EVALUATION OF DIRECT-SEEDED UPLAND RICE-BASED INTERCROPPING SYSTEMS UNDER STRIP PLANTING GEOMETRY

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In a field study the biological efficiency of intercropping in direct-seeded upland rice was determined at the University of Agriculture Faisalabad for two consecutive years. The intercropping systems comprised rice alone, rice + maize, rice + sesbania, rice + mungbean and rice + pigeonpea. The rice was seeded in 75cm spaced 4 - row strips (15/75 cm) while the intercrops as forage were seeded on the vacant spaces between the rice strips. The rice grain yield was decreased to a significant level by the forage intercrops compared to monocropped rice which varied from 10.94 to 25.87 %, with the maximum (25.87 %) by sesbania followed by pigeon pea (16.67) against the minimum (10.94 %) by maize intercrop. In terms of total rice grain yield equivalent (TRGYE), the highest TRGYE (6.45 tha^{-1}) was recorded for rice + forage maize intercropping system followed by rice + cowpea (5.08 t ha^{-1}) and rice + sesbania (4.92 t ha^{-1}) against the minimum (4.02 tha^{-1}) for monocropped rice clearly indicating yield advantages of intercropping over monocropping of rice. By contrast, the grain quality of rice was not affected significantly by different intercrops.
Key words: Component crops, direct seeded rice, intercropping system, planting geometry, Pakistan.

INTRODUCTION

In the modern era of rapid technological advancement in agriculture and consistent increase in population, poverty and food shortage, there is a need to develop new methods and techniques of crop production not only to increase the productivity per unit area and time in order to meet the increasing demand for food, feed and forage but also to make effective utilization of agricultural input resources. Any effort or plan to increase food production can not be a total success unless and until an appropriate production- oriented cropping system and production technology for each ecological zone is not developed and properly implemented.

Under the present system of sole cropping, small farmers are unable to manage their diversified domestic needs to maintain their normal livings from their limited land, water and economic resources. This envisages to go for another appropriate and more efficient production system which may ensure the proper utilization of their limited geo-agronomic resources towards increased production per unit area and time on sustainable basis (Trenbath, 1996).

Intercropping being a unique cropping system offers the possibility of yield advantage relative to sole cropping through yield stability and improved yield (Willey, 1979). Thus it provides diversified needs of the small farmers, stability of yield over different seasons, better control of weeds, insects and diseases as well as control of soil erosion. Besides through intercropping the potential of raising other crops such as forage legumes and non- legumes in association with major staple food crops like upland rice could be substantially enhanced (Saeed *et at.*, 1999). It also

helps maintaining the soil fertility (Patra *et al.*, 1986) making efficient use of nutrients (Aggarwal *et al.*, 1992, Nazir *et al.*, 1997, Ahmad and Saeed, 1998) and ensuring economic utilization of land, labour and capital (Morris and Garrity, 1993 and Singh *et al.*, 1996).

Rice (*Oryza sativa* L.) being a crop of worldwide importance and the staple food of the millions of people, is the 2nd major source of earning foreign exchange after cotton in Pakistan. Hence its role in the economic development of Pakistan can not be overlooked. At present, rice is grown on an area of 2.62 million hectares in Pakistan with total annual production of 5.54 million tonnes giving an average yield of 2110 kg ha^{-1} (Economic survey of Pakistan, 2005-2006). Maize and other forage legumes such as sesbania, cowpea, pigeonpea, rice bean and mungbean are important short duration "kharif" crops which provide more economic returns to the growers. The area under these crops cannot be increased as they compete with rice, a major kharif cereal of Pakistan. Moreover, during hot summer months these fodders help to maintain animal health and milk production besides improving soil fertility through biological nitrogen fixation and sufficient addition of organic matter. Thus one of the ways to supplement the kharif fodder production is to grow these crops as forage in association with uplands rice.

Although sufficient research work has been reported on maize, cotton, sugarcane and wheat-based intercropping systems in Pakistan and elsewhere, yet research on diversified rice-based intercropping systems is inadequate and non-systematic. Such lack of information necessitates developing such rice-based intercropping systems which may ensure sustained

crop productivity and land use in the rice growing areas. However, the conventional method of planting rice in 20 x 20 cm hills does not permit intercropping because of narrow row spacing and intensive binding of soil by root mass of closely growing rice plants. Consequently, a new pattern of planting rice in widely spaced multi-row strips maintaining normal plant population has been developed (Nazir *et al.*, 1998 and Saeed *et al.*, 1999) which not only gives paddy yield comparable to the conventional planting system in single rows or hills but also facilitates interplanting, management and harvesting of intercrops without doing damage to the base crop. It also facilitates easy relaying of other upland crops.

Keeping in view, the scope and significance of intercropping technology in the modern production systems, the present study was planned to evaluate the comparative performance of different upland rice-based intercropping systems under strip planting geometry in irrigated upland environment at Faisalabad, Pakistan.

MATERIALS AND METHODS

The present study on the agro-qualitative performance of different upland rice-based intercropping systems was conducted at the University of Agriculture, Faisalabad on a sandy-clay loam soil having an average fertility status of .042 % N, 6.5 ppm P_2O_5 and 123 ppm K_2o with a pH of 8.6, for two consecutive years (1998-99). The intercropping systems comprised rice alone (*Oryza sativa* L.), rice + maize (*Zea mays* L.), rice + sesbania (*Sesbania sesban* L.), rice + mungbean (*Vigna radiata* L. Wilezen), rice + ricebean (*Vigna umbellata* L.), rice + cowpea (*Vigna unguiculata*) and rice + pigeonpea (*Cajanus cajan* L. Millspergh). All the intercrops were grown as forage and harvested 45 days after sowing while the rice crop was harvested at full physiological maturity a grain crop.

The experiment was arranged in a randomized complete block design (RCBD) and replicated thrice. The net plot size measured 3.6 m x 6.0 m. Rice cultivar "Basmati 385" was direct seeded at optimum soil moisture on a finely prepared seed bed in 75cm spaced 4-row strips with 15cm space between the rows in a strip, with the help of a single row hand drill in the third week of June each year. The respective intercrops were also seeded simultaneously on spaces between the rice strips on the same date using their recommended seed rates. A uniform basal dose of 100 kg N + 100 kg P_2O_5 ha^{-1} was applied at seeding of rice crop while additional 50 kg N ha^{-1} was top dressed soon after the harvest of forage intercrops on the rice

strips only. The normal plant population of the direct-seeded rice crop was maintained by seeding the crop with a uniform seed rate of 37.5 kg ha^{-1} in all the treatments. Pre-sowing irrigation "Rauni irrigation" of 10 cm was given before sowing the rice and intercrops for the sake of seedbed preparation at optimum soil moisture while subsequent irrigations each of 7.5 cm were given as and when required according to the need of the rice crop. However, the first irrigation was applied a week after the sowing of the component crops at their full seedling emergence. The rice crop was kept free of weeds by hand weeding as and when a need was felt up till its final harvest. Observations on desired parameters of the component crops were recorded using standard procedures and the data obtained were analyzed statistically by using "MSTATC" statistical package on a computer. The differences among treatment means were compared by Least Significant Difference (LSD) test at P = 0.05.

The rice grain yield equivalent of each intercrop was computed by converting the yield of intercrops into grain yield of rice on the existing market price of each intercrop (Anjeneyula *et al.*, 1982)

RESULTS AND DISCUSSION

Plant height

The data presented in the Table 1 revealed that the plant height of rice was affected significantly by intercropping. Although the monocropped rice produced significantly taller plants (146.62cm) than the rice intercropped with forage legumes but was at par with that intercropped with maize (143.22cm). By contrast, significantly the minimum plant height (131.31cm) was recorded for the crop intercropped with sesbania while rest of the intercropping treatments showed statistically similar plant height which varied from 139.75 to 143.22cm. The maximum reduction in plant height of rice intercropped with sesbania was due to luxuriant growth of sesbania which over shaded the associated rice crop and thereby retarding its growth. Reduction in plant height of rice as a result of intercropping different forage legumes has also been reported by Saeed *et al.* (1999).

Number of panicle bearing tillers m^{-2}

The number of panicle bearing tillers m^{-2} differed significantly among the intercropping systems. All the intercropping treatments produced significantly less number of panicle bearing tillers m^{-2} than sole rice crop. Contrarily, significantly the minimum number of panicle bearing tillers (221.02 m^{-2}) was recorded for rice intercropped with sesbania while rest of the

Table 1. Agronomic and quality traits of direct-seeded upland rice as affected by different forage intercrops

(Two—year average data)

Intercropping systems	Plant height (cm)	No. of panicle bearing tillers m^{-2}	No. of grains per panicle	Grain weight panicle^{-1} (g)	1000-grain weight (g)	Grain yield (t ha^{-1})	Decrease over mono-cropped rice (%)	Total rice grain yield equivalent of the system (t ha^{-1})	Increase over mono-cropped rice (t ha^{-1})	% age of normal kernels	% age of sterile kernels	% age of abortive kernels	% age of opaque kernels
Rice alone	146.62 a	257.77 a	171.23 a	3.36 a	20.24 a	4.02 a	-	4.02	-	71.11ns	7.91ns	3.99ns	16.99ns
Rice + Maize	143.22 ab	239.65 b	163.09 b	3.11 b	19.26 b	3.58 b	10.94	6.45	37.67	72.18	7.54	3.91	16.37
Rice + Sesbania	131.31 c	221.02 c	151.81 d	2.89 c	18.99 b	2.98 c	25.57	4.92	18.29	71.22	7.89	3.75	17.15
Rice + Mungbean	142.14 b	232.67 b	159.64 bc	3.03 bc	19.05 b	3.36 b	16.42	4.81	16.42	71.24	7.99	3.86	16.91
Rice + Ricebean	139.75 b	232.95 b	159.27 bc	3.03 bc	19.05 b	3.47 b	13.68	4.85	17.11	72.07	7.90	3.79	16.25
Rice + Cowpea	141.28 b	235.95 b	158.42 c	2.98 bc	18.88 b	3.41 b	15.17	5.08	20.87	71.86	7.89	3.97	16.27
Rice + Pigeonpea	140.93 b	235.35 b	158.59 c	2.99 bc	18.94 b	3.35 b	16.67	4.45	16.60	71.33	8.07	3.99	16.62

The means within a column not sharing a letter differ significantly at P = 0.05.

NS = non-significant

intercropped treatments produced statistically the same number of panicle bearing tillers which ranged between 232.67 and 239.65 m^{-2}. Greater number of panicle bearing tillers m^{-2} in case of monocropped rice was attributed to competition free environment and extensive root development. Similar results were reported by Saeed *et al.* (1999).

Number of grains panicle^{-1}

Number of grains panicle^{-1} is an important yield contributing component in rice. The data on number of grains penicle^{-1} revealed that there was a significant variation among different intercropping systems under study. The rice grown alone produced significantly greater number of grains panicle^{-1} (171.23) followed by rice intercopped with maize (163.09) which was at par with rice intercropped with munghbean or ricebean producing 159.64 and 159.27 grains panicle^{-1}, respectively. The differences among rice + cowpea, rice + pigeon pea, rice + ricebean and rice + mungbean intercropping treatments were however, non-significant. By contrast, significantly the minimum grains panicle^{-1} (151.81) was recorded for rice intercropped with sesbania due to its luxuriant growth habits and dormant plant stature which over shaded its growth and development. Reduction in the number of grains panicle^{-1} as a result of intercropping has also bean reported by Banik and Bagchi (1994) and Saeed *et al.* (1999).

Grain weight panicle^{-1}

All the intercropping treatments reduced the grain weight panicle^{-1} to a significant level compared to sole rice crop. Among the intercropping treatments, the maximum reduction (13.99%) was recorded for rice intercropped with sesbania which was at par with rest of the intercropping treatments except rice + maize that differed significantly from rice + sesbania intercropping system. Suppressive effects of intercropping on grain weight panicle^{-1} of rice were also reported by Banik and Bagchi (1994) and Saeed *et al.* (1999)

1000-grain weight

There were significant differences in 1000-grian weight among the intercropping treatments. The sole crop of rice produced significantly higher 1000-grain weight (20.24g) than the intercropped treatments which were at par with one another and produced 1000-grain weight ranging between 18.88 and 19.05g. Saeed *et al.* (1999) also reported suppressive effect of intercropping on 1000-grain weight of rice.

Rice grain yield

The rice grain yield was decreased to a significant level by intercropping forage legume and non- legume cultures compared to monocropped rice. However, the percentage decrease in rice grain yield varied from 10.94 to 25.57 % with the maximum (25.57%) for rice + sesbania followed by rice + pigeonpea (16.87 %) and rice + mungbean (16.42 %). By contrast, the minimum (10.94 %) was recorded for rice + maize intercropping system. The maximum reduction in rice grain yield due to sesbania intercropping was attributed to the luxuriant growth of sesbania and its thick shading effect on the associated rice crop which ultimately resulted in poor growth and low yield of the rice crop. Reduction in grain yield of rice due to intercropping was also reported by Chandra *et al.* (1992), Saeed *et al.* (1999) Sewaram and Singh (2000) and Joshi (2002).

Total rice grain yield equivalent (TRGYE)

All the intercropping treatments resulted in substantially higher total rice grain yield equivalent than sole crop of rice. However, the highest TRGYE (6.45 tha^{-1}) was recorded for rice + maize followed by rice + cowpea intercropping system (5.08 t ha^{-1} while rest of the intercropping systems intermediated showing TRGYE ranging between 4.45 and 4.92 t ha^{-1} compared to the minimum (4.02 t ha^{-1}) for monocropped rice. The overall increase in TRGYE of intercropping treatments over sole crop of rice varied from 16.42 to 37.67% with the maximum (37.67%) in rice + maize and the minimum (16.42%) in rice + mungbean intercropping system. Increase in TRGYE as a result of intercropping was also reported by Banik and Bagchi (1994), Qayyum and Maniruzzaman (1995), Saeed *et al.* (1999) and Joshi (2002).

Grain quality

Intercropping of forage crops had non-significant effect on grain quality parameters of the associated rice like percentage of normal, sterile, abortive and opaque kernels. These results corroborate the findings of Saeed *et al.* (1999).

CONCLUSION

Under the present circumstances, farmers with small holdings and seriously constrained by low crop income due to low yields and some times, complete crop failure, can adopt the practice of intercropping of upland rice with different legume and non-legume forage crop to cover the risk of complete crop failure or very low crop income.

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