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Competitive Functions of Components Crops in Some Barley Based Intercropping Systems

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ABSTRACT

Behaviour of component crops in different barley based intercropping systems under different nutrient levels was investigated in a field study conducted for two consecutive years on a sandy-clay loam soil at the University of Agriculture, Faisalabad. The nutrient levels comprised 0-0-0 (control), 100-0-0, 100-75-0, 100-75-75 kg NPK ha^{-1} while intercropping systems were barley alone, barley+lentil, barley+gram, barley+methra, barley+linseed, barley+canola. The base barley crop was sown in 75 cm spaced 4-row strips with intercrops seeded between these strips. In all systems at different nutrient levels barley was dominant over all intercrops except canola in barley+canola system, where it proved to be better competitor. Barley showed higher values of aggressivity (+0.07), relative crowding coefficient (10.10) and competitive ratio (1.43) in barley+lentil intercropping system, while in barley+canola system, canola showed higher values of +0.43, 7.83 and 3.29 for aggressivity, relative crowding coefficient and competitive ratio, respectively.

Key Words: Barley; Legume and non-legume intercropping; Competitive behaviour; Component crops

INTRODUCTION

Intercropping in recent years has received great attention of the farming community, because of potential advantages it offers in respect of improved utilization of growth resources by the crops and sustaining productivity from season to season. It has long been a common practice in developing countries. There are 12 million hectares under double cropping system in South Asia only (Woodhead *et al*., 1994). Farmers are motivating to adopt intercropping primarely due to its economic gains (McCrown *et al*., 1988; Nazir *et al.,* 2002; Bhatti *et al.,* 2006). In intercropping systems when a legume is grown in association with other crop (intercrop) commonly a cereal, the nitrogen of the associated crop may be improved by dircect nitrogen transfer from legume to cereal (Giller & Wilson, 1991). Legumes with their adapalibility to different cropping patterns and their abiality to fix nitrogen, may offer opportunities to sustain increased productivity (Jeyabel & Kuppuswamy, 2001). Productivity normally is enhanced by intercropping legumes in cropping systems (Maingi *et al*., 2001). Legumes, both alone and as intercrop with cereals, have been advocated not only for yield augmentation but also for maintenance of soil health, particularly in degraded soil (Chatterjee & Bhattacharjee, 1986; Banik & Bagchi, 1993). The competitive behavior of component crops in different intercropping systems was determined in terms of relative crowding coefficient, aggressively, and competitive ratio. In general, non-legume crop is considered a suppressing crop in legume/non legume associations.

Pakistan is a sub-tropical country having adequate irrigation and land resources with high intensity of sunlight for plant growth. Therefore, possibility of raising two or more crops on the same piece of land in a year needs to be explored for effective and efficient utilization of these natural resources. Intercropping is being looked as an efficient and most economical production system as it not only increases the production per unit area and time but also improves the resource-use efficiency and economic standard of the growers (Noor & Saeed, 1998). Presently, interest in intercropping is increasing among the small growers, because of their diversified needs and low farm income from the mono-cropping system.

The present study describes the competitive behaviour of some barley based intercropping systems at different nutrient levels under agro-climatic conditions of Faisalabad, Pakistan.

MATERIALS AND METHODS

A field study to access yield advantages and competition functions of different barley based intercropping systems was conducted at the University of Agriculture, Faisalabad for two consecutive years (2004 & 2005). The soil was sandy clay loam. The intercropping systems were barley alone, barley+lentil (*Lens culinaris* Medic.), barley+gram (*Cicer arietnum* L.), barley+methra (*Trigonella usitatissimum* L.), barley+linseed (*Linum*

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usitatissimum L.) and barley+canola (*Brassica napus* L.), while nutrient levels were 0-0-0 (control), 100-0-0, 100-75-0, 100-75-75, kg NPK ha^{-1}. A triplicate split plot design placing nutrient levels in main plots and intercrops in sub-plots was used. The net plot size was 3.6 m x 6 m. All crops were drilled with single row hand drill at optimum soil moisture on a well prepared seedbed in 75 cm spaced 4 row strips with 15 cm space between the rows in a strip. The respective fertilizer doses were applied with two third nitrogen and whole P_2O_5 and K_20 as a basal dose and remaining 1/3rd nitrogen was top dressed at tillering stage of barley. The crops were kept free of weeds by hand weeding at 40 days after sowing (DAS). Three irrigations each of 7.5 cm were given during the entire growth period of crops. The first irrigation was given at tillering stage, second at booting and third at grain development stage of the crops. All crops were harvested manually at maturity. Data on desired parameters of main and component crops were recorded using standard procedures and analyzed statistically using MSTAT C statistics package on a computer (Freed & Eisensmith, 1986). The differences among treatments means were compared by least significant difference (LSD) test at P= 0.05 (Steel *et al*., 1997).

The competitive functions were computed in the form of relative crowding coffecient, aggressivity, competitive ratio. Abbreviations used to calculate different competitive functions were Yaa pure stand yield of crop "a", Yab intercrop yield of crop "a", Ybb pure stand yield of crop "b", Yba intercrop yield of crop "b". Zab and Zba are sown proportions of crop "a" and "b" in an intercropping system. Relative crowding coefficient (K) as proposed by Dewit (1960) was calculated Kab=(Yab/Yaa–Yab) – (Zba/Zab), where Kab is relative crowding coefficient for the component crop "a". The aggressivity (A) shows the degree of dominance of one crop over other when sown together. Aggressivity value was calculated by the formula proposed by McGilchrist (1965) as Aab=(Yab/Yaa + Zab) – (Yba/Yba + Zba), where Aab is aggressivity value for the component crop "a". Competitive ratio (CR) was calculated by the formula proposed by Willey *et al.* (1980) as CRa=(Yab/Yaa x Zab) ÷ (Yba/Ybb x Zba), where CRa is competitive ratio for the component crop "a". All the other abbreviations have been described above in this section.

RESULTS AND DISCUSSION

Relative crowding coefficient (RCC). All intercropping systems in this study except barley+canola, barley appeared to be highly dominant as it had higher value of `K' than the intercrops at all nutrient levels (Table I). It may be inferred that canola intercrop utilized the resources more competitively than lentil, gram, methra and linseed, which were dominated. As the product of the coefficient of component crops was greater than one, therefore all the intercropping systems had yield advantages. Among the intercropping systems, the maximum yield advantage was obtained from barley+gram as indicated by its maximum value of `K' (Table. I). Yield advantages increased at all nutrient levels with maximum relative crowding coffecient (K), where NPK was applied at 100-75-75 kg ha^{-1}. However, except barley+linseed showed highest K value, where NPK at 100-75-0 kg ha^{-1} was applied (Table I).

Aggressivity. 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 dominated negative. The greater the numerical value, the bigger the differences between actual and expected yields.

The data shown in Table II revealed that the component crops did not compete equally. Regardless of the nutrients levels, there was a positive sign for barley and the negative for intercrops showing there by that the barley was dominant, while intercrops were dominated. However, in a barley + canola intercropping system barley was dominated by canola. Aggressively value was the minimum for barley + canola under all the nutrient levels, which indicated that canola was the most competitive crop to barley. By contrast, lentil, gram, methra and linseed proved to be less competitive to barley at all nutrient levels.

Competitive ratio (CR). The competitive ratio is an important tool to know the degree with which one crop competes with the other. Higher CR values for barley than the intercrops except canola indicated that at all the nutrient levels barley was more competitive than lentil, gram, methra, linseed (Table III). The competitive ratio was higher for canola at all the nutrient levels. These results suggest that among intercrops, canola proved to be a better competitor as compared to other intercrops when grown in association with barley. It is evident from the competitive ratio that lentil, gram, methra and linseed are the most suitable crops for intercropping in barley.

Willey and Rao (1980) reported that CR gives a better measure of competitive ability of the crops and can prove a better index as compared with RCC and aggressively. Advantages from wheat-legume intercropping system have been reported by (Banik, 1996). Among the intercrops, canola proved to be more competitive. Sbedi (1997) reported that wheat when intercropped with toria (*Brassica compestris* L.) will be less profitable as compared with peas. Lentil, gram, methra and linseed exhibited almost similar competitive behavior regardless of the nutrient levels. Tahir *et al.* (2003) found that wheat proved to be a better competitor than other intercrops when grown in association with canola. Tofinga (1991) and Mandal *et al.* (1991) showed beneficial results of wheat and pea intercropping. Zaman (1989) also showed the benefit of intercropping wheat with lentil and chickpea respectively. Bhatti *et al.* (2006) reported that sesame grown in association with mungbean, mashbean and cowpeas utilizes the resources more aggressively than the respective intercrops.

Table I. Relative crowding coefficient as influenced by NPK (kg ha^{-1}) levels and barley-based intercropping systems

Intercropping systems	F_0 (0-0-0)			F_1 (100-0-0)			F_2 (100-75-0)			F_3 (100-75-75)		
	Barley (KB)	Intercrops (KI)	System (K=KB*KI)	Barley (KB)	Intercrops (KI)	System (K=KB*KI)	Barley (KB)	Intercrops (KI)	System (K=KB*KI)	Barley (KB)	Intercrops (KI)	System (K=KB*KI)
Barley + Lentil	8.1	1.06	8.59	7.33	1.32	9.68	8.99	1.32	11.87	10.10	1.32	13.33
Barley + gram	5.78	1.26	7.28	4.79	1.74	8.33	7.36	2.41	17.74	8.54	2.56	21.86
Barley + Methra	3.87	1.29	4.99	4.21	1.57	6.61	6.59	1.98	13.05	6.47	2.1	13.59
Barley + Linseed	3.25	0.93	3.02	3.34	1.22	4.07	3.23	1.29	4.17	2.24	1.37	3.07
Barley + Canola	0.85	4.24	3.6	0.82	6.18	5.07	0.74	7.53	5.57	1.57	7.83	4.46

K: Relative crowding coefficient
KB: Relative crowding coefficient for barley
KI: Relative crowding coefficient for intercrops

Table II. Aggressivity as influenced by NPK (kg ha^{-1}) levels and barley-based intercropping systems

Intercropping Systems	F_0 (0-0-0)		F_1 (100-75-0)		F_2 (100-75-0)		F_3 (100e-75-75)		Systems (F_0+F_1+F_2+F_3)/4	
	Barley (Aab)	Intercrop (Aba)	Barley (Aab)	Intercrop (Aba)	Barley (Aab)	Intercrop (Aba)	Barley (Aab)	Intercrop (Aba)	Barley (Aab)	Intercrop (Aba)
Barley + Lentil	0.08	-0.08	0.06	-0.06	0.06	-0.06	0.07	-0.07	0.07	-0.07
Barley + gram	0.06	-0.06	0.03	-0.03	0.01	-0.01	0.01	-0.01	0.03	-0.03
Barley + Methra	0.05	-0.05	0.03	-0.03	0.03	-0.03	0.02	-0.02	0.03	-0.03
Barley + Linseed	0.07	-0.07	0.04	-0.04	0.04	-0.04	0.02	-0.02	0.04	-0.04
Barley + Canola	-0.32	+0.32	-0.42	+0.42	-0.47	+0.47	-0.49	+0.49	-0.43	+0.43

Aab: Aggressivity value for the component crop "a"
Aba: Aggressivity value for the component crop "b"

Table III. Competitive ratio as influenced by NPK (kg ha^{-1}) levels and barley-based intercropping systems

Intercropping Systems	F_0 (0-0-0)		F_1 (100-0-0)		F_2 (100-75-0)		F_3 (100-75-75)		Systems (F_0 + F_1+F_2+F_3)/3	
	Barley	Intercrop	Barley	Intercrop	Barley	Intercrop	Barley	Intercrop	Barley	Intercrop
Barley + Lentil	1.55	0.65	1.37	0.73	1.39	0.72	1.4	0.71	1.43	0.70
Barley + gram	1.36	0.73	1.14	0.87	1.06	0.95	1.05	0.96	1.15	0.88
Barley + Methra	1.28	0.78	1.17	0.85	1.13	0.89	1.1	0.91	1.17	0.86
Barley + Linseed	1.48	0.68	1.28	0.78	1.24	0.81	1.11	0.9	1.28	0.79
Barley + Canola	0.38	2.66	0.32	3.17	0.29	3.5	0.26	3.81	0.31	3.29

Aggressively, relative crowding coefficient and competitive ratio indicated barley a dominant species in a crop mixture situation. Greater competitive ability of wheat to exploit resources in association with chickpea has been reported by (Li *et al*., 2002). The advantages accrued from intercropping systems, as evident from competitive functions are due to better growth resources under cereal-legume intercropping system (Ofori & Stern, 1987). All intercropping treatments of Indian mustard+legumes were greater in relative crowding coefficient than monocultures (Jana *et al.,* 1995). The primary object of intercropping in this situation is to achieve full yield of the staple crop and additional yield from the second crop so that the combination giving the best yield of the second crop without reducing the yield of main crop is desired.

It is concluded that barley appeared to be the dominant crop as indicated by its higher values of relative crowding coefficient, competitive ratio and positive sign of the aggressively. Barley grown in association with lentil, gram, methra and linseed utilized the resources more aggressively than the respective intercrops, which dominated except canola, and hence conferring their suitability as promising crops in barley based cropping systems.

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