http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences, 2 (3): 980-983, 1999 **Research Article**

Bioeconomic Assessment of Direct-seeded Rice-based Intercropping Systems Under Strip Plantation

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Abstract
Bioeconomic efficiency of different rice-based intercropping systems under different patterns of strip plantation wa determined at Faisalabad during the year 1997. Strip plantation of rice comprised 45-cm spaced 2-row strips, 75-cm space 4-row strips and 105-cm spaced 6-row strips while intercrops were maize, cowpea, sesbania and ricebean. All intercrop were utilized as green fodder crops. Although all intercrops caused substantial reduction in both plant biomass and padd yield ha^{-1} of the associated rice yet additional fodder yield from each intercrop not only compensated the reduction in plan biomass and paddy yield of rice but also increased farm net income by 19.69 to 125.33 per cent. Thus both legum (cowpea, sesbania, ricebean) and non-legume (maize) fodder crops can be intercropped in the upland rice seeded on a we prepared seedbed in 75-cm spaced 4-row strips in order to increase farm income per unit area. Maize intercropping give the maximum net income. Besides neither planting pattern nor intercropping affect the qualitative traits such as proportio of normal, fertile, sterile, abortive and opaque spikelets in a panicle of rice.

Introduction
Intercropping ensures yield stability and improved yield because of better control of weeds, pests and diseases and better use of growth resources. Besides intercropping meets diversified needs of small farmers. Pakistan is a subtropical country having adequate irrigation resources with high intensity of sunlight and favourable temperature ranges for raising two or more crops simultaneously on the same piece of land..

Rice (*Oryza sativa* L.) is one of the most important cereals of Pakistan. It is grown on an area of about 2317 thousand hectare with total annual production of 4333 thousand tones and an average yield of 1870 kg ha^{-1} (Anonymous, 1999). Besides rice, an adequate supply of green fodder is required for optimizing livestock productivity. Maize (*Zea mays* L.) is an important short duration "*kharif*" fodder crop which provides more economic return to the growers. Similarly there are legumes such as cowpea (*Vigna unguiculata* L. Walf.), sesbania (*Sesbania sesban*) and ricebean (*Vigna umbellata*) which can be fed to animals. During hot summer months these legume forages help in maintaining animal health and milk production besides improving soil fertility through biological N_2 fixation. But area under these fodder crops cannot be increased as they compete for area with rice a major "*kharif*" cereal of Pakistan. Thus the best way to supplement the "*kharif*" fodder production is to grow these fodder crops in association with rice.

Conventional method of planting rice, however does not permit intercropping because of narrow row spacing. Keeping this in view, a new method of planting rice in widely spaced multi-row strips has been developed (Shabbir, 1989). Strip plantation not only gives as good paddy yield as the conventional planting in single rows but also facilitates harvesting and handling of intercrops freely and conveniently without doing much damage to the base crop (Saeed *et al.*, 1998). However, a little work has bee done on exploring the possibility of intercropping differen legume and non-legume fodder crops in rice. Consequent the present study was planned to determine th bioeconomic efficiency of various rice-based legume an non-legume intercropping systems at different patterns rice strip plantation under the agro-ecological conditions Faisalabad.

Materials and Methods
The present study was conducted at the University Agriculture, Faisalabad during the year 1997 on a san loam soil. The experiment was laid out in randomiz complete block design with split plot arrangement in thr replications and a net plot size of 3.6 m x 8 m. Planti patterns of rice comprising 45-cm spaced 2-row strips, 7 cm spaced 4-row strips and 105-cm spaced 6-row stri were randomized in main plots while intercropping syste were placed in the sub-plots. Intercropping systems w rice (*Oryza sativa* L.) alone, rice + maize (*Zea mays* L.), r + cowpea (*Vigna unguiculata* L.), rice + sesba (*Sesbania sesban*) and rice + ricebean (*Vigna umbellat* Rice cv. Basmati-385 was direct-seeded on 17 June, 19 as per planting patterns under study on a well prepa seed bed while maize, cowpea, sesbania and ricebean w intercropped in space between the rice strips on the sa day. A seeding rate of 40 kg ha^{-1} for rice and 50, 25, and 15 kg ha^{-1} for maize, cowpea, sesbania and riceb respectively, was used. Fertilizer was applied @ 150 k and 100 kg P_2O_5 ha^{-1}. An initial dose of 100 kg N + kg P_2O_5 was applied at sowing while remaining 50 k was top dressed immediately after harvesting intercrops. Irrigation was applied by flood irrigation syst All the intercrops were harvested 50 days after so while rice crop was harvested at its physiological mat on 19 November, 1997.

Observations on panicles m $^{-2}$, spikelets per panicle, 1000-kernel weight, paddy yield, biological yield, harvest index, total paddy yield equivalent and percentage of normal, fertile, sterile, abortive and opaque spikelets were recorded by using the standard procedures.
The data were analyzed statistically by using the Fisher's analysis of variance technique and significance of treatment means was tested by using the LSD test at 0.05 P (Steel and Torrie, 1980).

Results and Discussion

Panicles m $^{-2}$: There were no significant differences in number of panicles m $^{-2}$ of rice among different planting patterns. However, number of panicle bearing tillers m $^{-2}$ varied from 248.95 to 272.60 (Table 1).
Intercrops caused significant reduction in panicles m $^{-2}$ of the associated rice compared to the sole rice. The minimum number of panicles m $^{-2}$ (242.66) was produced by the rice intercropped with sesbania that, in turn, was statistically on a par with that intercropped with ricebean but was preceded by rice + cowpea and rice + maize (Table 1). The latter two intercropping systems did not differ significantly from each other. Less number of panicles m $^{-2}$ for rice intercropped with sesbania might be attributed to partly over shading of rice crop by the sesbania crop and partly by severe competition between the two crops for various growth factors.
Interaction between the two factors was non-significant. However, number of panicles m $^{-2}$ varied from 229.00 to 299.33.

Spikelets per panicle: Planting patterns affected the number of spikelets per panicle of rice significantly. The maximum spikelets (163.56) were produced by the rice grown in 105-cm spaced 6-row strips followed by 45-cm spaced 2-row strips and 75-cm spaced 4-row strips, respectively (Table 1). These results are in agreement with those of Raju *et al.* (1989) who reported that closer spacing reduced spikelets per panicle.
Intercropping systems also had significant effect on spikelets per panicle. All intercrops caused substantial reduction in spikelets per panicle of the associated rice compared with sole rice (Table 1). Sesbania reduced spikelets per panicle to the maximum extent but it did not differ significantly from maize and cowpea. Among intercrops, ricebean had the minimum suppressive effect on spikelets per panicle of the associated rice. Probably over shading of rice crop by sesbania and maize plants might have affected the plant development adversely at early development stages as a result of which spikelets per panicle were reduced. While suppressive effect of cowpea and ricebean on spikelets per panicle of rice was probably due to competition between the component crops for different growth factors during early rice development and inability of rice to completely recover from the competition shock during the latter stages.
Interaction between planting patterns and intercropping systems was non-significant. However, spikelets per panicle ranged between 125.44 and 180.75.

1000-kernel weight: Intercropping of maize, cowpea and sesbania decreased 1000-kernel weight of the associated rice significantly compared with the sole rice (Table 1). On the contrary, ricebean did not cause significant reduction in the 1000-kernel weight of rice.
Effect of planting patterns and interactive effects of planting patterns and intercropping systems on 1000-kernel weight of rice were non-significant (Table 1). Singh *et al.* (1985) also reported that 1000-grain weight of rice was not affected by different plant spacings.

Paddy yield: There were non-significant differences in paddy yield ha $^{-1}$ among different patterns of rice plantation (Table 1). These results concur with the findings of Shah *et al.* (1991) who reported that spacing had no significant effect on paddy yield.
Intercrops reduced paddy yield ha $^{-1}$ of the associated rice significantly compared with that of the sole rice (Table 1). Sesbania caused the maximum reduction in paddy yield, preceded by the rice intercropped with cowpea, maize and ricebean. Reduction in paddy yield due to intercropping was attributed to less number of panicles m $^{-2}$, spikelets per panicle and 1000-kernel weight. These results are in consonance with the findings of Parida *et al.* (1988) and Prasad and Singh (1992) who reported that intercrops significantly reduced paddy yield of the associated rice.
Interaction between planting pattern and intercropping system was also significant (Table 1). Although sole rice grown in 45-cm spaced 2-row strips (P_1I_0) produced the maximum paddy yield of 3.32 t ha $^{-1}$ yet it was statistically on a par with rice grown in 45-cm spaced 2-row strips and intercropped with maize or 105-cm spaced 6-row strips with no intercropping. The minimum paddy yield (2.05 t ha $^{-1}$) was produced by the rice grown in 75-cm spaced 4-row strips and intercropped with sesbania which was statistically on a par with rice grown in 45-cm spaced 2-row strips and intercropped with sesbania.

Plant biomass: Planting patterns had no significant effect on total plant biomass (PB) of rice. However PB varied from 8.07 to 9.12 t ha $^{-1}$ (Table 1).
Intercropping of maize, cowpea, sesbania and ricebean reduced the PB of rice significantly. Sesbania caused the maximum reduction in PB of the associated rice, preceded by the rice intercropped with cowpea, ricebean and maize (Table 1). Low PB of rice intercropped with sesbania was due to less dry matter accumulation by rice because of shading effect of sesbania and severe competition between component crops for essential growth factors.
Interaction between rice planting patterns and intercropping systems was significant (Table 1). The maximum PB (10.68 t ha $^{-1}$) was produced by the rice grown in 45-cm spaced 2-

Table 1: Effect of different patterns of rice plantation and intercropping systems on plant biomass, paddy yield and its components, total paddy yield equivalent, net income and benefit cost ratio (BCR)

Treatment	1	2	3	4	5	6	7	8	9
A. Planting patterns of rice (P)									
P_1 = 45-cm spaced 2-row strips	248.95NS	153.45b	16.64NS	2.91NS	9.12NS	0.32NS	-	10990	1.62
P_2 = 75 cm spaced 2-row strips	260.53	143.67c	18.09	2.62	8.07	0.33	-	8050	1.45
P_3 = 105-cm spaced 6-row strips	272.60	163.56a	18.09	2.73	8.16	0.34	-	8966	1.51
LSD (0.05)		6.10							
B. Intercropping systems									
I_0 = Rice alone	283.77a	167.13a	18.39a	3.23a	9.46a	0.35a	3.23	13710	1.77
I_1 = Rice + maize	261.44bc	148.66c	17.41b	2.74bc	9.18ab	0.30d	5.33	30894	2.68
I_2 = Rice + compea	266.22b	149.07c	17.46b	2.66c	8.27c	0.33c	4.04	19351	2.05
I_3 = Rice + sesbania	242.66d	144.63c	17.16b	2.25d	6.66d	0.34b	3.78	16410	1.88
I_4 = Rice + ricebean	249.33cd	158.77b	17.63ab	2.87b	8.70bc	0.34b	3.95	18844	2.03
LSD (0.05)	15.03	5.92	0.82	0.16	0.567	0.003	-	-	-
C. P X I									
$P_1 \times I_0$	274.33NS	162.62NS	17.83NS	3.38a	9.79ab	0.35NS	3.38	15091	1.8
$P_1 \times I_1$	259.00	151.17	16.95	3.05bc	10.68a	0.28	5.35	31785	2.7
$P_1 \times I_2$	249.33	148.46	16.03	2.63ef	8.82bc	0.30	3.79	17634	1.9
$P_1 \times I_3$	229.00	150.13	15.84	2.24gh	6.55fg	0.34	3.64	15113	1.8
$P_1 \times I_4$	233.00	154.84	16.32	3.21abc	9.75b	0.35	4.14	20953	2.1
$P_2 \times I_0$	277.66	158.02	18.52	2.99cd	8.95bc	0.34	2.99	11508	1.6
$P_2 \times I_1$	256.66	139.66	18.08	2.61ef	8.84bc	0.30	5.52	32414	2.7
$P_2 \times I_2$	268.00	141.13	18.44	2.75de	8.42cd	0.34	4.36	22116	2.2
$P_2 \times I_3$	247.00	125.44	17.46	2.05h	6.28g	0.33	3.74	15929	1.8
$P_2 \times I_4$	253.33	154.12	17.97	2.68ef	7.87cde	0.35	3.90	18104	1.9
$P_3 \times I_0$	299.33	180.75	18.83	3.32ab	9.63ab	0.35	3.32	14538	1.8
$P_3 \times I_1$	268.66	155.16	17.19	2.56ef	8.01cde	0.33	5.12	28470	2.5
$P_3 \times I_2$	218.33	157.65	17.92	2.59ef	7.56def	0.35	4.07	19181	2.0
$P_3 \times I_3$	252.00	156.92	18.16	2.45fg	7.15efg	0.35	3.97	18110	1.9
$P_3 \times I_4$	261.66	167.33	18.39	2.73de	8.47cd	0.33	3.80	17560	1.9
LSD (0.05)				0.272	0.983				

Means followed by the same letter do not differ significantly by LSD at 5% probability level. NS = Non-significant by LSD at 5% probabili level. 1 = Panicles (m^{-2}); 2 = Spikelets per panicle; 3 = 1000-kernel weight (g); 4 = Paddy yield (t ha^{-1}); 5 = Plant biomass (t ha^{-1}); = Harvest index; 7 = Total paddy yield equivalent (t ha^{-1}); 8 = Net income (Rs. Ha^{-1}); 9 = BCR.
Market price: Rice paddy = Rs. 8.50/kg; Rice straw = Rs. 25/40 kg; Green fodder = Rs. 25/40 kg.

row strips and intercropped with maize which was statistically on a par with the rice grown in 45-cm spaced 2-row strips or 105-cm spaced 6-row strips with no intercropping. Rice grown in 75-cm spaced 4-row strips and intercropped with sesbania gave the minimum PB (6.28 t ha^{-1}) but was statistically on a par with rice grown in 45-cm spaced 2-row strips or 105-cm spaced 6-row strips intercropped with sesbania.

Harvest index: Planting patterns did not significantly affect the harvest index (Table 1). These results are similar to the findings of Shah *et al.* (1991) who reported that harvest index was not affected by different plant spacings.
All intercrops, i.e. maize, cowpea, sesbania and ricebean decreased the harvest index of the associated rice significantly compared to the sole rice (Table 1). The minimum harvest index (0.30) was recorded for rice intercropped with maize, preceded by the rice intercropped with cowpea, sesbania and ricebean. The latter two intercrops however, did not differ significantly from each other. These results are supported by the findings of Chauhan *et al.* (1994) who reported that intercropping reduced the harvest index of rice.
Interaction between the planting pattern and intercroppi system was non-significant. However, harvest index vari from 0.28 to 0.35 among different treatment combinatio

Proportion of normal, fertile, sterile, abortive and opaq spikelets in a panicle: Both the main and interactive effe of planting pattern and intercropping system on percenta of normal, fertile, sterile, abortive and opaque spikelets a rice panicle were non significant (Data not show However, the percentage of normal, fertile, sterile, abort and opaque spikelets varied from 62.33 to 71.00, 79.3 88.66, 8.33 to 15.00, 2.66 to 6.66 and 13.67 to 23. respectively.

Paddy yield equivalent: Regardless of the planting patt total paddy yield equivalent (PYE) of different intercrop systems was substantially higher than that of sole (Table 1). The highest PYE (5.52) was obtained when was grown in 75-cm spaced 4-row strips and intercrop with maize (P_2I_1) followed by rice planted in 45-cm spa 2-row strips and intercropped with maize (P_1I_1). On contrary, the minimum PYE of 3.64 t ha^{-1} was recorded for rice grown in 45-cm spaced 2-row strips and intercropped with sesbania (P_1I_3). These results are supported by the findings of Sharma and Shyam (1992) who reported that intercropping gave higher equivalent yield than rice alone.

Net income and benefit-cost ratio: All the patterns of rice plantation differed from one another in terms of net income ha^{-1} (Table 1). Similarly intercropping systems gave considerably higher net income ha^{-1} than monocropped rice (Table 1). Among treatment combinations, rice grown in 75-cm spaced 4-row strips and intercropped with maize (P_2I_1) gave the maximum net income of Rs. 32414 ha^{-1} with a BCR of 2.76, closely followed by rice grown in 45-cm spaced 2-row strips and intercropped with maize (P_1I_1) giving a net income (Rs.) and BCR of 31785 and 2.72, respectively. On the contrary, the minimum net income of Rs. 11508 ha^{-1} and BCR of 1.65 were obtained for rice alone grown in 75-cm spaced 4-row strips. An increase in net income ha^{-1} by intercropping of maize, soybean or *Eleusine ceracana* in rice over rice alone has also been reported by Honagodimath *et al.* (1989) in India.

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