HELIA, **19**, Nr. 25, p.p. 71-78, (1996) UDC 631.584.5:633.854.78

SUNFLOWER-SUMMER LEGUMES INTERCROPPING SYSTEMS UNDER RAINFED CONDITIONS: COMPETITION AND YIELD ADVANTAGE

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Received: November 13, 1996.
Accepted: December 20, 1996.

SUMMARY

Competition and yield advantage of sunflower-summer legumes intercropping systems were studied at University of Arid Agriculture, Rawalpindi, Pakistan, during summer 1994 to determine their feasibility for increased yield from the same resources. Sunflower-soybean and sunflower-mungbean intercropping systems gave the highest (1.38) land equivalent ratio, followed by sunflower-mashbean intercropping system (1.34). The three intercropping systems gave higher combined yield than single cropping of component crops. Among the component crops, sunflower appeared to be the dominant with higher values for relative crowding coefficient, positive aggressivity and higher competitive ratio. Sunflower in the three intercropping systems showed similar behaviour for aggressivity and competitive ratio. Also, the degree of competition offered by summer legumes was very similar.

Key words: *Helianthus annuus* L., *Glycine max* Merr., *Vigna radiata* Roxb., *V. mungo* L., land equivalent ratio, relative crowding coefficient, aggressivity value, competitive ratio.

INTRODUCTION

One of the more promising ways to increase productivity is intercropping. Crops grown in association with each other compete for available resources. The degree of competition between component crops determines the advantage of intercropping. Sandhu (1988) reported that all the soybean (*Glycine max* Merr.) - mashbean (*Vigna mungo* L.) intercropping combinations gave higher land equivalent value than single crops. Sunflower (*Helianthus annuus* L.) - pigeonpea (*Cajanus cajan*) intercropping also gave higher value for land equivalent than the single cropping of the component crops (Ujjinaiah et al., 1991 and Umrani et al., 1987). Highest land equivalent ratio of 1.61 was obtained in groundnut (*Arachis hypogaea* L.) - sunflower intercropping system (Koppalkar and Sheelavantar,

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1990). Intercropping the same crops gave the highest yield advantage of 40 % as measured by the land equivalent ratio (Biradar et al., 1988). Also, Iqbal (1987) stated that alternate single rows pattern gave 36.05% yield advantage compared with single cropping of component crops. He also concluded that lentil (*Lens culinaris* L.) showed higher values for relative crowding coefficient, higher positive aggressivity values and higher values of competitive ratio in all the intercropping patterns showing thereby that lentil grown in association with gram utilized the resources more aggressively than gram (*Cicer arietinum* L.) which appeared to be dominated. The present study was designed to determine the competition and yield advantages of sunflower - summer legumes intercropping systems under rainfed conditions.

MATERIALS AND METHODS

Sunflower-summer legumes intercropping systems were evaluated for competition and yield advantage under rainfed conditions at University of Arid Agriculture, Rawalpindi, Pakistan, during the summer of 1994. Treatments comprised of single sunflower, soybean, mungbean (*Vigna radiata* Roxb.), mashbean as single crops and sunflower+soybean, sunflower+mungbean and sunflower + mashbean intercropping systems in an alternate row arrangement. The single sunflower crop was planted in rows 75 cm apart, whereas 30 cm row to row and 10 cm plant to plant distance was maintained in summer legumes. In the intercropping systems, alternate rows of summer legumes were planted in between the rows of sunflower. The crops were grown under normal rainfed conditions with normal agronomic practices. The design used was randomized complete block design (RCBD) with four replications maintaining a plot size of 4.5 x 10 m^2. For determining economic yield an area of 18 m^2 per plot was harvested and the yield converted to kg ha^{-1}. The competitive effects and yield advantages were calculated by the following formulas:

$$\text{Land equivalent ratio (LER)} = La + Lb = \frac{Ya}{Sa} + \frac{Yb}{Sb}$$

(Willey, 1979)

where, La and Lb are the LERs for the individual crops. Ya and Yb are the individual crop yields in intercropping. Sa and Sb are the individual crop yields in single crops.

$$\text{Expected Yield} = \frac{\text{Sown proportion of crop (a)} + \text{Yield of crop (a) in mixture}}{\text{Land equivalent ratio of crop (a) in percent}}$$

(Willey, 1979)

$$\text{Advantage percentage over expected yield} = \frac{\text{Difference between combined expected yield and combined mixture yield}}{\text{Combined expected yield}}$$

(Willey, 1979)

$$\text{Relative crowding coefficient} = \frac{\text{Mixture yield of crop (a)}}{\text{Pure stand yield of crop (a)} - \text{Mixture yield of crop (a)}}$$

(De Wit, 1960)

$$\text{Aggressivity value} = \frac{\text{Mixture yield of crop (a)}}{\text{Pure stand yield of crop (a) x sown proportion of crop (a)}} - \frac{\text{Mixture yield of crop (b)}}{\text{Pure stand yield of crop (b) x sown proportion of crop (b)}}$$

(McGilchrist, 1965)

$$\text{Competitive ratio} = \frac{\text{LER of crop (a)}}{\text{LER of crop (b)}}$$

(Willey and Rao, 1980)

RESULTS AND DISCUSSION

Land equivalent ratio

It is the relative area of single crops required to produce the yield achieved in intercropping. Figure 1 shows that the diagonal line (a) expresses the area of land equivalent ratio equal to one. If the actual points are lying above this diagonal line (a), it means that there is yield advantage in this mixture, if below, then a yield disadvantage. The diagonal line (d) arising from the origin gives the information about the dominance of crops. If LER value of any crop is above this line, then the crop of vertical axis is dominant, if below, then the crop of horizontal axis is dominant.

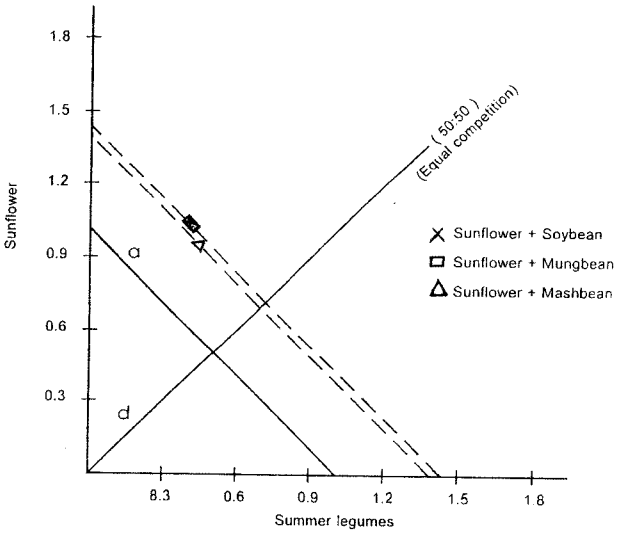

Figure 1: Land equivalent ratios in sunflower-summerlegumes intercropping-systems

The diagram clearly showed that sunflower crop was dominant while summer legumes were dominated. It is clear from Table 1 that maximum LER value of 1.38 was obtained for both sunflower-soybean and sunflower-mungbean intercropping and a minimum of 1.34 for the sunflower-mashbean intercropping. In other words there was a 38% advantage in sunflower-soybean and sunflower-mungbean intercropping over single component crops. This resulted in a saving of 38% area whereas there was a 34% advantage in sunflower-mashbean intercropping over the single component crops. These results agreed with those of Koppalkar and Sheelavantar (1990) who reported that the highest LER of 1.61 was obtained in a groundnut - sunflower intercropping system.

Yield advantage

Yield advantage from intercrops (soybean, mungbean and mashbean) can be seen in Figures 2, 3 and 4, respectively. The actual yields in mixtures are shown by solid lines and expected yields in mixtures by the dashed lines for each crop and for the total of both crops in a system. The diagonals (dashed lines) are thus the pure stand yields of each crop and uppermost dashed line becomes a combined pure stand yield. A vertical comparison between this combined pure stand yield and the combined mixture yield would now seem to give a simple assessment of any yield advantage of mixtures.

It is apparent from the three intercropping systems under study that the mixture yield of sunflower was higher than the expected yield, whereas the mixture yield of summer legumes was lesser than the expected yield. Situation where the yield of one crop is higher than its expected yield and the yield of another crop is less than its expected yield is termed as compensation. So in all the three intercropping systems studied, compensation occurred. As reported by Iqbal (1987) in gram-lentil intercropping system, that gave 36.05 % yield advantage in alternate single rows pattern compared with monocropping of component crops.

Relative crowding coefficient

Relative crowding coefficient plays an important role in determining the competitive effects and intercropping advantages. It measures whether a species has produced more or less yield than the expected. If a species has a coefficient less than, equal to, or greater than one it means that it has produced less yield, the same yield or more yield than the expected respectively. The component crop with the higher coefficient is the "dominant" one while the lower one is "dominated". To determine if there is yield advantage of mixing or intercropping, the product of coefficient of both the component crops is calculated, usually designated as K. If $K > 1$, there is yield advantage. If $K = 1$, there is no difference and if $K < 1$, there is a yield disadvantage.

Data regarding relative crowding coefficient are presented in Table 2 in which sunflower in a sunflower - summer legumes intercropping system produced considerably higher mixture yields than their expected yields, whereas summer legumes produced lesser mixture yields than their expected yields. The results

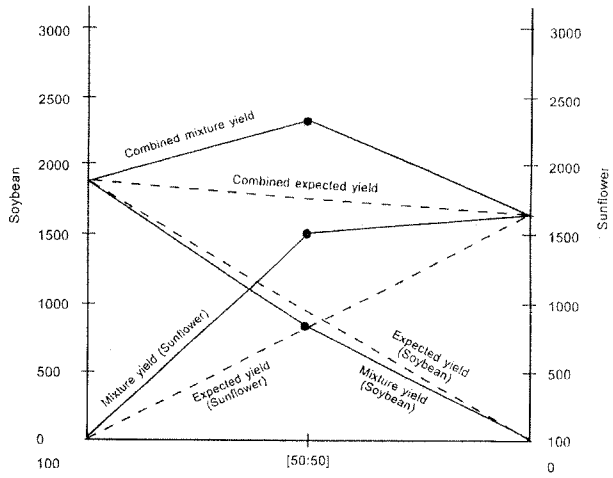

Figure 2: Competition and yield advantages in sunflower-soybean intercropping system

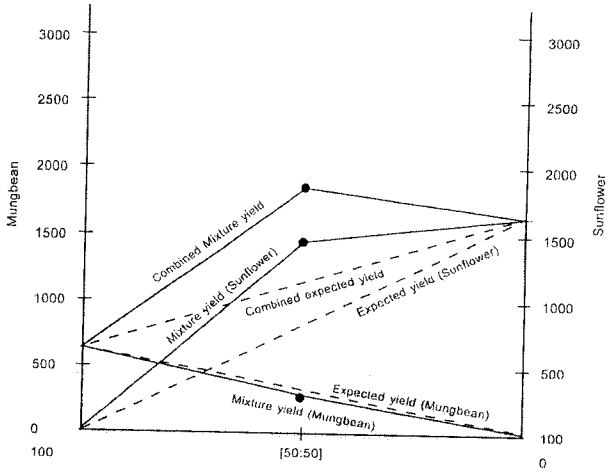

Figure 3: Competition and yield advantages in sunflower-mungbean intercropping

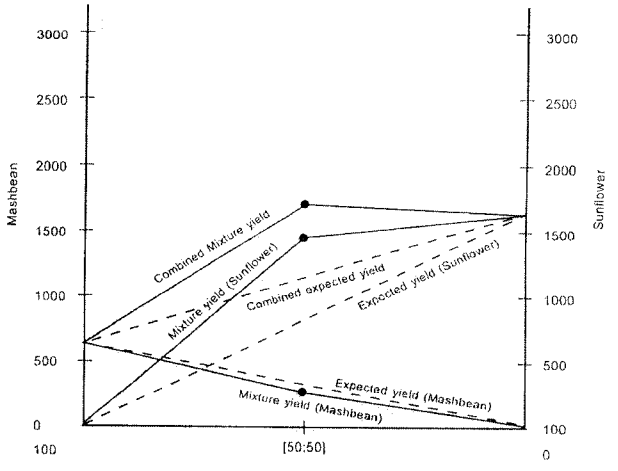

Figure 4: Competition and yield advantages in sunflower-mashbean intercropping

Table 1: Land equivalent ratios of sunflower-summer legumes intercropping systems.

Treatment	Land equivalent ratio (a)	Land equivalent ratio (b)	Land equivalent ratio (a+b)
Sunflower + Soybean	0.94	0.44	1.38
Sunflower + Mungbean	0.93	0.45	1.38
Sunflower + Mashbean	0.91	0.43	1.34

(a) = Sunflower (b) = Summer legumes

Table 2: Relative crowding coefficient, aggressivity and competitive ratio values in sunflower, summer legumes intercropping systems.

Treatment	Relative crowding coefficient			Aggressivity		Competitive ratio	
	(a)	(b)	(a+b)	(a)	(b)	(a)	(b)
Sunflower + Soybean	15.24	0.78	16.02	+ 0.99	- 0.99	2.14	0.47
Sunflower + Mungbean	12.73	0.82	13.55	+ 0.95	- 0.95	2.05	0.49
Sunflower + Mashbean	9.77	0.77	10.53	+ 0.95	- 0.95	2.09	0.48

(a) = Sunflower (b) = Summer legumes

further indicated that of the component crops, sunflower appeared to be dominant because it showed higher values of relative crowding coefficient than that of summer legumes in all the intercropping systems. It can be inferred that sunflower grown in association with summer legumes utilized the resources more aggressively than summer legumes which appeared to be dominated. This difference might also arise because in the intercropping systems a full population of sunflower was maintained whereas summer legumes were planted in alternate rows between the sunflower rows leading to fewer rows of summer legumes in the intercropping systems compared to pure stands. Among the intercropping systems under study, sunflower - soybean intercropping system gave the highest yield advantage compared to rest of the intercropping systems by having the highest total relative crowding coefficient of 16.02 compared to 13.55 and 10.53 for sunflower - mungbean and sunflower - mashbean intercropping systems respectively. As reported by Iqbal (1987) in lentil that showed higher values of relative crowding coefficient when grown in association with gram in different intercropping patterns.

Aggressivity

Aggressivity value is also 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 the component crops are equally competitive. On the other hand, the sign of the dominant species or crop will be positive and that of the dominated negative.

Data regarding the aggressivity values of sunflower and summer legumes revealed that the component crops did not compete equally (Table 2). The aggressivity values for sunflower had a positive sign indicating the dominant behaviour

of sunflower over summer legumes which had negative sign. The numerical values indicated that there were large differences between competitive abilities of the component crops and there are big differences among their expected and actual yields. The results agree with the findings of Iqbal (1987) who inferred that lentil showed higher positive aggressivity values in all the intercropping patterns showing thereby that lentil grown in association with gram utilized the resources more aggressively than gram which appeared to be dominated.

Competitive ratio

Competitive ratio is also an important way to assess the degree with which any crop competes with another. It clearly shows the competitive ability of a crop. Data regarding the competitive ratio is presented in Table 2. It is clear from the table that sunflower grown in rows 75 cm apart, with single alternate rows of soybean exhibited the highest competitive ratio (2.14) followed by alternate rows of mashbean and mungbean with competitive ratios of 2.09 and 2.05, respectively.

The results further indicated that sunflower proved to be a better competitor when grown in association with soybean, mungbean or mashbean. The results agree with Iqbal (1987) who studied gram-lentil intercropping relationship and found that lentil showed higher values of competitive ratio in all the intercropping patterns. Competitive ratios of 0.47, 0.49 and 0.48 for soybean, mungbean and mashbean, respectively, showed that all offered almost same degree of competition.

CONCLUSION

Efficiency of available resources is increased by intercropping compatible crops. Summer legumes; soybean, mungbean and mashbean have shown compatibility to be intercropped with sunflower. These summer legumes when intercropped with sunflower, keeping legume population low, produced higher total yield without causing much loss of sunflower yield. The degree of competition offered by these legumes was similar and added benefit is harvested from intercropping.

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SISTEMAS DE INTERCULTIVO GIRASOL-LEGUMINOSAS DE VERANO EN CONDICIONES DE SECANO: COMPETICIÓN Y VENTAJAS EN RENDIMIENTO

RESUMEN

La competición y vantaja de rendimiento en sistemas de intercultivo de girasol-leguminosas de verano fueron estudiadas en Basani Agricultural Collage, Rawalpindi durante el verano de 1994.

El sistema de intercultivo girasol-soja y girasol-judia mungo (*Vigna radiata)* dieron la relación equivalente de tierra mas alta (1.38), seguido por el sistema girasol-mungo (*Vigna mungo)* (1.34). Los tres sistemas de intercultivo dieron un rendimiento combinado mas alto que el cultivo simple de las especies componentes. Entre los cultivos componentes, el girasol apareció ser el dominante ya que mostró valores mas altos para el coeficiente relativo de población. El girasol en los tres sistemas de intercultivo mostró un comportamiento similar para agresividad y relación de competencia. También, el grado de competencia ofrecido por leguminosas de verano fué casi similar.

SYSTÉMES DE CULTURES ASSOCIÉES TOURNESOL / LÉGUMINEUSES D'ÉTÉ, EN CONDITIONS PLUVIALES: COMPÉTITION ET CONSÉQUENCES SUR LA PRODUCTIVITÉ

RÉSUMÉ

La compétition et l'avantage en termes de productivité de cultures associées tournesol / légumineuses d'été étudiées au Collége Agricole de Barani, Rawalpindi, durant l'été 1994. Les associations tournesol / soja et tournesol / haricot Mungo donnent les coefficients de surface relative équivalente, les plus élevés (1.38), devant l'association tournesol / vigna (1.34). Les trois systémes d'association donnent un rendement global plus élevé que la culture isolée d'une seule des composantes. Au sein des différentes cultures, le tournesol apparaît dominant, comme le montrent les fortes valeurs du coefficient d'occupation relativite, l'agressivité positive ainsi que le rapport élevé de compétition. Le tournesol dans les trois systémes d'association présente un comportement similaire pour les indices d'agressivité et de compétition. De même, le degré de compétition des légumineuses d'été apparaît quasi identique.