

## STUDY OF MUNGBEAN INTERCROPPING IN COTTON PLANTED WITH DIFFERENT TECHNIQUES

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**Abstract:** Bio-economic efficiency of different cotton-based intercropping systems was determined at the Agronomic Research Area, University of Agriculture, Faisalabad, (Pakistan) during 1996-97 and 1997-98. Cotton cultivar NIAB-78 was planted in 80-cm apart single rows and 120-cm spaced double row strips with the help of a single row hand drill. Intercropping systems were cotton alone, and cotton + mungbean. Experiment was laid out in a RCBD with split arrangements in four replications. Planting patterns were kept in main plots and intercropping systems in sub-plots. Intercrop was sown in the space between 80-cm apart single rows as well as 120-cm spaced double row strips. Competition functions like relative crowding coefficient, competitive ratio, aggressivity, land equivalent ratio and area time equivalent ratio were calculated for the assessment of the benefits of the intercropping. Partial budget was prepared for determining net field benefits of the systems under study. Growing of cotton in 120-cm spaced double row strips proved superior to 80-cm spaced single rows. Intercropping decreased the seed cotton production significantly in both years, however, intercrop not only covered this loss but also increased overall productivity. Higher net field benefit (NFB) was obtained from cotton + mungbean than sole cropping of cotton. Farmers with small land holdings, seriously constrained by low crop income can adopt the practice of intercropping of mungbean in cotton.

**Keywords:** Competition functions, cotton, intercropping systems, legumes, mungbean, planting patterns.

### INTRODUCTION

Cotton is the most important cash crop of Pakistan and it accounts for about 58.70 % of the total export earning and over 57.43 % of the domestic edible oil production [Govt. of Pakistan 2003]. Mungbean is very important pulse crop of the country. However, Pakistan is still deficient in many food commodities including pulses. A vast majority of Pakistani farmers (75%) have land holdings < 5 hectares [Govt. of Punjab 1990], extra domestic labor force, less resources and practice subsistence farming. Such situation demands a simultaneous increase in the productivity of cotton and pulses to fulfill the increasing diversified needs of the ever-growing population.

Vertical increase in the productivity of these crops can be achieved by adopting cotton-based intercropping systems. Low average yields necessitate developing an intercropping technology for increasing net income per hectare without doing much damage to the base crop.

The magnitude of the agro-economic advantages depends upon the type of intercrop [Rao 1991]. However, conventionally planted cotton does not

permit convenient intercropping in it. Therefore new patterns of cotton plantation in widely spaced multi-row strips need to be tested which can not only give seed cotton yields compatible with that of the conventional single-row plantation but also facilitates intercropping.

Details of different aspects of intercropping in cotton at various patterns of cotton plantation need to be explored in order to make the cotton-based intercropping system more feasible and economical. Work on this aspect is well documented, however, further research on different cotton-based intercropping systems is needed for the development of new systems of intercropping.

The objectives of this study were to compare the single-row and strip plantation of cotton in order to find out cotton planting pattern, facilitating intercropping without affecting the productivity of cotton at large and assess the feasibility and bio-economic efficiency of different cotton-based intercropping systems.

### MATERIALS AND METHODS

The study was conducted under irrigated conditions of Central Punjab at Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan during 1997 and 98. Experiment was laid out in randomized complete block design (R.C.B.D.) with split arrangement and four replications. Patterns were randomized in main plots and intercrops in subplots. Plot size was 4.8 m x 7 m. Cotton was sown in two different planting patterns i.e. 80-cm spaced single rows ( $P_1$ ) and 120-cm spaced 2-row strips [40/120 cm] ( $P_2$ ). Mungbean (*Vigna radiata* L.) cv. NM 121 was sown as intercrop in cotton. Mungbean was also sown as a sole crop for determining the land equivalent ratio (LER) and area time equivalent ratio (ATER). All the cultural practices were kept uniform during both the years under study.

Planting density, branches plant<sup>-1</sup>, pods plant<sup>-1</sup>, seeds pod<sup>-1</sup>, 1000 seeds weight, seed yield and biomass were recorded plant<sup>-1</sup> according to standard procedures. Harvest index (HI) and different competition functions were calculated by the following formulae:

$$\text{Harvest Index} = \frac{\text{Economic Yield}}{\text{Biological Yield}} \times 100$$

$$\text{Relative Crowding Coefficient} = K_{ab} = \frac{Y_{ab}}{Y_{aa} - Y_{ab}} - \frac{Z_{ba}}{Z_{ab}} \quad [\text{Dewit 1960}]$$

$$\text{Aggressivity (Aab)} = \frac{Y_{ab}}{Y_{aa} \times Y_{ab}} - \frac{Y_{ba}}{Y_{bb} \times Z_{ba}} \quad [\text{Mc Gillchrist 1965}]$$

$$\text{Competitive Ratio} = \frac{Y_{ab}}{Y_{aa} \times Z_{ab}} \div \frac{Y_{ba}}{Y_{bb} \times Z_{ba}} \quad [\text{Willey et al. 1980}]$$

$$\text{Land equivalent ratio (La + Lb)} = \frac{Y_{ab}}{Y_{aa}} + \frac{Y_{ba}}{Y_{bb}} \quad [\text{Willey 1979}]$$

$$\text{Area time equivalent ratio} = \frac{(R_{yc} \times t_c) \times (R_{yp} \times t_p)}{T} \quad [\text{Hiebsch 1980}]$$

where  $Y_{aa}$  = 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,  $Z_{ab}$  and  $Z_{ba}$  = sown proportions of crop "a" and "b" in intercropping system  $L_a$  and  $L_b$  are LER for individual components of system,  $R_{yc}$  = Relative yield of crop c,  $R_{yp}$  = Relative yield of crop p,  $t_c$  = Duration (days) for crop c,  $t_p$  = Duration (days) for crop p,  $T$  = Duration (days) for the whole system.

## RESULTS AND DISCUSSION

### YIELD AND YIELD COMPONENTS

#### Plant Density

Number of plant  $m^{-2}$  was not affected due to single row (80-cm spaced) or double row strips but number of plant  $m^{-2}$  in the sole mungbean crop were significantly higher than the aforementioned two planting patterns. Variable plant population of mungbean in intercropping system as compared with sole crop was attributed to more area available in sole cropping. Sahi [1988] and Saleem [1991] also reported that plant population  $m^{-2}$  of lentil was reduced significantly by the associated wheat crop as compared to its sole planting. Data on number of plant  $m^{-2}$  (Table 1) showed a non-significant difference during both the years under study.

#### Plant Height (cm)

Plant height of mungbean intercropped in any of the planting patterns was statistically at par with the height of mungbean plants grown as a sole crop (Table 1). On an average plant height ranged between 64.2-66.8 cm. Ashraf [1997] reported plant height of green gram within range of 55.5-69.9 cm, which was not affected by variation due to years.

#### Branches Plant<sup>-1</sup>

Significantly more branches plant<sup>-1</sup> (6.41) were recorded when mungbean was grown as sole crop as against those recorded in cotton+mungbean intercropped at either 80-cm apart single rows (5.45) or at 120-cm spaced double row strips of cotton with 5.70 branches plant<sup>-1</sup> and the later two being statistically at par (Table 1). Years and years x planting patterns had non-significant effect on number of branches plant<sup>-1</sup> because branching is basically a genetic character [Wilson *et al.* 1985]. However, agronomic management may influence this character and may play a role in enhancing seed yield. A fewer number of branches in intercropped mungbean were attributed to competition between intercrops for resources like nutrients, water, light as compared with the sole crop. This

resulted in depressed growth of mungbean plants in association with cotton at either planting pattern.

**Table 1:** Performance of mungbean intercropped in cotton planted in different planting patterns.

Parameter	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>	Sx
Plant density (m <sup>-2</sup> )	22.7 <sup>b</sup>	22.2 <sup>b</sup>	30. <sup>a</sup>	0.67
Plant height (cm)	64.2 <sup>ns</sup>	66.8	64.3	1.17
Branches plant <sup>-1</sup>	5.45 <sup>b</sup>	5.70 <sup>b</sup>	6.41 <sup>a</sup>	0.11
Pods plant <sup>-1</sup>	9.20 <sup>b</sup>	10.4 <sup>a</sup>	10.5 <sup>a</sup>	0.21
Seeds plant <sup>-1</sup>	67.0 <sup>b</sup>	74.5 <sup>a</sup>	75.0 <sup>a</sup>	2.17
1000-seed weight (g)	45.4 <sup>ns</sup>	45.3	44.4	1.48
Seed yield (kg ha <sup>-1</sup> )	465 <sup>c</sup>	642 <sup>b</sup>	792 <sup>a</sup>	13.1
Biological yield (kg ha <sup>-1</sup> )	2308 <sup>b</sup>	3118 <sup>a</sup>	3023 <sup>a</sup>	52.4
Harvest index (%)	20.1 <sup>b</sup>	20.6 <sup>b</sup>	26.2 <sup>a</sup>	

P<sub>1</sub> =80-cm spaced single rows of cotton. P<sub>2</sub> =120-cm spaced double rows strips of cotton.

P<sub>3</sub> =Sole crop, Figures followed by different letters are significant at 0.05 probability levels using LSD.

### Pods Plant<sup>-1</sup>

Number of pods plant<sup>-1</sup> (9.20) was significantly reduced when mungbean was intercropped in 80-cm spaced single row of cotton as against the sole crop of mungbean with 10.5 pods plant<sup>-1</sup> (Table 1). However, intercropping mungbean in 120-cm spaced double row strips of cotton produced 10.4 pods plant<sup>-1</sup>, which were similar to those produced by the sole crop of mungbean. Variation in the number of pods by various intercropping practices has also been reported by Subramaniam and Maheswari [1992]. Years had a non-significant effect on pods plant<sup>-1</sup> of mungbean. Interactive effect of years x planting patterns was also non-significant.

### Seeds Plant<sup>-1</sup>

Planting patterns influenced the seed plant<sup>-1</sup> in mungbean to significant level. Number of seeds plant<sup>-1</sup> in the 120-cm spaced double row strips of cotton were at par with sole mungbean but both were significantly higher than 80-cm spaced single rows. A fewer number of seed in the intercropped mungbean at 80-cm spaced single rows of cotton was ascribed to more and longer pods as compared with those of intercropped in 120-cm spaced double row strips as well as sole mungbean crop. Similar effects of different agro-management levels on seeds plant<sup>-1</sup> have been reported by Arya and Kalra [1988].

### 1000-Seed Weight (g)

Mungbean intercropped in either planting pattern of cotton produced statistically similar 1000-seed weight, which was at par with that recorded for the sole crop of mungbean. The years and years x planting pattern effect was non-significant. These results are contrary to those reported by Nishat [1989] concluded that 1000-seed weight of lentil decreased due to wheat+lentil intercropping. Statistically similar 1000-seed weight was recording for both years under study.

**Seed Yield (kg ha<sup>-1</sup>)**

Planting patterns significantly affected the seed yield of mungbean. A significantly higher yield was recorded when mungbean was sown as a sole crop (792 kg ha<sup>-1</sup>). The lowest yield was recorded when it was planted in 80-cm spaced single rows of cotton (465 kg ha<sup>-1</sup>). In both planting patterns yield also differed significantly. Rao [1991] also reported that, due to different planting patterns, yield differed by 34.8%.

The resulting lower yield due to intercropping is ascribed to a lower plant population, fewer branches plant<sup>-1</sup> and a fewer number of seeds plant<sup>-1</sup> (Table 1) in the former situation as compared with the sole crop of mungbean. A higher yield in the 120-cm spaced double row strips of cotton was attributed to a greater number of seeds plant<sup>-1</sup> as well as a higher 1000-seed weight due to more and longer pods plant<sup>-1</sup> in contrast to 80-cm spaced single rows. This was achieved by the availability of more space for light interception and air circulation and less shading of associated cotton crop. Several authors [Rao and Sadaphal 1993, Rao 1982] have also reported reduction in yield of mungbean in intercropping as compared with its sole cropping. Statistically similar seed yield was recorded during both years under study.

**Biological Yield (kg ha<sup>-1</sup>)**

Mungbean intercropped in the 120-cm spaced paired rows gave the highest biological yield (3118 kg ha<sup>-1</sup>) as compared to intercropped in either 80-cm spaced single rows of cotton (2308 kg ha<sup>-1</sup>) or as sole crop (3023 kg ha<sup>-1</sup>). Biological yields recorded during 1996 and 1997 were statistically similar. The competition for light, moisture and nutrients between intercrops in the 80-cm spaced single rows resulted in a reduction in various growth and yield parameters as compared with 120-cm spaced paired rows, as well as in the sole crop of mungbean (Table 1).

**Harvest Index (%)**

Mungbean grown in cotton planted 80-cm apart in single rows or in 120-cm spaced double row strips exhibited statistically similar harvest indices of 20.1 and 20.6, respectively (Table 1). However, harvest index from the sole crop was significantly higher than both intercropping treatments. Statistically similar harvest indices of mungbean were realized during both years under study. Years x planting pattern interaction was also found to be non-significant. Results reported by Hay and Walker [1989] were contrary to these findings.

**COMPETITION FUNCTIONS**

Competitive behavior of component crops was determined in terms of relative crowding coefficient, aggressivity and competitive ratio, land equivalent ratio and area-time equivalent ratio as follows:

### Relative Crowding Coefficient (RCC=K)

It can be inferred from the results that the intercropped cotton utilized the resources more competitively than mungbean, which appeared to be dominated [Abdel Malik *et al.* 1991] Across the planting patterns the yield advantage increased in 120-cm apart double row strips of cotton ( $P_2$ ) over 80 cm apart single rows ( $P_1$ ) as is indicated by the K values for  $P_1$  and  $P_2$  for each intercropping system (Table 2). Maize-soybean intercropping was reported for grain yield advantages over the respective monoculture as evaluated on the basis of RCC [EI-Edward *et al.* 1985].

Table 2: Competition functions as affected by mungbean intercropping in cotton in different planting patterns

Competition functions	80 cm apart single rows of cotton ( $P_1$ )		120 cm apart double row strips of cotton ( $P_2$ )		Systems	
	Cotton (C)	Intercrop (I)	Cotton (C)	Intercrop (I)	( $P_1$ ) C+I	( $P_2$ ) C+I
LER	0.90	0.59	0.90	0.81	1.50	1.71
ATER	0.90	0.29	0.90	0.40	1.19	1.30
C.R	3.13	0.39	2.20	0.46	2.67	0.43
Aggressivity	0.61	-0.60	0.49	-0.49	0.55	-0.55
RCR	7.73	0.92	7.11	7.00	3.78	26.46
Net benefits (Rs. ha <sup>-1</sup> )	Sole cotton =		31508	Cotton+mungbean =		34156

### Aggressivity (A)

Regardless of the planting patterns, a positive sign with values of cotton indicated the dominant behavior of cotton over the intercrops, which had negative 'A' values. Mungbean proved to be less competitive with cotton as there was a little difference among the aggressivity values across planting patterns. Other researchers [Gomaa and Radwan 1991] also reported the dominant effect of cotton having a positive 'A' value when grown in association with mungbean and mashbean.

### Competitive Ratio (CR)

Competitive ratio is an important way to know the degree with which one crop competes with the other. Higher CR values for cotton than those for all the intercrops indicated that at both the planting patterns cotton was more competitive than mungbean in 80-cm apart single rows of cotton (Table 2).

### Land Equivalent Ratio (LER)

LER values were greater than one in the intercropping system (Table 2) indicating the yield advantage of intercropping over sole cropping of cotton.

Aal [1991] and Raghuwanshi *et al.* [1994] also reported a higher LER in intercropping as compared to sole crops. In 80-cm apart single rows of cotton, maximum LER was recorded. In other words it is possible to harvest from a hectare of intercropping equal to that from 1.50 hectare of sole cropping of cotton. Similarly intercropping in 120-cm apart double

row strips of cotton showed maximum LER in case of cotton+mungbean (1.71) indicating yield advantages as high as 71%.

As regards planting patterns, LER values in double row strips of cotton were higher than single rows of cotton which indicated higher bio-economic efficiency of strip plantation over single row planting. Based on the average two years and regardless of planting patterns, cotton+mungbean gave the highest LER (1.61). However, LER in intercropping treatments compared with mono cropping of cotton was ascribed to better utilization of natural (land and light) and added (fertilizer and water) resources.

### **Area-Time Equivalent Ratio (ATER)**

The ATER provides more a realistic comparison of the yield advantage of intercropping over that of sole cropping than LER as it considers variation in time taken by the component crops of different intercropping systems. In all the treatments, the ATER values were smaller than LER values (Table 2), indicating the over estimation of resource utilization in the latter. On the basis of two years average data, ATER value indicated an advantage of 1 to 33% in intercropping compared with sole cropping of cotton regardless planting pattern (Table 2). Regarding the planting patterns, the ATER values for double row strips of cotton were higher than those for single rows of cotton indicating a better bio-economic efficiency of strip plantation of cotton over single row plantation. In 80-cm apart single rows of cotton, ATER values indicated yield advantages in the range of 19% for cotton+mungbean, which was 30% in the case of 120-cm apart double strips of cotton.

Higher values of ATER in intercropped treatments compared with monoculture of cotton were attributed to efficient utilization of natural and added resources. Higher ATER values have also been reported in cotton+cowpeas [Allen and Obura 1983].

The dominance analysis proved that cotton+mungbean intercropping system was actually more profitable (Rs. 2648 ha<sup>-1</sup>) than growing cotton alone.

### **CONCLUSIONS**

Intercropping systems reduced the seed cotton yield to a significant extent. However, additional production from intercrops obtained from cotton+mungbean compensated more than the losses in cotton production. Intercropping of mungbean in 120-cm apart double row strips of cotton proved to be feasible as well as convenient for farm operations.

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