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Production potential and economic feasibility of introducing arrowhead (*Sagitaria sagitifolia*) as an intercrop of lowland rice (*Oryza sativa* L)

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ABSTRACT

An experiment was conducted during *kharif* 2005 and 2006 at the Research Farm of College of Agriculture, Central Agricultural University, Imphal to determine the production potential and economic feasibility of rice + arrowhead intercropping under rainfed condition of Manipur. Highest grain yield of rice (4.65 t ha^{-1}) was recorded in sole rice, followed by rice + arrowhead in 1:1 row ratio combination maintaining normal population of rice. Similarly, the highest tuber yield of arrowhead was recorded in sole arrowhead followed by rice + arrowhead intercropping in 1:1 row ratio combination by replacement series. Other than the sole arrowhead, among the remaining treatments 1:1 row ratio combination by replacement series produced highest total rice equivalent yield (135.22qha^{-1}), per day ha rice equivalent yield (96.58 kg ha^{-1}day^{-1}), gross return (Rs.94,694ha^{-1}), net return (Rs.79,458ha^{-1}), return per rupee invested (Rs.5.21ha^{-1}) and labour use efficiency (Rs 11.34ha^{-1}). Whereas the highest land equivalent ratio (1.31) was found in 1:1 row ratio combination maintaining normal population of rice with higher monetary advantage (Rs. 24163).

***Key words*:** Economics, labour use efficiency, production potential, rice arrowhead intercropping, rice equivalent yield.

In Manipur, rice is primarily grown as monocrop during *kharif* season. In recent years, due to increasing labour cost the net return per rupee invested on the crop under rainfed condition is estimated to be Rs. 0.3 only. Thus rice cultivation is becoming unprofitable, but the farmers are reluctant to shift the crop with some other more profitable crops as rice cultivation is a way of life forfarmers of Manipuri. On the other hand, arrowhead (*Sagittaria sagittifolia*), an unexplored plant often grown as wild plant in marshy land mixed with lowland rice crop, is becoming a valued plant. In Manipur, fortunately it is recognized as a vegetable crop and used as a herbal medicine while in other states this plant has been destroyed being considered as a weed. The plants are used in pisciculture as a good oxygenator and are useful for ponds and ditches where, fish are bred. Its knots in tuber help in fixing nitrogen in soil, thus helpful for agriculture too and the plant itself is a good green manure (Ghosh, 2000). Under natural condition arrowhead is grown favourably where Arrowheads are coming into the lowland rice eco-system as their natural habitat. Therefore, the present experiment was undertaken to fit arrowhead as an intercrop of rice with the aim of exploring the production potential and economic feasibility of the intercropping system.

MATERIALS AND METHODS

A field trial was carried out during kharif 2005 and 2006 at the Research Farm (24.5^0 N and 93.560 E at an elevation of 790 m MSL), College of Agriculture, Central Agricultural University, Imphal. The soil was clay in texture with acidic reaction (pH 5.40), high in organic carbon (3.83 %), medium in available nitrogen and phosphorus (439.04 kg ha^{-1} and 40.56 kg ha^{-1} respectively) and high in available potassium (415.23 kg ha^{-1}). The two crops i.e. rice and arrowheads were set in six different intercropping combinations at three different planting geometry. For comparison two sole crop treatments i.e. rice and arrowhead were also included in the system as check. Thus, altogether eight treatments were laid out in randomized block design and replicated three times. The treatments are: T_1-Sole rice; T_2 - Sole arrowhead; T_3 - Rice + arrowhead (1:1 row ratio maintaining normal population of rice); T_4 - Rice + arrowhead (1:1 row ratio by replacement series); T_5 - (Rice + arrowhead (2:1 row ratio pair row technique maintaining normal population of rice); T_6 - Rice + arrowhead (2:1 row ratio by replacement series); T_7 - Rice + arrowhead (3:2 row ratio maintaining normal population of rice by spacing adjustment); T_8 -Rice + arrowhead (3:2 row ratio by replacement series). The rice cultivar “Leimaphou” was cultivated by following standard package of practices. The arrowhead was transplanted in the main field after full recovery stage *i.e.,* 14 days after transplanting of rice. The productivity of base crop rice due to arrowhead intercropping, as well as their combine effect on the total productivity, labour-use–efficiency and economics were analysed following standard statistical methods.

RESULTS AND DISCUSSION

Crop productivity

Regarding rice grain yield sole rice recorded highest grain yield over other treatments (Table 1). Among the intercropping systems, the maximum grain yield (43qha^{-1}) was obtained in 1:1 row ratio maintaining normal population of rice. Arrowhead intercropping also did not bring any significant change in the harvest index of rice. Higher grain yield in sole crop might be due to comparably higher filled grains along with higher plant population in sole crop than other treatments. A similar finding of higher grain yield in sole treatments in comparison to intercropping treatments was reported by Mandal *et al*. (2000). The higher tuber yield of arrowhead (56.6qha^{-1}) was found in sole arrowhead and this might be due to higher plant population and higher number of tubers per plant in the treatment. Among the intercropping treatments, the highest tuber yield was revealed in 1:1 row ratio by replacement series (29.8qha^{-1}). These were related with the population of arrowhead in the intercropping system. Aribumozhi *et al*. (2002) also reported possibility of increasing crop yield in intercropping system by manipulation of planting geometry.

Rice equivalent yield

The highest total rice equivalent yield were revealed in sole arrowhead, but among the intercropping treatments, 1:1 row ratio combination by replacement series recorded the highest total rice equivalent yield (135.22qha^{-1}), closely followed by 2:1 row ratio combination by pair row technique maintaining normal population of rice (122.82 q ha^{-1}). This might be due to higher proportionate yield of arrowhead in these treatments along with considerably high yield of rice. Similar findings were reported by Sarawagi and Tripathi (1999) and Abaje *et al*. (2002) in other crops. Due to higher total rice equivalent yield without lengthening the duration of crops, the per day per hectare rice equivalent yield were also recorded the highest in sole arrowhead and closely followed by 1:1 row ratio combination of rice + arrowhead by replacement series (96.58qha^{-1}day^{-1}).

Competitive functions

The highest value of land equivalent ratio and maximum monetary advantages were observed in rice + arrowhead in 2:1 row ratio combination by pair row technique maintaining normal population of rice (Table 2). The combined intercrop was found to have 31% more land advantage. The land equivalent ratio of the different intercrop treatments were found greater than sole crops indicating better land utilization. Similar results were reported by Gulzar and Zar (2001) and Nargis *et al*. (2004).The component crop rice was found highly competitive in intercropping treatment of 1:1 row ratio combination maintaining normal population of rice. While in other treatments the component crops were more or less competitive indicating that the systems were adoptable. This might be due to favourable planting geometry of the crops in these treatments. Similarly the proportionate yield of rice was found to be higher when it was intercrop with arrowhead in 1:1 or 3:2 row ratio combinations maintaining normal population of rice. This might be due to the same reason of the competitive nature in these treatments. While for arrowhead, proportionate yield was the highest in 1:1 row ratio by replacement series. This might be due to higher competitive ability of the crop in their planting geometry. Moreover the two crops were more or less equally competitive in this treatment indicating that the system was adoptable..

Economics

The highest capital investment was required for production of rice + arrowhead in 1:1 row ratio maintaining normal population of rice (Table 3). It was due to higher number of man days required with higher requirement of planting materials i.e. rice seed. The lowest investment incurred in rice + arrowhead (3:2 row ratio by replacement series) was due to less man days required. The highest net return per rupee investment was recorded in sole arrowhead (Rs.8.78ha^{-1}), closely followed by rice + arrowhead (1:1 row ratio by replacement series) which was significantly higher than any other intercropping treatments. It might be due to higher net return with low investment. The lowest value was recorded in sole rice and in intercropping rice + arrowhead in 3:2 row ratio by replacement series.

Labour use efficiency

Due to higher return without increasing much on the labour investment the higher return per rupee investment on labour was obtained in sole arrowhead (Rs. 23.7ha^{-1}), but among the intercropping treatments the highest value (Rs. 11.34 ha^{-1}) was observed in rice + arrowhead 1:1 row ratio by replacement series, while the lowest was recorded in sole rice (Rs.2.95 ha^{-1}).

From the above results, it was revealed that growing of rice alone as a sole crop under rainfed

Table 1. Yield component of rice and intercrop under different intercropping systems (Mean of 2 years)

Intercropping system	Rice yield (qha^{-1})	Rice straw yield (qha^{-1})	Harvest index (%)	Intercrop yield (qha^{-1})	Rice equivalent yield of intercrop (qha^{-1})	Total rice equivalent yield (qha^{-1})	Per day per hectare rice ($kg\ ha^{-1}day^{-1}$)
T_1	46.50	72.48	0.38	-	-	46.50	33.21
T_2	-	-	-	56.60	204.76	204.76	146.26
T_3	43.00	68.20	0.38	16.00	57.11	100.11	71.50
T_4	28.86	49.90	0.36	29.80	106.37	135.22	96.58
T_5	42.86	66.70	0.37	22.40	79.96	122.82	87.73
T_6	34.90	64.31	0.38	20.80	74.27	109.17	77.98
T_7	39.90	51.86	0.40	14.37	51.30	91.20	65.14
T_8	30.84	53.33	0.43	24.84	89.60	120.44	86.03
S.Em.(±)	**1.02**	**1.83**	**0.04**	**1.60**	**5.30**	**6.15**	**6.15**
C.D. (P=0.05)	**2.20**	**3.98**	**NS**	**3.49**	**11.38**	**13.19**	**13.19**

Local market price of rice = Rs 7 kg^{-1} and arrowhead = Rs 25 kg^{-1}

Table 2. Land equivalent ratio, competitive ratio, yield proportion and monetary advantage of the different intercropping systems (Mean of 2 years)

Intercropping systems	Land equivalent ratio	Competitive ratio		Yield proportion		Monetary advantages (Rs.)
		Rice	Intercrop	Rice	Intercrop	
T_1	1.00	-	-	-	-	-
T_2	1.00	-	-	-	-	-
T_3	1.20	3.37	0.30	0.76	0.24	11874
T_4	1.14	1.21	0.84	0.55	0.45	11955
T_5	1.31	1.19	0.85	0.70	0.30	20.615
T_6	1.11	1.04	0.97	0.67	0.33	24163
T_7	1.10	2.29	0.44	0.77	0.23	6130
T_8	1.09	1.03	0.98	0.60	0.40	7191
S.Em(±)	**0.03**					
C.D. (P=0.05)	**0.07**					

Table 3. Economics of the different rice + arrowhead intercropping system (Mean of 2 years)

Intercropping system	Cost of production (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Net return day^{-1} hectare^{-1}	Net return rupee^{-1} invested (Rs.)	Net return rupee^{-1} invested labour (Rs.)
T_1	15833	32552	16719	119	1.05	2.95
T_2	14665	143383	128718	919	8.78	23.70
T_3	20265	70092	49827	356	2.46	5.16
T_4	15236	94694	79458	568	5.21	11.34
T_5	19085	85991	66906	478	3.51	6.93
T_6	15794	76441	60647	433	3.84	8.24
T_7	18567	63853	45286	323	2.44	5.20
T_8	13941	83627	69686	498	5.00	10.87
S.Em.(±)		**3945.27**	**3945.27**	**28.18**	**0.25**	**0.54**
C.D. (P=0.05)		**8463.00**	**8463.00**	**60.00**	**0.55**	**1.15**

condition is not remunerative. For higher economic return it can be grown in combination with arrowhead either in 1:1 row ratio by replacement series or 3:2 row ratio by replacement series under rainfed condition of Manipur. The remuneration can be further increased by arrowhead sole cropping if the farmer can devote the whole field for this new crop.

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