▼ Journal of Research (Science), Bahauddin Zakariya University, Multan, Pakistan.
Vol.15, No.3, December 2004, pp. 325-331 ISSN 1021-1012

STUDIES ON INTERCROPPING SUMMER FODDERS IN COTTON

Muhammad Bismillah Khan[1] and Abdul Khaliq[2]
[1]Department of Agronomy, Bahauddiun Zakariya University, Multan, 60800. Pakistan
[2]Department of Agronomy, University of Agriculture, Faisalabad, 38040, Pakistan

Abstract: Performance of different summer fodders as intercrops in cotton was studied at the Agronomic Research Area, University of Agriculture, Faisalabad (Pakistan). Cotton was planted in 80-cm apart single rows and 120-cm spaced double row strips, while maize, sorghum, ricebean and cowpea fodders were intercropped in the space between 80-cm apart single rows as well as 120-cm spaced double row strips of cotton. The intercrops produced substantially smaller fresh weights in either planting pattern compared to the sole crop yields. However, intercropping system as a whole resulted in higher economic returns as compared to the sole crop of cotton. All the fodders intercropped in 120-cm apart double row strips of cotton produced significantly higher fresh weight as compared to 80-cm apart single rows, intercropping system.

Keywords: Cowpeas, cotton, cultivar, double row strip, fodders, intercropping, maize, planting pattern, rice bean, sorghum.

INTRODUCTION

In Pakistan a vast majority (75%) is of subsistence farmers having land holdings < 5 hectares [Govt. of Pakistan 1990]. Our small farms are overloaded with surplus family labor and yields on these farms are far low. Cotton is the most important cash crop of Pakistan; however its yield is low. 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]. Shortage of fodder is a serious problem especially with small farmers [Abdullah and Chaudhary 1996]. Such situation demands a simultaneous increase in the productivity of cotton and fodders to fulfill the increasing diversified needs of the ever growing population. Fodder needs could be met partially by growing fodders as inter and/or mixed crops at small farms of Pakistan.

Many workers [Mohamed and Salwau 1994, Saeed *et al*.1999, Rao 1991] reported that total crop productivity and net return per unit area as well as land equivalent ratio are higher in intercropping as compared to mono crop. However, conventional method of planting cotton in closely-spaced single rows does not permit convenient intercropping of fodders. New pattern of cotton plantation in widely spaced multi-row strips had to be developed which not only gives seed cotton yields comparable with that of the conventional single-row plantation but also facilitates intercropping [Bismillah *et al*. 2001]. This study was conducted to find out a planting pattern of cotton, facilitating intercropping of different fodders 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 experiment was conducted at Agronomic Research Area, University of Agriculture, Faisalabad (Pakistan), during 1999-2000 and 2000-2001. The crop was sown on a well drained sandy loam with pH 7.7. Split arrangement of randomized complete block design with four replications was used. Planting patterns were randomized in main plots and intercrops in subplots. Plot size was 4.8 m x 7 m.

Cotton cultivar NIAB 78 was sown in 80-cm spaced single rows and 120-cm spaced double row strips with the help of a single row cotton drill on May 27 and 29 during *kharif* 1999 and 2000, respectively.

Maize (*Zea mays* L.) cv. Neelum, sorghum (*Sorghum vulgare* L.) cv. BR-319, cowpeas (*Vigna unguiculata*) cv. P 76 and ricebean (*Vigna umbellata*) cv. IC 7588 were sown next day as intercrops in cotton. Each intercrop was also sown as a sole crop for determining the land equivalent ratio (LER) and area time equivalent ratio (ATER). A single cut of all these forages was taken 40-50 days after planting. Data on fresh forage weight per plot were recorded. Different competition functions were calculated by the following formulae:

$$\text{Aggressivity (Aab)} = \frac{Yab}{Yaa \times Yab} - \frac{Yba}{Ybb \times Zba}$$ [Mc Gillchrist 1965]

$$\text{Area time equivalent ratio} = \frac{(Ryc \times tc) \times (Ryp \times tp)}{T}$$ [Hiebsch 1980]

where 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=sown proportions of crop “a” and “b” in intercropping system, T = Duration (days) for the whole system,
Ryc = Relative yield of crop c, Ryp = Relative yield of crop p,
tc = Duration (days) for crop c, tp = Duration (days) for crop p.

RESULTS AND DISCUSSION

RICEBEAN

The highest significant fresh fodder yield (16.82 t ha^{-1}) was recorded in the sole ricebean crop (Table 1). This was followed by intercropping of ricebean in 120 cm apart double row strips of cotton (P_2) with 12.57 t ha^{-1} fresh fodder yield. Reduction in fresh fodder yield was 59.6 and 25.3% for P_2 and $P_{1,}$ respectively, of the sole crop of ricebean. Variable and less fodder yield of ricebean in different intercropping patterns as compared with sole cropping of ricebean was attributed to a variable covered area of cotton and ricebean. A suppressive effect of cotton on vegetative growth of the associated ricebean reduced its yield in associated cultures [Bismillah 2000].

MAIZE

Maize intercropped at 120 cm spaced double row strips of cotton produced significantly higher fodder yield (+22.77%) than that grown in 80 cm spaced single rows of cotton (Table 1). However, maize intercropped in double row strips gave significantly lower yield than that obtained from the sole crop.

Table 1: Performance of different summer fodders fresh weight tons ha^{-1} intercropped in cotton planted in different planting patterns (mean values for two years).

Fodders (Fresh)	P_1	P_2	P_3	Sx
Ricebean	10.19^c	12.57^b	16.82^a	0.29
Maize	18.01^c	22.11^b	36.48^a	0.60
Sorghum	18.31^c	22.16^b	27.48^a	0.40
Cowpeas	16.72^c	25.65^b	42.89^a	0.58

P_1 =80-cm spaced single rows of cotton, P_2 =120-cm spaced double rows strips of cotton, P_3 =Sole crop, Figures followed by different letters are significant at 0.05 probability levels using LSD.

Sole crop produced 65% higher fodder than 120 cm spaced double row strip plantation, that was 102% less in 80 cm spaced single rows. Reduction in yield of fresh fodder in associated cultures has also been reported by Anjum [1996] and Saeed *et al*. [1999]. Fresh fodder yield reduction of maize intercropped in cotton was attributed to a variable covered area of cotton and maize. A higher fodder yield in the 120 cm spaced paired rows of cotton might be due to less competition for resources as compared with the 80 cm apart single rows of cotton.

SORGHUM

In sorghum fresh fodder yield patterns were almost similar to those of maize. Sorghum production was significantly higher (+3.85 tons) in 120 cm spaced double row strips of cotton as compared to the fodder production in conventionally sown cotton. However, sole crop in turn produced 5.32 and 9.17 tons higher yield as compared to double row strip and 80 cm apart conventional cotton plantation. Reduction in sorghum fodder in cotton-based intercropping was also reported by Chandravanshi [1975]. Increase in fodder quantity in modern planting technique of cotton planting can be attributed to more space and solar radiation availability.

COWPEAS

Cowpeas planted in 80-cm apart single rows of cotton produced 35% less fresh fodder than when it was planted in double row strips of cotton. Cowpeas planted in double row strips of cotton in turn produced 40.1% less yield than that obtained from its sole crop. The sole crop of cowpeas produced 157% more fodder yield than that obtained from 80 cm apart single rows of cotton (Table 1). Tsay *et al*. [1988] and Muhammad *et al*. [1991] also found that cowpeas fodder yield was reduced in intercropping treatments as compared to its sole crop. However, these findings were contrary to those documented by Natarajan and Naik [1992].

COMPETITION BEHAVIOR

Competition behavior of component crops across different intercropping systems was determined in terms of aggressivity and area time equivalent ratio (ATER) as follows:

Aggressivity (A)

Aggressivity 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 dominated negative. The greater the numerical value the bigger is the difference in competitive abilities and higher the differences between actual and expected yields.

The component crops did not compete equally (Table 2). Regardless of the planting patterns, a positive sign with values of cotton at 120 cm apart double row strips of cotton (P_2), indicated the dominant behavior of cotton over all intercrops which had negative ‘A’ values. All fodders proved to be less competitive with cotton as there was a little difference among their aggressivity values across planting patterns. This was due to the early harvest of forages before the establishment of cotton plants. Many other researchers [Ahmed 1990, Gomaa and Radwan 1991, Shahid and Saeed 1997]) also reported the dominant effect of cotton having a positive ‘A’ value when grown in association with different legume crops.

Table 2: Aggressivity as affected by planting pattern and cotton-based intercropping systems.

Systems	80-cm apart single rows of cotton (P_1)		120-cm apart double row strips of cotton (P_2)		Systems (P_1+ P_2)/2	
	Cotton (Aab)	Intercrop (Aba)	Cotton (Aab)	Intercrop (Aba)	Cotton (Aab)	Intercrop (Aba)
Cotton+ricebean	0.49	-0.49	0.56	-0.56	0.53	-0.53
Cotton+maize	0.62	-0.62	0.59	-0.59	0.61	-0.61
Cotton+sorghum	0.53	-0.53	0.44	-0.44	0.49	-0.49
Cotton+cowpeas	0.74	-0.74	0.62	-0.62	0.68	-0.68

P_1=80-cm spaced single rows of cotton P_2=120-cm spaced double rows strips of cotton P_3 =Sole crop

Area-Time Equivalent Ratio (ATER)

Since land equivalent ratio does not take into account the time for which land is occupied by the component crops of an intercropping system, area-time equivalent ratio (ATER) was also determined. 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 3), indicating the over estimation of resource utilization in the latter. Thus contrary to LER, ATER is free from problems of over estimation of resource utilization. On the basis of two years average data, ATER value indicated an advantage of 1-33% in intercropping compared with sole cropping of cotton regardless planting pattern (Table 3).

ATER was the maximum for cotton+ricebean followed by cotton+ cowpeas, respectively. 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 19-27% which were in the range of 30-38 % in the case of 120 cm apart double strips of cotton.

Table 3: Area–time equivalent ratio as affected by cotton-based intercropping systems and planting patterns.

Intercropping Systems	80-cm apart single rows of cotton (P_1)		120-cm apart double row strips of cotton (P_2)		Systems	
	Cotton (C_1)	Intercrop (I_1)	Cotton (C_2)	Intercrop (I_2)	(P_1) $C_{1+}I_1$	(P_2) $C_{2+}I_2$
Cotton+ricebean	0.79	0.14	0.93	0.18	0.93	1.11
Cotton+maize	0.87	0.11	0.89	0.13	0.98	1.02
Cotton+sorghum	0.84	0.15	0.84	0.18	0.99	1.00
Cotton+cowpeas	0.92	0.09	0.92	0.14	1.01	1.06

P_1 = 80-cm spaced single rows of cotton, P_2 = 120-cm spaced double rows strips of cotton, P_3 = Sole crop.

Higher values of ATER in intercropped treatments compared with monoculture of cotton were attributed to efficient utilization of natural (land and light) and added (fertilizer and water) resources. Higher ATER values have also been reported in cotton+cowpeas [Allen and Obura 1983)] rice+pigeonpea [Banik and Bagehi 1994], Cassava+cowpeas [Kuruvilla *et al*. 1994] and wheat+lentil [Ahmad 1997] associations compared with monoculture of their component crops.

ECONOMIC ANALYSIS (Dominance Analysis)

A partial budget analysis gave an insight into the total costs that vary and the net gains from any intercropping system. It did not give information on relative/comparable gains in extra (marginal) benefits from the extra (marginal) costs involved for different intercropping systems. For this purpose a dominance analysis was carried out first by listing the intercropping systems in order of increasing costs that vary.

Table 4: Dominance analysis of different cropping systems.

Cropping system	Costs that vary Rs. ha^{-1}	Net benefits Rs. ha^{-1}
Cotton alone	4924	31805
Cotton+ricebean	7308	29131 D
Cotton+maize	7759	33232 D
Cotton+cowpeas	7869	35017
Cotton+sorgum	7915	32102 D

Figures followed by “D” are dominated cropping systems.

Any intercropping system that had net benefits that were less than or equal to those of intercropping system with lower costs that vary was dominated and listed as ‘D’. The dominance analysis of different cropping systems (Table 4) showed that intercropping systems of cotton+ricebean, cotton+maize and cotton+sorghum were dominated by cotton+cowpeas systems. The dominated intercropping systems were actually less profitable than intercropping system of cotton+cowpeas.

CONCLUSIONS

Intercropping of ricebean, maize, sorghum and cowpeas in 120-cm apart double row strips of cotton proved to be feasible as well as convenient for farm operations. Additional production from intercrops obtained from cotton+maize, cotton+sorghum and cotton+cowpeas compensated more than the losses in cotton production. On the basis of two years of data, the highest net benefit of Rs. 35017 ha^{-1} was obtained from cotton+ cowpeas and hence this system proved superior to all other intercropping systems facilitating fodder production.

Reference

Abdullah, M. and Chaudhary, M.T. (**1996**) "Improved fodder and seed production in central irrigated Punjab in Fodder production in Pakistan", *Proceedings of National Conference on Production, Improvement and Utilization of Fodder Crops in Pakistan*, March 25-27, 1998, PARC/ FAO, pp. 55-65.

Ahmad, N. (**1997**) "Agro-economic relationships of the component crops in some wheat-based intercropping systems at different patterns of wheat plantation", Ph.D. Thesis, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan.

Ahmed, H.K. (**1990**) "Studies on biological intercrop relationship and water use techniques in wheat", Ph.D. Thesis, University of Agriculture, Faisalabad (Pakistan).

Allen, J.R. and Obura, R.K. (**1983**) "Yield of corn, cowpeas, and soybean under different intercropping systems", *Agron. J.*, 75 (6), 1005-1009.

Anjum, M.A. (**1996**) "Agro-management studies on biological fixation of Nitrogen in wheat legume intercropping systems", Ph.D. Thesis, University of Agriculture, Faisalabad (Pakistan).

Banik, P. and Bagehi, D.K. (**1994**) "Evaluation of rice and legume intercropping in upland situation of Bihar Plateau", *Ind. J. Agric. Sci.*, 64(6), 364-368.

Bismillah, M. (**2000**) "Bio-economic efficiency of different cotton based inter/relay cropping systems", Ph. D. Thesis, University of Agriculture, Faisalabad (Pakistan).

Bismillah, M., Akhtar, M. and Khaliq, A. (**2001**) "Some competition functions and economics of different cotton-based intercropping systems", *Internat. J. Agric. Biol.* 3 (4), 428-431.

Chandravanshi, B.R. (**1975**) "Study on intercropping in sorghum [Sorghum bicolor (L) Moench] under uniform and paired row planting systems", *Jawarlal Nehru Krishi Viswa Vidyalaya Res. J*, 9, 24-26.

Gomaa, M.A. and Radwan (**1991**) "The effect of intercropping cotton plant with soybean on yield and yield components of soybean plant", *Annals of Agric. Sci., Moshtohor*, 29 (2), 745-756.

Government of Pakistan (**2003**) "Agricultural Statistics of Pakistan", Ministry of Food, Agric. and Livestock, Economic Wing, Islamabad, pp. 109-215.

Government of Punjab (**1990**) "Census of Agriculture", Lahore, Punjab, Pakistan.

Hiebsch, C.K. (**1980**) "Principles of intercropping. Effect of N fertilization and crop duration on equivalency ratios in intercrops versus monoculture comparasions", Ph.D. Thesis (Order No. 811110301), North Carolina State University, Raleigh, N.C., USA (Diss. Absts. 41 B, 4337).

Kuruvilla, V., Meetabai, M. and Babu, K.S. (**1994**) "Evaluation of multi-season intercropping in Cassava", *Ind. J. Agric. Sci.*, 64(7), 438-441.

McGillchrist, I.A. (**1965**) "Analysis of competition experiments", *Biometrics* 21, 975-985.

Mohamed, H.M.H. and Salwau, M.I.M. (**1994**) "Effect of intercropping cotton with maize", *Proceedings of Beltwide Cotton Conferences*, January 5-8, San Diego, California, USA, pp. 1570-1572.

Mohamed, M.K., El-din, G.M.S. and Hosny, A.A. (**1991**) "Evaluating three patterns of intercropping cotton and forage cowpeas", *Annals of Agric. Sci., Moshtohor*, 29(4), 1269-1284.

Natarajan, M. and Naik, D.M. (**1992**) "Competitive effects of short duration, bushtype cowpeas when intercropped with cotton in Zimbabve", *Ezpt. Agric.*, 28(4), 409-416.

Rao , V.P. (**1991**) "A study on intercropping of cotton with grain legumes under rainfed conditions", *Journal of Research* , Andra Pradesh Agriculture University, 19(20), 73-74.

Saeed, M., Shahid, M.R.M, Jabbar, A., Ullah, E. and Bismillah, M. (**1999**) "Agro-economic assessment of different cotton- based inter/relay cropping systems in two geometrical patterns", *Internat. J. Agric. and Biol.*, 4(1), 234-237.

Shahid, M.R.M. and Saeed, M. (**1997**) "Competitive relationship of component crops in different wheat-based intercropping systems", *JAPS*, 7(1-2), 37-39.

Tsay, J.S., Fukai, S. and Wilson, G.L. (**1988**) "Intercropping Cassava with legume cultivars of varying maturities", *Field Crop Res.*, 19, 211-225.