ISSN 1819-1894

Asian Journal of Agricultural Research

Knowledgia SCIENTIFIC
A Place to Publish Outstanding Research
http://knowledgiascientific.com

Asian Journal of Agricultural Research 5 (6): 306-311, 2011
ISSN 1819-1894 / DOI: 10.3923/ajar.2011.306.311

Management of Weeds of Rainfed Lowland Rice Using Cultivar Mixture Strategies

[1]W.B. Binang, [2]F. Ekeleme and [1]J.D. Ntia
[1]Department of Crop Science, University of Calabar, Calabar
[2]Department of Agronomy, Michael Okpara University of Agriculture, Umudike

Corresponding Author: W.B. Binang, Department of Crop Science, University of Calabar, Calabar Tel:+2348033553486

ABSTRACT

The aim of this field study conducted in Calabar, Southeastern Nigeria was to investigate whether mixtures of rice cultivars with different characteristics and in varying proportions and deployment times could be effective in suppressing weed growth. Two lowland rice cultivars; Faro 15 (improved, semi-dwarf, profuse tillering, lodge-tolerant, early maturing),and Muduga (local, tall, lodging-susceptible ,medium maturing), were raised in nurseries and 24 day old seedlings transplanted, 2 seedlings per hill at 20×20 cm spacing. Treatments were factorial combinations of 2 planting proportions (Faro 15: Muduga at 4:1 and 3:2) and 5 times of introduction (Faro 15 introduced 2 weeks before, 1 week before, same day as, 1 week after and 2 weeks after-Muduga). The results indicate that in rainfed, low-input, lowland rice production systems, cultivar mixtures can improve the competitive ability of rice, reducing weed biomass production and diminishing rice biomass losses. Across both cultivars, the population of weeds was reduced by 39.7% when Faro 15 was introduced 2 weeks after Muduga in a 3:2 ratio, but the effect on weed biomass was not significant. The time of component cultivar introduction significantly affected the weed suppressive ability of the mixture and the best time depended on the grain preference of the farmer. On the basis of combined grain yield, introducing Muduga 1 or 2 weeks after Faro 15 gave the best results.

Key words: Lowland rice, cultivar mixture, cultivar ratio, time of introduction, competitive ability, weeds management

INTRODUCTION

Crop mixtures are a useful tool for disease management (Lannou and de Vallavieille-Pope, 1997; Finckh *et al.*, 2000) and for attaining other objectives including yield stabilization and increased yield (Bowden *et al.*, 2001). Mixtures may be composed of different species (inter specific) or of different genotypes (intra specific), the later being made up of cultivars of the same species, multilines (mixtures of genetically uniform lines of a crop species differing in a single character) or bulk hybrids. Intra specific mixtures have been proposed as a means of increasing crop heterogeneity thereby giving the crop a greater capacity to adjust to the many and varied stresses that can occur, and ultimately leading to higher yields than pure-line mono crops. They do this through mechanisms such as complementary resource use above and below-ground (Fukai and Trenbath, 1993), compensatory effects and facilitation which is the positive effect of plants on the establishment and growth of other plants (Garcia-Barrios, 2003). Another benefit of intra specific mixtures is the fact that they offer better opportunities for on-farm conservation of genetic resources because farmers are able to cultivate varieties which, perhaps because of their low yield potential would otherwise not be grown and may therefore become extinct.

Rice cultivar mixtures have a number of benefits from their use in low-input systems such as practiced in Nigeria (Binang *et al.*, 2010a, b). While it is known that cultivar mixtures generally stabilize crop yields and reduce lodging, their influence on weeds have not been investigated to any significant extent. The competitive effects of different crop cultivars against weeds vary depending on botanical characteristics, and management practices such as time of deployment might be expected to affect competitive ability. Estavan (2006) in a preliminary study indicated that cultivar mixtures could improve the competitive ability of barley, but suggested the need to "devise a formula that allows us to design correct mixtures for use in weed control". Binang *et al.* (2010b) who evaluated the effect of cultivar interplanting ratio on the productivity of rice concluded that the Muduga:Faro 15 ratios of 1:4 and 2:3 yielded highest because of the synergy of a meaningful reduction in weed incidence and significant reduction in plant lodging. Such weed suppressive activity could be particularly useful in subsistence farming systems where the use of herbicides is prohibitive. Resistance to herbicides and lack of viable control options have led to an interest in increasing the role of crop competition as a weed control management tool. Weed-suppressive rice cultivars have been suggested as a tool that could improve weed control and reduce the reliance on herbicides. The use of cultivar mixtures could thus be a potent supplement to present weed management practices and could reduce production costs and the potential for environmental pollution, as well as alleviate some of the social constraints associated with labour-intensive manual weeding. The aim of this study was to evaluate the usefulness of cultivar mixtures as a strategy for managing weeds of lowland rice in a rain-fed, low-input production system.

MATERIALS AND METHODS

The experiment was conducted at the Research Farm of the University of Calabar, Southeastern Nigeria in 2009 and 2010. The area was located in the rain forest belt and characterized by humid tropical climate with distinct wet and dry seasons, with a bi-modal rainfall pattern which peaks in July and September. The site was manually cleared with machete and tilled with hoe. Stumps were uprooted and bunds 30 cm high and 30 cm wide at the base constructed by raising the soil around the plot. The field was then divided into 3 blocks, each with 12 experimental plots of 5×5 m, and separated by 2.0 m wide paths. Two lowland rice cultivars, Faro 15 (improved, semi-dwarf, mid-maturing, profuse tillering habit) and Muduga (traditional, tall, lodging-susceptible) were used for the study. Bed nurseries were raised and 24 day old seedlings transplanted, 2 seedlings per hill at 20×20 cm. Treatments were factorial combinations of 2 planting ratios (Faro 15:Muduga at 4:1 and 3:2) and 5 times of introduction (Faro 15 introduced 2 weeks before, 1 week before, same day as, 1 week after, 2 weeks after-Muduga). The sole crops were planted to permit computation of Land Equivalent Ratio (LER). All plots received 50 kg N ha^{-1}, 40 kg K_2O ha^{-1} and 40 kg P_2O_5 ha^{-1} in the form of sulphate of ammonia, muriate of potash and single superphosphate, respectively. Nitrogen was split applied at transplanting and at panicle initiation stage, while P and K were worked into the soil, one week before transplanting. Weeding was by hand pulling and hoeing at 3 and 7 weeks after transplanting (WAT) and birds were controlled by scarring using "scare crows" and "bird boys". Weed density was taken as the number of weeds from a 1 m^2 quadrant prior to each weeding operation, while weed biomass was taken as the weight of weeds collected as described above, washed, oven-dried at 70°C for 48 h and weighed with a sensitive Mettler™ weighing scale. Rice straw weight taken at maximum tillering was recorded after sun-drying to constant weight. Productivity of the mixture was assessed by calculating the Land Equivalent Ratios (LERs) from component cultivar yields (Mead and Willey, 1980). If LER is greater than unity, then interplanting has a yield advantage (Willey, 1979).

Statistical analysis: Data collected were weed density, weed dry matter, plant height, productive tiller number and rice straw weight and grain yield. This data were subjected to analysis of variance (ANOVA) according to the procedure for a factorial experiment in randomized complete block design using GENSTAT (2003) and mean separation by Least Significant Difference (LSD) at 5% probability, as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Table 1 shows the effect of cultivar ratio, time of introducing different cultivars and the interaction effect on weed incidence. Cultivars differed widely in the growth of weeds they permitted. At both times of weed sampling, the effect of cultivar ratio was not significant on weed density and weed dry matter production, although transplanting Faro 15 after Muduga tended to have supported the production of lower weed population. At 7 weeks after transplanting however, the most weed-suppressive combination was the introduction of Faro 15 1 or 2 weeks after Muduga

Table 1: Weed density and dry weight as influenced by cultivar ratio and time of cultivar introduction

Cultivar ratio	Weed density (No. m^{-2})		Weed dry weight (g^{-2})	
Faro 15: Muduga	3 WAT	7WAT	3WAT	7WAT
4:1	113.43	63.51	40.90	35.73
3:2	106.48	58.51	40.72	33.43
Sole Faro 15	124.56	76.35	50.76	39.03
Sole Muduga	135.0	87.32	48.92	38.07
Time of introduction				
2 weeks before Muduga	114.05	70.50	43.05	39.30
1 week before Muduga	118.80	66.05	40.18	34.44
Same day as Muduga	109.40	57.92	43.58	30.28
1 week after Muduga	106.06	55.60	36.39	38.28
2 weeks after Muduga	101.45	54.97	38.63	30.67
Cultivar ratio×Time of introduction				
4:1×2 weeks before Muduga	115.77	74.20	45.66	38.37
4:1×1 week before Muduga	123.59	65.19	45.47	31.19
4:1×same day as Muduga	115.05	60.49	43.81	38.43
4:1×1 week after Muduga	109.45	62.60	43.90	36.0
4:1×2 weeks after Muduga	103.29	55.07	40.22	37.37
3:2×2 weeks before Muduga	112.34	66.80	45.07	36.09
3:2×1 week before Muduga	114.0	66.92	43.92	36.42
3:2×same day as Muduga	103.75	55.35	40.11	34.05
3:2×1 week after Muduga	102.69	48.60	38.60	31.23
3:2×2 weeks after Muduga	99.62	49.50	37.64	30.11
LSD ($_{0.05}$) for:				
Cultivar ratio (C) means	Ns	Ns	Ns	Ns
Time of introduction(T) means	9.77	2.08	Ns	Ns
C×T means	Ns	4.05	Ns	Ns

in the ratio of 3:2. Across both cultivars, per cent weed population reduction was 39.7 when Faro 15 was introduced after Muduga in a 3:2 ratio. Weed biomass on the contrary was unaffected by the different treatments at the various times assessed, probably because the weeds though, numerous had low weight, probably due to the effectiveness of land preparation method adopted as well as early vigor of rice seedlings. Significantly higher weed density was recorded with pure populations of both cultivars than with their mixtures indicating the weed suppressive effect of this cultivar in a mixture. Faro 15 supported the production of lower weed density than Muduga. Weed biomass was negatively correlated with rice plant height, tiller number, straw weight and grain yield.

Plant heights at 10 WAT when Faro 15 headed, were similar in both cultivars. However, given that Muduga stayed longer in the field, its height at maturity was much taller than that of its companion cultivar. The earlier the introduction of a cultivar, the taller it tended to be perhaps because of the 'transplanting shock which the introduced component would have to overcome'. However, whereas cultivar proportion did not influence the height of Faro 15, the 3:2 Faro 15 to Muduga ratio resulted in significantly taller Muduga plants (Table 2). Significant differences between cultivars were observed in tillering ability, as the improved, semi-dwarf Faro 15 expectedly bore many more tillers than the local Muduga cultivar. When grown in mixture, either cultivar tillered most when introduced before the other, suggesting an intra specific competition for resources between them.

Table 2: Rice yield and some other parameters as influenced by competition with weeds

Cultivar ratio	Plant height (cm)		Total tiller (No. plant^{-1})		Rice straw yield (t ha^{-1})		Grain yield (t ha^{-1})	
Faro 15 Muduga	Faro15	Muduga	Faro15	Muduga	Faro15	Muduga	Faro15	Muduga
4:1	57.44	67.95	11.98	7.78	4.14	5.25	3.67	1.79
2:3	55.28	70.01	13.14	9.26	4.84	6.36	4.09	2.11
Sole Faro 15	56.79	-	15.56	-	6.14	-	5.26	-
Sole Muduga	-	72.06	-	9.41	-	8.43	-	0.69
Time of introduction								
2 weeks before Muduga	63.43	63.19	15.26	8.27	6.58	4.69	4.67	1.57
1 week before Muduga	62.98	65.36	14.42	7.90	6.23	4.70	5.11	1.80
Same day as Muduga	61.25	68.59	10.80	8.39	3.07	4.34	3.12	1.87
1 week after Muduga	47.90	73.16	11.69	8.09	3.30	7.45	3.31	2.22
2 weeks after Muduga	46.23	74.11	10.70	9.97	3.27	7.85	3.21	2.30
Cultivar ratio×Time of introduction								
4:1×2 weeks before Muduga	66.47	61.93	14.50	7.08	5.52	4.22	4.29	1.35
4:1×1 week before Muduga	60.77	66.63	13.34	7.57	6.13	4.16	5.06	1.58
4:1×same day as Muduga	64.25	67.90	10.95	7.61	2.88	4.03	2.37	1.76
4:1×1 week after Muduga	49.03	71.05	11.06	7.98	3.16	6.58	3.49	1.99
4:1×2 weeks after Muduga	46.67	72.23	10.14	8.68	3.01	7.27	3.16	2.27
3:2×2 weeks before Muduga	60.39	64.45	16.01	9.47	7.64	5.16	5.04	1.79
3:2×1 week before Muduga	65.19	64.09	15.49	8.22	6.33	5.24	5.16	2.01
3:2×same day as Muduga	58.25	69.28	10.64	9.17	3.26	4.65	3.87	1.98
3:2×1 week after Muduga	46 .77	76.26	12.32	8.19	3.44	8.32	3.13	2.45
3:2×2 weeks after Muduga	45.79	75.99	11.26	11.26	3.52	8.42	3.25	2.32
LSD ($_{0.05}$) for:								
Cultivar ratio (C) means	Ns	Ns	Ns	0.71	Ns	Ns	Ns	Ns
Time of introduction (T) means	5.58	Ns	2.38	0.87	1.76	1.88	1.46	Ns
C×T means	Ns	2.60	Ns	Ns	Ns	Ns	Ns	Ns

Although, there is no universal agreement about how tillering affects the plants' competitive ability (Fischer *et al.*, 1995; Dingkhun *et al.*, 1999), both the plant height and tiller number are a good measure of plant vigor and it is thought that rice cultivars that compete well against weeds are tall and rapid in early growth and have high specific leaf area. The tall erect Muduga probably complemented the semi-dwarf Faro 15 in forming a more effective canopy than the respective mono crops, which prevented sunlight from reaching the underlying weeds and thereby smothering them. Therefore, weed growth suppression could be attributed to resource competition, although, this analysis did not take into account allelopathic differences between the two rice cultivars. This probably explains the superior weed-suppressive ability of these cultivars in mixtures than as pure populations.

Rice straw yield of Faro 15 was highest when the variety was sown in a 3:2 ratio, 1 or 2 weeks before Muduga, while the treatment combination that gave the highest Muduga straw weight was also the 3:2 Faro 15 to Muduga proportion but with Faro 15 being introduced 1 or 2 weeks after Muduga. Given that plant biomass at tillering is the best predictor of modern cultivar competitiveness against weeds (Fischer *et al.*, 1995), the best weed-suppressing mixture would be the 3:2 Faro 15 to Muduga mixture with the later component introduced after the former. The high straw weight of Muduga relative its grain yield was due to the fact that this data was taken at maximum tillering which was much earlier than the heading to grain-filling stage at which the cultivar is most susceptible to lodging. It however, demonstrates the yield potential of the cultivar if effective lodging-reducing measures are adopted in its cultivation.

Cultivar ratio as well as its interaction with cultivar time of deployment did not affect grain yield significantly ($p = 0.05$) but the time of introduction did influence the yield of Faro 15 (Table 2). The grain yield of Faro 15 ranged from 2.37 to 5.16 t ha^{-1} while that of Muduga was much lower, and ranged from 1.35 to 2.32 t ha^{-1} when interplanted with Faro 15. Sole Muduga only gave an average yield of 0.69 t ha^{-1}. The actual yield of sole Faro 15 exceeded that of the mixture, but the yield of Muduga was increased by between 48.9 and 71.8% relative to the pure population, when interplanted, because of a reduction in lodging brought about by the physical support provided by Faro 15 (Binang *et al.*, 2010a).

Cultivar weed-competitiveness is a function of weed tolerance, or the ability to maintain high yields despite weed competition, and weed-suppressive ability, or the ability to reduce weed growth through competition. Differences in cultivar weed competitiveness have been demonstrated in barley (Christensen, 1995) and rice (Fischer *et al.*, 2001; Haefele *et al.*, 2004), amongst other crops. Although these individual cultivars possessed weed-suppressive traits such as early vigorous growth, tall plant stature and high plant biomass, growing them in mixture was more effective in suppressing weeds because of complementary resource use which ensured vigorous early growth due to intra specific competition that led to the development of a better canopy cover. Planting geometry did not seem to affect mixture weed-competitiveness because the cultivars were similar in growth habit at least, up to maturity of the early-maturing Faro 15. The time of cultivar introduction was however, more influential on mixture weed-suppressiveness and this differed between mixtures. In terms of effect on rice grain yield, the optimum competitive mixture was the introduction of Muduga was 1 or 2 weeks after Faro 15, but if the absolute yield of Muduga were to be considered important, the preferred time would be its introduction before Faro 15.

It is concluded that cultivar mixtures could be an effective weed management strategy in rainfed, low-input lowland rice systems, but for successful adoption of this weed control method, the time of cultivar deployment is of critical importance. In addition, cultivars for inclusion should be carefully selected to reduce intra specific competition by ensuring that they have different plant architectures and maturity periods.

REFERENCES

Binang, W.B., D.O. Okpara, J.D. Ntia and J.O. Shiyam 2010a. Evaluation of cultivar interplanting ratio on the productivity of rice/rice system. Res. J. Agric. Bio. Sci., 6: 1055-1059.

Binang, W.B., D.O. Okpara, J.D. Ntia and J.O. Shiyam, 2010b. Spatial and temporal deployment of cultivar effects on rice cultivar mixtures. Res. J. Agric Bio. Sci., 6: 1099-1102.

Bowden, R., J. Shoyer, K. Roozeboom, M. Claasen and P. Evans *et al.*, 2001. Performance of wheat variety blends in Kansas. Kansas State University Agricultural Extension Bulletin No. 128.

Christensen, S., 1995. Weed suppression ability of spring barley varieties. Weed Res., 35: 241-247.

Dingkhun, M., D.E. Johnson, A. Sow and A.Y. Audebert, 1999. Relationships between upland rice canopy characteristics and weed competitiveness. Field Crops Res., 61: 79-95.

Estavan, E., 2006. Effect of cultivar mixture on the competitive ability of barley against weed. M.Sc. thesis, Lincoln College, University Uppsala, Sweden.

Finckh, M.R., E.S. Gacek, H. Goyeau, C. Lannou and U. Merc *et al.*, 2000. Cereal variety and species mixtures in practice, with emphasis on disease resistance. Agronomie, 20: 813-837.

Fischer, A., M. Chatel, H. Ramirez, J. Lozano and E. Guimaraes, 1995. Components of early competition between upland rice (*Oryza sativa* L.) and *Brachiaria brizantha* (Hochst. ex A. Rich) Stapf. Intl. J. Pest Mgt., 41: 100-103.

Fischer, A.J., H.V. RamArez, K.D. Gibson and B.D.S. Pinheiro, 2001. Competitiveness of semi dwarf upland rice cultivars against palisade grass (*Brachiaria brizantha*) and signal grass (b. decumbens). Agron. J., 93: 967-973.

Fukai, S. and B.R. Trenbath, 1993. Processes determining intercrop productivity and yields of component crops. Field Crop Res., 34: 247-271.

GENSTAT, 2003. Genstat Release 4.23DE for Windows. 1st Edn., Lawes Agricultural Trust, Rothamsted Experimental Station, Oxford, UK.

Garcia-Barrios, L., 2003. Plant-Plant Interactions in Tropical Agriculture. In:Tropical Agroecosystems, Vandermeer J. (Ed.). CRC Press, Boca Raton, Florida, pp: 11-58.

Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research. John Wiley and Sons, New York, pp: 19-97.

Haefele, S.M., D.E. Johnson, D.M. Bodj, M.C.S. Wopereis and K.M. Miezan 2004. Field screening of diverse rice genotypes for weed competitiveness in irrigated lowland ecosystems. Field Crops Res., 88: 39-56.

Lannou, C. and C. de Vallavieille-Pope, 1997. Mechanisms of Variety Mixtures for Reducing Epidemics. In: Variety Mixtures in Theory and Practice, Wolfe, M.S. (Ed.). Europaen Union Variety and Species Mixture Working Group of COST Action 817, UK.

Mead, R. and W.R. Willey, 1980. The concept of land equivalent ratio and advantages in yields from intercropping. Exp. Agric., 16: 217-228.

Willey, R.W., 1979. Intercropping its importance and research needs Part I. Competition and yield advantages. Field Crop Abst., 32: 1-10.