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Neighbour effects in maize/okra mixed cropping

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Abstract

Maize (Zea mays L.) and okra *(Abelmoschus esculentus L. Moench)* were grown in pure and mixed stands with the mixtures having the same plant density as the pure stands. The sole crops gave higher yields than in mixtures. There was competition for growth factors between the two species with their relative yield total (R YT) slightly above unity. The taller maize was at an advantage in the mixture and its yield was only slightly reduced compared with the pure stand, while the shorter okra plants were heavily shaded and the yield greatly reduced.
Planting both crops together was more efficient as their land equivalent ratio was above unity.

Introduction

Mixed cropping which is widely practised in the humid tropics, has been shown to be more efficient than sole cropping (Andrews, 1972, 1974; Abalu, 1976, Baker, 1978; Kass, 1978, 1978; Remison, 1978; Willey, 1979; Adelana, 1984).

The interactions between crops in mixed cropping has received the attention of many workers and attempts have been made to assess the effects of mixed cropping on the productivity of the components that form the mixtures. The following mixtures have been studied, namely: maize/cowpea (Enyi, 1973; Haizel, 1974; Remison, 1978, 1980); maize/groundnut (Koli, 1975; Mutsaers, 1978; Baker, 1978); maize/beans (Enyi, 1978, Fisher, 1977); sorghum/cowpea (Enyi, 1973); maize/pigeon pea (Dalal, 1974); sorghum/beans (Osiru and Willey, 1972) and maize/soyabean (Sing, *et al,* 1973). Various methods of evaluation of yield and yield advantages in mixtures have also been proposed (Willey, 1979).

In Nigeria, crop combinations vary from one ecological zone to the other. Maize/okra is one of such numerous mixtures even though it does not appear to have been studied. In order to obtain information on the plant interactions in this mixture, experiments were carried out at two ecological zones of south-western Nigeria.

Materials and Methods

The experiments were conducted in 1981 and 1982 on the farms of the Institute of Agricultural Research and Training situated at Ikenne (6^0 55'N, 3^0 42'E) in the rain-forest zone, and Ilora (7^0 55'N, 3^0 51'E) in the savanna zone of southwestern Nigeria. Treatments were: (i) maize as a sole crop, (ii) maize intercropped with okra, (iii) okra as a sole crop.

The commonly grown varieties, Western Yellow I (maize) and V35 (okra) were used for the experiments. In the mixed treatment, both crops were grown in a mixture of 1:1 within rows, while their monocultures were grown at the same total plant population of 30,000 plants/ha i.e. replacement series. A randomised complete block design was used with six replicates. All plots received a basal dressing of 70 kg N/ha as ammonium sulphate, 40 kg $P_2 0_5$/ha as single superphosphate and 60 kg $K_2 0$/ha as muriate of potash. The fertilizers were applied broadcast and incorporated into the soil before sowing. The plots were hand-weeded twice. Maize was harvested when all leaves were dry (115 days from sowing), dried and shelled by hand. Data were taken on the date of flowering in okra, the number of cobs/plant in maize and the number of pods/plant in okra. Plant height in maize was taken after tasselling while ear height was taken as the distance from ground level to the position of the first cob. Similarly, plant height in okra was taken immediately after the opening of the first flower.

Analyses of variance were carried out on yield data and other growth parameters evaluated. Neighbour effect was quantified by the relative yield method proposed by de Wit and van den Bergh (1965); i.e.

$$r = \frac{0}{M}$$

where r = relative yield, 0 is the yield of the species in mixture and M its yield in monoculture. The relative yield total (RYT) of the two species a and b is the sum of their relative yields, that is,

$$RYT \; r_a + r_b = \frac{0_a}{M_a} + \frac{0_b}{M_b}$$

For two species competing for the same limiting growth factors, RYT will be unity.

Productivity of the crop mixtures in relation to their monocultures was evaluated by the Land Equivalent Ratio (L) of Willey (1979) which is defined as the relative land area under sole crops that is required to produce the yields achieved in intercropping.

Using the notation of Mead and Willey (1980),

$$L = L_a + L_b \quad \frac{M_a}{S_a} + \frac{M_b}{S_b}$$

where M_a, M_b are the component crop yields from intercrops a and b and S_a, S_b are the corresponding sole crop yields.

Result

Mixed cropping significantly ($P < 0.01$) delayed both flowering and fruiting in okra and to a lesser extent both tasselling and silking in maize (Tables 1 and 2). Mixed cropping delayed flowering and fruiting by about five days in okra, and tasselling and silking by two days in maize. Plant and ear heights of maize were significantly increased ($P < 0.05$) by 6cm under mixed cropping. Similarly, mixed cropping increased plant height in okra by about 25cm.

TABLE 1: EFFECTS OF MIXED CROPPING ON DAYS TO FLOWERING FRUITING AND PLANT HEIGHT OF OKRA

	Days to flowering	Days to fruiting	Plant height (cm)
		ILORA	
1981			
Okra (sole)	62.4	69.8	99.2
Okra/maize	67.5	74.6	130.3
S.E.	0.43	2.53	2.61
1982			
Okra (sole)	60.8	67.2	101.5
Okra/maize	65.2	73.8	128.7
S.E	0.51	2.82	4.16
		IKENNE	
1981			
Okra (sole)	61.5	68.4	103.6
Okra/maize	66.8	73.9	131.2
S.E.	0.38	3.15	4.63
1982			
Okra (sole)	61.3	68.3	102.5
Okra/maize	67.2	74.4	129.3
S.E.	0.58	3.16	3.62

TABLE 2: EFFECTS OF MIXED CROPPING ON TASSELLING, SILKING AND PLANT AND EAR HEIGHTS OF MAIZE

	Days to 50% tasselling	Days to 50% silking	Plant height (cm)	Ear height (cm)
		ILORA		
1981				
Maize (sole)	53.6	61.6	215	76.8
Maize/okra	55.8	62.4	221	92.6
S.E.	0.18	0.26	4.8	6.5
1982				
Maize (sole)	55.0	62.3	212	77.2
Maize/okra	56.7	63.7	223	88.3
S.E.	0.09	0.18	4.5	7.2
		IKENNE		
1981				
Maize (sole)	52.6	59.3	216	80.3
Maize/okra	54.3	61.7	240	92.8
S.E.	0.11	0.21	5.6	6.3
1982				
Maize (sole)	56.3	60.4	214	77.8
Maize/okra	57.2	63.6	233	82.5
S.E.	0.09	0.25	6.4	6.8

The yields of maize and okra involved in the mixed cropping are presented in Table 3. In all the trials, maize yields were higher when grown sole than in mixture. On the average, yield of maize was reduced by 20 and 25 percent at Ilora and Ikenne respectively and this was significant ($P < 0.01$). Similarly, okra yields were significantly higher ($P < 0.01$) in the pure stands than in mixtures. Reduction in yield resulting from mixed cropping was 34 and 43 percent at Ilora and Ikenne respecitively. The effects of mixed cropping on yield were also reflected in its components (Table 4). Interference of maize caused about 34 percent reduction in the number of fruits/plant in okra, while interference of okra caused about 11 percent reduction in the number of cobs/plant in maize. A combined analysis of each crop over the two years and the two locations showed that there were no interactions between years and locations.

TABLE 3: YIELDS (t/ha) OF MAIZE AND OKRA WHEN GROWN IN PURE AND MIXED STANDS

	1981		1982	
	Maize	Okra	Maize	Okra
		ILORA		
Maize (sole)	3.08_a	–	3.05_a	–
Maize/okra	2.44_b	4.67_b	2.46_b	4.22_b
Okra (sole)	–	6.72_a	–	6.91_a
		IKENNE		
Maize (sole)	3.10_a	–	3.06_a	–
Maize/okra	2.37_b	4.67_b	2.23_b	4.28_b
Okra (sole)	–	8.14_a	–	7.66_a

Means in each row not followed by the same letter are significantly different at 5% level.

TABLE 4: COMPONENTS OF YIELD IN MAIZE AND OKRA GROWN IN PURE AND MIXED STANDS AT ILORA

	1981	1982	Mean
	cobs/100 plants (maize)		
Maize (sole)	114	121	117.5
Maize/okra	101	105	103.0
Mean	107.5	113	
S.E. (excluding means)		3.94	
	Fruits/plant (Okra)		
Okra (sole)	16.4	15.6	16.1
Okra/maize	11.7	10.5	11.1
Mean	14.0	13.1	
S.E. (excluding means)		1.84	

Yield advantage of the mixture over monocultures was evaluated by Land Equivalent Ratio (L) and these are given in Table 6. In all the trials, L values ranged between 1.33 and 1.48 indicating that between 33 and 48 percent more land would be required as sole crops to produce the same yields as in intercropping. The interference between maize and okra are also given in Table 6. In all cases, the relative yield of both maize and okra was less than 1 (P > 0.01); i.e, 0.73 – 0.81 in maize and 0.55 – 0.69 in okra. The sum of relative yields; that is, RYT, was less than 2 in all experiments.

TABLE 5: COMPONENTS OF YIELD IN MAIZE AND OKRA GROWN IN PURE AND MIXED STANDS AT IKENNE

	1981	1982	Mean
	Cobs/100 Plants (maize)		
Maize (sole)	121	123	122.0
Maize/okra	108	109	108.0
Mean	11.0	116.0	
S.E. (excluding means)		1.86	
	Fruits/plant (Okra)		
Okra (sole)	15.9	17.4	16.6
Okra/maize	10.7	11.8	11.3
Mean	13.3	14.6	
S.E. (excluding means)		1.92	

TABLE 6: RELATIVE YIELD AND LAND EQUIVALENT RATIO OF MAIZE AND OKRA AT ILORA AND IKENNE

	ILORA		IKENNE	
	1981	1982	1981	1982
Maize	0.79	0.81	0.76	0.73
S.E.	0.042	0.037	0.032	0.043
Okra	0.69	0.61	0.57	0.55
S.E.	0.034	0.036	0.205	0.028
Relative yield total (RYT)	1.48	1.42	1.33	1.38
Land equivalent ratio (LER)	1.48	1.42	1.33	1.38
S.E.	0.051	0.048	0.048	0.54

Disαι ssion

The yields of the crops in the monoculture were higher than those of their mixtures. While the yield of maize was reduced by about 20 percent in the mixture, that of okra was reduced by more than 40 percent. Maizc was therefore a better "competitor" in the mixutre. For two species competing for the same limiting growth factors, the RYT, that is, the sum of their relative yields will be unity (de Wit and van dcn

Bergh, 1965). Results presented in Table 6 show that the RYT in all the trials ranged between 1.33 and 1.48 indicating that there was some competition between maize and okra for the same growth factors.

Plants can be conceived as "competing" for the limited supplies of environmental resources necessary for growth (Donald, 1963) and these are usually nutrients, water and light above ground. The effects of shoot competition was not usually as large as those of the soil factors (Donald, 1958). In this study, there appears to be some competition for nutrient requirements since nutrient requirements of maize are usually larger than those of okra (Adelana, unpublished). Both the mixutres and their monocultures received the same basal dose of fertilizérs in this study. This stituation contrasts with results obtained with maize/legume mixutres where there have been complementation arising from nitrogen fixed by the legume companion (Mutsaers, 1978; Remison, 1978).

There might have been some competition for light as plant height in okra was significantly higher in mixed stands. The general conclusion from experiments involving competition for light is that the taller plant is at an advantage (Black, 1958). In this study, maize was observed to be taller than okra and also to develop a larger leaf area, thus shading the shorter okra component. This probably contributed to the large reduction in okra yield in the mixture when compared with the monoculture.

Large complementation or over-yielding that occurs in maize/legume mixtures did not occur in this study. Both maize and okra suffered some inhibition in the mixutre although this was larger in the caseof okra. Such inhibition can probably be minimused if the soil nutrient factor is imporved through application of higher rates of fertilizers. A similar objective may also be achieved if the population pressure is reduced to allow sufficient light to reach the shorter okra plant.

Inspite of the reduction in yield of both maize and okra in mixed stands, their Land Equivalent Ratio values were above unity thus indicating that more land will be required to produce sole crops in order to achieve combined yields of the mixed crops. Maize/okra mixed cropping was therefore more productive than either crop grown alone.

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