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INFLUENCE OF INTERCROPS AND ROW RATIOS ON WEED SUPPRESSION AND PERFORMANCE OF UPLAND RICE (*ORYZA SATIVA* L.)UNDER DIFFERENT WEED REGIMES

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ABSTRACT

Direct-seeded rice ecosystems are most vulnerable to weed competition that reduces not only its grain yield (30-100%) but also deteriorates the grain quality. The investigation aimed at employing cultural techniques for economically viable and effective weed control rather than complete weed elimination. Hence, a field experiment was carried out to assess the impact of cropping systems involving crops of diverse growth nature such as pigeon pea and cowpea on weed occurrence and productivity of the system under weed control regimes comprising of single and two hand weedings. In rice + cowpea intercropping system, three row ratios i.e. 4:1, 4:2 (replacement series) and 5:1 (additive series) whereas two row ratios i.e., 4:1 (replacement series) and 5:1 (additive series) were tested in rice + pigeon pea intercropping system. Besides intercropping, all the three crops (rice, pigeon pea and cowpea) were also grown as the sole crop. Results showed that cowpea and pigeon pea intercropping with rice minimized the weed infestation. Least density and biomass of weeds was recorded in rice + cowpea (5:1) intercrop system. A slight decrease in weed count and biomass of broadleaf weeds was observed with intercropping of cowpea. Reduction in the grain yields of rice, pigeon pea and cowpea were recorded (16.7 to 35.2%) across the years under intercropping system in comparison to sole cropping. The land equivalent ratio (LER) values showed that, irrespective of spatial combinations of the crops, a useful yield increase was always attainable in all intercropping treatments. In particular, intercropping of rice and pigeon pea with 4:1 row ratio was found to be the most effective for land use efficiency and better economics.

KEYWORDS: Intercropping, Weed Control, Rice Equivalent Yield, Upland Rice, Cowpea, Pigeon Pea

INTRODUCTION

Upland rice is grown on around fifteen million hectares of land globally and rice produced from these lands feed nearly 100 million people. In upland rice cultivation, the crop is directly sown in unpuddled, well-drained soil, where weeds and rice germinate simultaneously. Therefore, among different rice ecosystems, the greatest weed pressure and competition occurs in upland rice. Rice crop growth invariably suffers from severe weed infestation under upland situation. A mixture of annuals and perennials, and grasses and broad leaf weeds, intensifies the competitive effects of weeds in upland rice. Generally, grasses are predominant over other classes of weeds.

Several methods of weed control are used to control weeds in the upland rice. Direct methods of weed control are used to remove weeds completely from the upland fields; the substitutive, preventive, and complimentary weed control measures generally minimize weed populations to a manageable level instead of complete elimination. Repeated cropping on the same land could lead to a build-up of weed populations not easily controlled by existing methods. Such a build-up may be managed by rotating with another crop in which different weed control measures are used. Diversification of cropping systems, for instance, by increasing the number of crop species grown, has been proposed as a solution to some problems of modern agriculture (Altieri, 1999). Intercropping, the practice of growing two (or more) crops simultaneously in the same land area, represents an option to diversify cropping systems (Altieri, 1999).

Intercrop systems are reported to use resources more efficiently and are able to remove more resources than monocrop systems, thus decreasing the amount available for weed production (Liebman, 1988). Legumes, with their adaptability to different cropping patterns and their ability to fix nitrogen, may offer opportunities to sustain increased productivity (Jeyabal and Kuppuswamy, 2001). Weed suppression, the reduction of weed growth by crop interference, has been referred as one determinant of yield advantage of intercropping, being a viable alternative to reduce the reliance of weed management on herbicide use (Liebman and Davis, 2000). Intercrops may also provide yield advantages without suppressing weed growth below levels observed in component monocrops by using resources that are not exploited by weeds and convert resources to harvestable materials more efficiently than monocrops (Liebman and Elizabeth, 1993). Thus, theme of low-canopy crops as smother crops for biological weed control is now receiving greater attention (Akobandu, 1981; Shetty and Rao, 1981) and crops such as groundnut, cowpea, soybean, black gram and green gram could serve as smother crops. However, ability of a legume crop to suppress weeds depends on cultivar's rate of growth and establishment of canopy cover besides several other factors. Considering yield advantages and weed suppression ability of intercrop systems reported by various researchers, an investigation was planned to assess impact of crops with differing canopy structure in various row proportions and combinations with different weed control measures.

MATERIALS AND METHODS

Field experiments were conducted during the wet seasons of two consecutive years at the research farm of the Central Rainfed Upland Rice Research Station, Hazaribag (23°56'46"N latitude and 85°21'46"E longitude), India under rainfed conditions. The climate of the location is characterized as warm and sub-humid. The average annual rainfall of 1215 mm is received mostly (about 85%) from South West monsoon during June to October. The mean maximum temperature varied between 20.7 ^{0}C (January) and 38.2 ^{0}C (May) while the mean minimum temperature fluctuated between 5.2 ^{0}C (January) and 23.8 ^{0}C (July). The mean maximum relative humidity varied from 45.5 percent (April) to 89.3 percent (August), while the mean minimum relative humidity varied between 21.4 percent (April) and 84.8 per cent (August). Number of wet days varied from 53 to 55 days a year during cropping seasons of experimentation.

The soil of the experimental site was red (Udic Rhodustalf) with silty loam texture having pH 5.4, organic carbon 0.4%, available P 12.8 kg/ha and K 385 kg/ha. In rice + cowpea intercropping system, three row ratiosi.e. 4:1, 4:2 (replacement series) and 5:1 (additive series) were tested. Similarly, in rice + pigeon pea intercropping system, two row ratios i.e., 4:1 (replacement series) and 5:1 (additive series) were tested. In case of replacement series either in 4:1 or 4:2 row ratio, 5th or both 5th and 6th rice row was substituted with the intercrop row respectively whereas in case of additive series full population of the base crop (rice) was maintained by adjusting the row spacing of rice crop. Besides intercropping system, all the three crops (rice, pigeon pea and cowpea) were also grown as the sole crop. In all, different combinations of eight cropping systems and two weed control treatments were tested. Thus, sixteen treatment combinations were investigated following randomized complete block design (Factorial) with three replications.

Sowing was done during the third week of June in both the years using 75 kg seed of rice, 18 kg of pigeon pea and 80 kg of cowpea per hectare in case of sole crops and proportionately as per row ratios in different intercropping systems.

Standard agronomic practices were followed for raising sole crops of rice, pigeon pea and cowpea. The intercrop of rice, pigeon pea and cowpea in treatments of replacement series received N according to proportionate area occupied. In basal application, the both N P and K fertilizers were applied in bands. All data were subject to analysis of variance as per the standard procedure and least significant difference values were calculated at 5% significance level wherever the F-ratio was found to be significant.

RESULTS AND DISCUSSION

Weed Flora, Intensity and Biomass

Predominant broadleaf weeds included *Ageratum conyzoides*, *Portulaca oleracea*, *Commelina benghalensis*. and *Euphorbiahirta*. *Digitaria ciliaris* (Retz.) Koel. *Echinochloa colona*, *Eleusine indica*, and *Paspalum* spp., were present in abundant numbers among the grassy and *Cyperus iria* L., *Fimbristylis miliacea* among the sedges.

It is observed from table 1 that in direct seeded rice as well as in pigeon pea and cowpea field, population wise grasses constituted major weed population followed by broadleaf weeds and sedges Similar trend was observed for dry matter production by weeds. There was significant influence of both sole as well as intercropping, row ratios and weed management practices on dry matter production of weeds. Among the three sole crops, cowpea proved the most efficient crop in restricting weed growth at harvest. Dry matter of weeds was further reduced when intercropping with rice was practiced. Intercropping of cowpea with rice was found to be more effective in reducing dry matter than intercropping with pigeon pea. Minimum dry matter of weeds was recorded in rice + cow pea intercropping system at 5:1 ratio.

At harvest, maximum count and dry weight of weeds was registered in sole rice followed by pigeonpea. Sole crop of cowpea had significantly less weed population and dry matter as compared to sole rice in both the years. In monocropping, cowpea proved more efficient in suppressing weeds than the pigeon pea and rice. Cowpea with its broader leaves and early rapid growth might have blocked the light from reaching the ground. Cowpea intercropping suppressed the weed population and minimized the weed infestation. In rice + cowpea (5:1) intercropping system, weed density and weed dry matter were minimum. These findings are in agreement with the results reported by Dutta and Gogoi (1994). Cowpea with its broader leaves and early rapid growth might have blocked the light from reaching the ground. Shetty and Rao (1991), Prusty *et al.* (1990) and Kar *et al.*(1993) have also attributed the lower weed growth to the smothering effect caused by the well-developed crop canopy. Less weed dry matter and density registered under intercropping may be due to the weed suppressing capability of intercropping over monocropping. Intercrops may also provide yield advantages without suppressing weed growth below levels observed in component monocrops by using resources that are not exploited by weeds and convert resources to harvestable materials more efficiently than monocrops (Liebman and Elizabeth, 1993). Less weed production under monocropped cowpea over monocropped rice may be due to better weed smothering efficiency of pulse crops. Less weed biomass production and weed density under intercropping system is due to higher inter-specific competition combined with complementarity between intercrop species that improve the crop stand competitive ability towards weeds (Nielson et al., 2003). Among the weed regimes imposed, two hand weeding (2HW) proved most efficient in effective control of weeds.

The grain yield of rice, pigeon pea and cowpea grown as sole crop or intercrop and also the equivalent yield of rice is shown in Table 2. The grain yields of all the crops were reduced under intercropping system compared to sole cropping. It is observed that under intercrop system the rice yield was reduced by 18.1% (0.32 t/ha) in rice + PP (4:1), 18.6% (0.33%) in rice + PP (5:1) to 33.3% (0.59 t/ha) in rice + cowpea (4:2). The sole crop had less interspaced competition and better environment for growth and development than intercrops (Manchanda et al 2006). The higher yields under sole crop might be due to availability of better conditions of growth, less interspace competition and increased habitat population. This reduction in rice yield is attributed to less number of fertile tillers m^2, spikelets per panicle and length per panicle in all the intercropping systems (data not presented here. Singh et al. (1996) and Saeed et al. (1999) also reported similar reduction in paddy yield by intercropping. Rice grain yield was affected by the weed regimes but intercrop yields remain unaffected. Weed management practices also influenced rice grain yield substantially. Similarly, the pigeon pea and cowpea yields were also reduced in intercrop system compared to sole pigeon pea and cowpea yields. However, differences in grain yields of pigeon pea and cowpea appeared to be non-significant due to weed management practices.

In terms of rice equivalent yield, all the intercropping treatments yielded higher than sole rice except sole cowpea which produced less rice equivalent yield. These results corroborate Saud (1999) who reported that intercropping gave higher rice grain-equivalent yield compared to sole cropping. Higher rice-equivalent yield when intercropped compared to respective monocrops was due to higher total productivity because intercropping exploited resources more efficiently (Midya et al., 2005).

When the values of land equivalent ratio appear to be greater than unity under intercropping system, this usually indicates the efficiency of this system over the sole cropping system (Vandermeer, 1989).The land equivalent ratio (LER) shows that, irrespective of spatial combinations of the crops, a useful yield increase was always attained in all intercropping treatments (Table 2). This could be because the crop occupied in part different spaces, competed for different resources, and hence had adequate utilization (Willey, 1979). The land equivalent ratios as an indicator of biological efficiency in intercropping systems were always greater than 1 with intercropping in this study. In the study the highest value of LER(1.49) was obtained in rice intercropped with pigeonpeain 4:1 row ratio.

CONCLUSIONS

Studies on intercropping revealed that grain yields of rice, pigeon pea and cowpea were reduced under intercropping system compared to sole cropping. Rice grain yield in intercropping showed a minimum decrease of 18.1 to maximum decrease of 33.3per cent across the years. Rice grain yield was affected by the weed regimes but intercrop yields remain unaffected. In terms of rice equivalent yield, all the intercropping treatments yielded higher than sole rice except sole cowpea which produced either equal or less rice equivalent yield in different years. The land equivalent ratio (LER) showed that, irrespective of spatial combinations of the crops, a useful yield increase was always attained in all intercropping treatments. In this study, the highest value of LER was obtained in rice intercropped with pigeonpea and gave a LER from 1.38 and 1.49 over the years. Generally, rice and cowpea reached their peak vegetative growth at about 8-9 weeks after seeding while the much slower-growing pigeon pea does not peak until about 100-110 DAS, around the time of rice or cowpea harvest. Intercropping with cowpea in different row ratios proved efficient in reducing weed pressure but advantages gained with pigeon pea as intercrop in terms of land resource utilization and harvesting more economic benefits suggested cultivation of rice +pigeon pea intercropping in rainfed uplands instead of monocropping of rice. Rice equivalent yield and economics indicated overall advantage accrued from intercropping of pigeonpea and cowpea with rice in 4:1 and 4:2 row ratios, respectively. Intercropping systems were superior than sole rice cropping in terms of weed management. In particular, intercropping of rice and pigeonpea with 4:1 row ratio was found to be the most effective for land use efficiency and better economics.

Table 1: Weed Dry Matter, Weed Intensity and Floristic Composition as Influenced by Different Cropping Systems and Weed Control Measures (Mean of Two Years)

Treatment	Weed Intensity (no./m^2)	Weed Dry Matter (g/m^2)	Floristic Composition (%, Intensity Basis)		
			Grasses	Sedges	Broadleaf
Cropping systems					
Rice sole	149	101	63.4	4.5	32.0
Pigeon pea (PP) sole	132	91	60.6	4.6	33.7
Cowpea (CP) sole	86	59	58.0	4.7	35.2
Rice + PP (4:1) intercrop	89	58	59.8	4.7	34.3
Rice + PP (5:1) intercrop*	67	48	57.8	5.0	34.9
Rice + CP (4:1) intercrop	69	48	56.4	4.7	35.6
Rice + CP (4:2) intercrop	55	41	55.8	5.2	36.0
Rice + CP (5:1) intercrop*	45	26	55.5	4.9	36.3
SEm±	4.6	6.9	-	-	-
LSD (p=0.05)	14.0	20.0	-	-	-
Weed regimes					
1 Hand weeding (HW)	126.0	83.4	59.3	5.0	34.2
2 Hand weeding (HW)	46.0	33.1	57.5	4.5	35.3
SEm±	11.6	12.5	-	-	-
LSD (p=0.05)	35.0	37.0	-	-	-
*5:1 row ratio represents additive series & others (4:1 & 4:2) replacement series					

Table 2: Yields and Yield Attributes of Upland Rice As Affected By Different Cropping Systems and Weed Control Measures (Mean of Two Years)

Treatment	Grain Yield (t/ha)			Rice Equivalent Yield (REY)	Partial LER (Rice)	Partial LER (intercrop)	Land Equivalent Ratio (LER)
	Rice	PP/CP	Total				
Cropping systems							
Rice sole	1.77	-	1.77	1.77	-	-	1.00
Pigeon pea (PP) sole	-	0.85	0.85	2.32	-	-	1.00
Cowpea (CP) sole	-	0.60	0.60	1.65	-	-	1.00
Rice + PP (4:1) intercrop	1.45	0.55	2.00	2.95	0.84	0.65	1.49
Rice + PP (5:1) intercrop*	1.44	0.52	1.96	2.78	0.76	0.62	1.38
Rice + CP (4:1) intercrop	1.25	0.30	1.55	2.07	0.71	0.49	1.20
Rice + CP (4:2) intercrop	1.18	0.41	1.59	2.31	0.68	0.67	1.35
Rice + CP (5:1) intercrop*	1.30	0.35	1.65	2.27	0.75	0.47	1.22
SEm±	0.11	0.11		0.16	-	-	-
LSD (p=0.05)	0.34	0.33		0.46	-	-	-
Weed regimes							
1 Hand weeding (HW)	1.19	0.49	1.68	2.52	0.76	0.56	1.32
2 Hand weeding (HW)	1.60	0.68	2.28	3.44	0.72	0.60	1.32
SEm±	0.11	0.15		0.11	-	-	-
LSD (p=0.05)	0.33	ns		0.32	-	-	-

*5:1 row ratio represents additive series & others (4:1 & 4:2) replacement series

REFERENCES

1. Akobundu, I.O. (1981). Weed Control in Intercropping Mixtures, In: S.J. Pandey (Ed.), Agronomy Training Manual for Ago-Service Agronomists. Llta/National Accelerated Food Production Project, Lagos, Nigeria, pp. 217-227.
2. Altieri, M.A. (1999), The Ecological Role of Biodiversity in Agroecosystems, Agriculture Ecosystems and Environment, 74: 19-31.
3. Dutta, R. and Gogoi, A.K. 1994. Evaluation of weed control practices in direct seeded rice. *Indian Journalof Weed Science*, 26:109-111.
4. Jeyabal, A., G. Kuppuswamy. (2001), Recycling of Organic Wastes for the Production of Vermicompost and Its Response in Rice–Legume Cropping System and Soil Fertility, *European Journal of Agronomy*, 15:. 153–170.
5. Kar, B.C., Behera, B., Satpathy, S.C. and Mishra, P.K. 1993. Growth pattern of weeds and semi-dry rice (Oryza sativa) under weed management practices. *Indian Journal of Agronomy*, 38:511-512.
6. Liebman, M., and A.S. Davis. (2000), Integration of Soil, Crop and Weed Management in Low-Input Farming Systems, *Weed Research*, Vol. 40, pp. 27–47.
7. Liebman, M., Elizabeth, D., 1993. Crop rotation and intercropping strategies for weed management. *Ecological Applications* 3, 92–122.
8. Manchanda Anirudh, Basandrai Daisy, Basandrai Ashwani, Thakur H.L. 2006. Productivity and economics of cowpea (*Vigna unguiculala* L. walp) under mono and intercropping systems at paonta valley of Himachal Pradesh., *Journal of Research*, SKUAST–J, 5(2): 165-172
9. Midya A, Bhattacharjee K, Ghosh SS, Banik P (2005). Deferred seeding of black gram (*Phaseolus* mungo L.) in rice (Oryza sativa L.) field on yield advantages and smothering of weeds. *Journal of Agronomy and Crop Science*, 191:195-201
10. Nielson, Hauggaard, H., Jornsgaard, B., Steen, J.E., 2003.Legume-cereal intercropping system as a weed management tool. In: Proceedings of the 4th Eur. Weed Research Society Workshop: Crop weed competition interaction. Universita Tusca, Viterbro, Italy, 10–12th April, 2003
11. Prusty, J.C., Mishra, A., Behera, B. and Parida, A.K. 1990. Weed competition study in upland rice. *Orissa Journal of Agricultural Research*, 3: 275-276.
12. Saeed, M., A. Ullah, R. Ahmad and A. Jabbar, 1999. Bio-economic assessment of direct-seeded rice-based intercropping systems under strip plantation. *Pakistan Journal of Biological Science*, 2: 980–83.
13. Saud, R.K., 1999. Growth and yield attributes in direct-seeded rice and cowpea fodder intercropping system. *Journal of Soils and Crops*, 9: 53–56.
14. Shetty, S.V.R. and A.N. Rao. 1981. Weed management in sorghum/pigeonpea and pearl millet/groundnut intercrop systems – some observations. In: International Crops Research Institute for the Semi-Arid Tropics. Proceedings of the International Workshop on Intercropping, January 1979, p. 238-248, Hyderabad, India.

15. Singh, C. V., Chauhan, V.S. and Singh, R. K. 1993. Rice (Oryza sativa)- based intercropping systems in rainfed uplands of Chhotanagpur plateau. *Indian Journal of Agricultural Sci*ences, 63(10): 621-624.
16. Singh, G., O.P. Singh, M. Kumar, A.L. Rajput and S. Maurya, 1996. Effect of intercrops on yield and economics, weeds and pest infestation of deep water rice. Ann. Agri. Res., 17: 14–7.
17. Vandermeer, J. (1989), The Ecology of Intercropping. Cambridge University Press, Cambridge.
18. Willey, R.W. (1979a), Intercropping. Its Importance and Research Needs. Part 1. Competition and Yield Advantages, *Field Crop Abstracts*, 32: 1–10.