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A competitive ratio for quantifying competition between component crops in cereal based intercropping system

K.R. LATHA AND R. DURAI SINGH
Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu.

***Abstract*: Investigations carried out at the Regional Research Station, Aruppukottai, Tamil Nadu, India during 1994-'95, 1995-'96 and 1996-'97 revealed that grain yield from sole cropping was higher than from intercropping. The competitive ratio (CR) of main crop increased and intercrop decreased irrespective of cropping systems in the first two years of study. In sorghum + cowpea system the CR value of sorghum was more than unity (1.01 to 1.34) and cowpea was less than unity (0.74 to 0.99) in all the three years of study. In sorghum + pearlmillet system the CR value of sorghum was more than unity (1.28 to 1.50) during first two years and less than unity during third year with application of fertilizers. However, the CR value of intercropped pearlmillet during less rainfall year was more than unity (1.03 to 1.22). In maize + cowpea system, the CR value of maize was more than unity (1.05 to 1.18) during first two years and the CR value of intercropped cowpea was higher at increased levels of fertilizer application.**

Key words : Competitive ratio, Component crops, Cropping system.

Introduction

Although intercropping research has greatly increased during recent years, there has been little attempt to produce any simple and meaningful measure of the competition which occurs between component crops. The broad effects of competition are of course frequently examined by comparing intercropping with sole crop yields, and this can be particularly useful if yields of the different crops are put on a valid comparable basis by using some relative measure, such as Land Equivalent Ratio (Rao and Willey, 1980). But these general comparison have not produced any measure which can be used to define quantitatively the exact degree of competition in any given situation. A simple CR value is proposed by Willey and Rao, 1980 as a measure of intercrop competition. It indicates the number of times by which one component crop is more competitive than the other. In this paper, the CR was used for quantifying the competition between component crops in sorghum and maize based cropping systems under varied fertility levels.

Materials and Methods

Field experiments were conducted during 1994-'95, 1995-'96 and 1996-'97 *rabi* seasons to evaluate the performance of cereal based intercropping systems in rainfed vertisols at Tamil Nadu Agricultural University, Regional Research Station, Aruppukottai. The treatments consisted of five cropping systems *viz.* sorghum + cowpea, sorghum + pearlmillet, maize + cowpea, sole sorghum and sole maize and four levels of fertilizers *viz.* N_0P_0, $N_{40}P_{20}$, $N_{60}P_{30}$, $N_{80}P_{40}$ kg ha^{-1}. The trial was carried out through two experiments in factorial randomized block design with three replications.

The soil of the experimental fields was low in available nitrogen (149.8 to 162.5 kg ha^{-1}) and phosphorus (4.9 to 6.2 kg ha^{-1}) and high in available potassium (410-416 kg ha^{-1}). Seeds were sown in already formed compartmental bunds in lines which were spaced at 45 cm. In intercropping system, every third row of main crop was replaced by intercrops (replacement series). The intra row spacing was 15 cm for sorghum, maize and pearlmillet and 10 cm for cowpea. Among the fertilizers, half the dose of N and full dose of P_2O_5 were applied basally and the remaining N was top dressed after 20 days from basal application on receipt of sufficient rainfall in all the years.

During the experimental period, the rainfall received was 503.7, 565.9 and 185.5 mm during first, second and third years, respectively. Considering this, the rainfall received during the cropping period was above normal during first two years and below normal during third year.

The CR value for different intercrops with sorghum and maize were worked out by using the formula given by Willey and Rao (1980).

Table 1. Grain yield of component crops in cropping system as influenced by fertilizer levels

System	Fertilizer level (kg ha^{-1})	Grain yield (kg ha^{-1})					
		1994-'95		1995-'96		1996-'97	
		Main crop	Inter crop	Main crop	Inter crop	Main crop	Inter crop
Intercropping			*Sorghum + cowpea*				
	N0 P0	1860	288	1940	299	802	78
	N40 P20	2436	292	2498	324	1124	89
	N60 P30	2752	310	2706	346	1206	95
	N80 P40	2868	316	2922	357	1252	98
			Sorghum + pearlmillet				
	N0 P0	1693	138	1826	126	758	188
	N40 P20	2208	143	2346	138	1076	225
	N60 P30	2495	146	2602	140	1159	258
	N80 P40	2608	151	2749	147	1196	261
			Maize + cowpea				
	N0 P0	1110	290	1207	308	526	86
	N40 P20	3125	306	3240	315	622	91
	N60 P30	3310	338	3431	343	670	98
	N80 P40	3400	347	3514	351	712	105
Sole cropping			*Sorghum*				
	N0 P0	2096	-	2166	-	1030	-
	N40 P20	2684	-	2784	-	1426	-
	N60 P30	3061	-	3010	-	1560	-
	N80 P40	3139	-	3228	-	1624	-
			Maize				
	N0 P0	1262	-	1372	-	796	-
	N40 P20	3462	-	3577	-	945	-
	N60 P30	3616	-	3709	-	985	-
	N80 P40	3650	-	3766	-	1010	
			Cowpea				
		780	-	794	-	268	-
			Pearlmillet				
		462	-	449	-	584	-

[Data not statistically analysed (used only for working out competitive ratio)]

$$CR_a = \frac{L_a}{L_b} \times \frac{Z_b}{Z_a}$$

where, CRa is the competitive ratio for species 'a' in mixture with 'b'.

Za and Zb are the proportions of species 'a' and 'b' in the mixture.

La and Lb are the relative yields (intercrop monoculture) of species 'a' and 'b'.

Results and Discussion

Grain yield (Table 1)

The data presented in table 1 is used to work out the competitive ratio of component

Table 2. Competitive Ratio of component crops in cropping systems

Treatment	1994-'95		1995-'96		1996-'97	
kg ha^{-1})	CRa	CRb	CRa	CRb	CRa	CRb
N0 P0	1.22	0.82	1.19	0.84	1.34	0.74
N40 P20	1.18	0.85	1.11	0.90	1.18	0.85
N60 P30	1.13	0.88	1.03	0.97	1.09	0.91
N80 P40	1.12	0.89	1.01	0.99	1.05	0.95
	Sorghum + pearlmillet					
N0 P0	1.34	0.74	1.50	0.67	1.13	0.88
N40 P20	1.32	0.76	1.37	0.73	0.97	1.03
N60 P30	1.28	0.78	1.38	0.72	0.83	1.20
N80 P40	1.28	0.78	1.31	0.77	0.82	1.22
	Maize + cowpea					
N0 P0	1.18	0.85	1.14	0.88	1.03	0.97
N40 P20	1.14	0.87	1.14	0.88	1.03	1.03
N60 P30	1.05	0.95	1.07	0.94	0.93	1.08
N80 P40	1.05	0.95	1.05	0.95	0.90	1.11

*Not analysed

erops in cereal based cropping system and hence this data was not statistically analysed. Grain yield from sole cropping was higher when compared to intercropping. During normal rainfall years, maize + cowpea system was found to give higher yields. Among the intercrops, cowpea performed better during high moisture availability period and pearlmillet performed better during low rainfall year.

Competitive ratio (Table 2)

The CR value of main crop was higher than unity in all the cropping systems irrespective of fertilizer levels during first two years of study (normal rainfall years). However, during third year (less rainfall year), the CR value of main crop sorghum was more than unity in sorghum + cowpea system alone. In sorghum + pearlmillet system, the CR value of intercropped pearlmillet was more than unity (1.03 to 1.22) and in maize + cowpea system the CR value of intercropped cowpea was more than unity (1.03 to 1.11) at higher levels of fertilizer application.

In replacement series of experimental design, reduction in main crop yield was inevitable because of the lower plant density in intercrop situation. On the basis of plant population, the expected yield of main crop was only 66 per cent in intercropping. During first two years, the rainfall received during sorghum growth period was 503.7 mm in 29 rainy days and 565.9 mm in 29 rainy days, respectively hence the minimum variation in grain yield of sorghum was recorded under solecropping and intercropping. The third year was characterised by low rainfall as well as early cessation of rainfall. There was a long dry spell from 57 days after sowing and available soil moisture content receded below wilting point much earlier than physiological maturity. The occurrence of such end of season drought was found to reduce the yield of sorghum in both sole cropping and intercropping.

From the values of the CR it would be seen that sorghum was more competitive. Again considering these values, sorghum ought to have yielded more with cowpea than with pearlmillet. Sorghum in general was more dominant and the competition from either cowpea or pearlmillet was too minimal to cause any differential effect on the performance of sorghum. The yield variation of sorghum in sole as well as intercropping could

be mainly due to the rainfall quantity and distribution. Therefore the CR values of sorghum can be taken to indicate the degree of competition stress for cowpea and pearlmillet. Accordingly cowpea crop experienced more competition from sorghum during third year of study and pearlmillet experienced more stress from sorghum during first two years of experimentation and yield was less with such intercrops. Munshal and Malik (1986) reported that the CR values of intercrops showed that legume intercrops grown with redgram as base crop were less competitive than cereal intercrop.

Among the cropping systems, sorghum based cropping system was more competitive than maize based system in normal rainfall years. However during less rainfall year, sorghum and pearlmillet were more competitive and dominant crops. This might be due to the drought tolerant nature of sorghum and pearlmillet.

In sorghum + pearlmillet system reported here, total intercrop population was the same as the sole crops, and the population of each individual crop was therefore, a proportion of its sole crop. In this situation some complementarity between crops can result in component crops experiencing less competition in intercropping than in sole cropping.

There was only one situation where pearlmillet was more competitive than sorghum. It is not so easy to explain how this could occur when both the crops are C4 and better suited to the top of the canopy. The higher competitiveness of pearlmillet than sorghum during less rainfall year at higher fertility levels might be due to the less competitive nature of sorghum at high fertility levels. This could be very well seen with the CR values. Jokinen (1991) reported that the dominance of an aggressor usually increased with increasing nitrogen fertilization especially when the total density was high.

Tilman (1988) reported that competition within mixtures is more complex than in more cultures as physiological and morphological differences between genotypes, for instance in the extent of the stems or roots, will affect competition for resources. The results of this study was in confirmity with the above findings. In the less rainfall year, cowpea was the dominant crop and maize was the dominated crop. However, in sorghum based system, the cowpea was less competitive and dominated by sorghum. From the results, it was clear that pearlmillet and sorghum were more tolerant to stress and were more dominant.

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