garlic exploit the resources more aggressively and efficiently.

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