Spatial arrangement on maize and kenaf intercropping

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SUMMARY

The study was undertaken at Nyankpala in the northern savanna zone under rainfed conditions to find out how best kenaf can be arranged as an intercrop with maize to give combined high yield of both crops per unit area. There were seven treatments, and these were two sole crops and five intercrop treatments involving maize/kenaf in 1:1, 1:2, 2:1, 2:2 ratios between rows and maize and kenaf within the same row. The intercropping of maize and kenaf gave mean land equivalent ratio values between 1.04 and 1.32 indicating higher agronomic advantage than any of the crops planted in pure culture. The intra-row cropping was more productive in terms of yield (LER 1.32) and was more profitable in monetary returns than any of the crop mixtures.

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RÉSUMÉ

ASANTE, A. K. : *La disposition spatiale sur l'inter-culture du maïs et kenaf* (Hibiscus cannabinus, *L.*). Cette étude actuelle s'est déroulée à Nyankpala dans la zone nord-savane sous les conditions pluvieuses pour se renseigner sur la maniére dont le kenaf pourrait être bien arrangé comme inter-culture avec le maïs pour avoir un rendement plus-élevé par superficie de deux cultures. Il y avait sept traitements qui étaient deux cultures principales et cinq inter-cultures entraînant maïs-kenaf dans les proportions de 1:1, 1:2, 2:1, 2:2 entre les rangées avec le maïs et le kenaf dans la même rangée. L'inter-culture du maïs et kenaf donnent l'équivalent de la moyenne proportion entre 1.04 et 1.32 indiquant un avantage agronomique supérieur que chacune de cultures cultivées purement en mono-culture. La cultivation intra-rangée a été plus productive dans le sens de rendement (LER 1.32) et plus rentable dans le sens de recette monétaire par rapport à des cultures mixtes.

Introduction

Intercropping is an age-old traditional system of agriculture in West Africa. In Ghana, almost every peasant farmer practises intercropping in one form or another. In the cocoa-growing areas, young cocoa plants are intercropped with plantain, cocoyam and cassava. Vegetables like pepper, tomato, garden eggs and okro are also intercropped with food crops. In the Northern and Upper regions of Ghana, legumes such as cowpea, groundnuts and bambara beans are intercropped with sorghum, millet and maize.

Evidence for higher yields from crop mixtures have been reported from experiments carried out elsewhere. Singh & Sharma (1987) evaluated yield stability in intercropping in India and reported that inter-crops gave additional yields and increased the net returns. Koli (1975) working on pure and mixed croppings of maize and groundnuts in Ghana reported that among the mixed cropping treatments, inter-row cropping appeared to be the best in terms of yield and cash return. He indicated that yields of groundnuts in the mixed cropping treatments were from one-third to one-half the yields obtained from the pure culture but the yield of maize was not reduced to the same extent. Work conducted on a cowpea-maize association in Nigeria indicated that inter-cropping advantage increased from cowpea planted between maize rows planted 1m apart to alternate 1m row arrangement and to alternate rows, 2 m apart of cowpea and maize (Adetiloye, 1986).

Norman (1972) showed that in Nigeria, variability in annual returns from crop mixtures was less

than that from sole crops. Norman also collected data which demonstrated that labour was more uniformly used through the season under mixed cropping.

Rao & Willey (1980) reported higher productivity advantage and stability in intercropping of sorghum with pigeon pea than sole crop sorghum in India. Dwivedi & Awasthi (1986) working on intercropping of soybean and maize in Nagaland State in India indicated higher total productivity and net returns in all intercropping systems than maize and soybean in pure stand. Sobhan (1986) in Bangladesh, (1986) obtained the highest productivity in terms of land equivalent ratio when roselle was intercropped with wingbean. Adetiloye & Adekunle (1989) reported that intercropping of cassava-maize-cowpea in Nigeria gave land equivalent ratio values between 1.12 and 1.63, indicating higher agronomic yield advantage than from any of the crops, planted in pure culture.

Leihner (1983) indicated that intercropping cassava with cowpea in Colombia resulted in 20 to 100 per cent greater land use efficiency than for either crop grown alone. Shetaia (1990) reported that the land equivalent ratio was greater than one by intercropping safflower with broad bean in Egypt.

Although total productivity of an intercropping system can be greater, productivity of at least one or even both component crops in usually less than that of respective sole crops in popular binary systems (Rees, 1986). Working on the effects of intercropping roselle with black gram, cowpea, soybean, groundnuts and sesame, Roy, Sasmal & Bhattacharjee (1990) reported that fibre yield of roselle was reduced by intercropping.

Bast fibre production in Ghana has been on the decline for the past few years. The decline in the fibre industry is primarily attributed to the fact that local farmers have not accepted the cultivation of bast fibres as monocrops. However, by intercropping bast fibres it is believed fibre production will be acceptable to farmers and gingered up.

The paper describes a study carried out to investigate the most productive and profitable row pattern in maize-kenaf combination under rainfed conditions at Nyankpala in northern Ghana.

Materials and methods

The experiments were conducted for 2 years at Nyankpala in the northern savanna zone of Ghana in the rainy seasons of 1989 and 1990.

Kenaf variety C 2032 and maize variety Dobidi were used. The kenaf seeds were sown spaced at 25 cm between rows and 5 cm within rows while the maize were spaced at 80 cm between rows and 50 cm within rows.

Three seeds each maize and kenaf were sown per hole on 3.6 m by 4.5 m plots. Both the maize and the kenaf seedling were thinned to two per stand, 3 weeks after emergence.

A randomized complete block design was used (Fig. 1). There were seven treatments with four

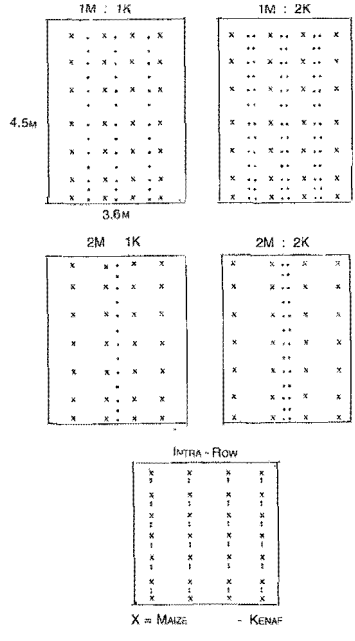

Fig. 1. Maize-kenaf mjixed cropping.

replications. The treatments were as follows:

Sole maize
Sole kenaf
1M: 1K - 1 row of maize: 1 row of kenaf
1M: 2K - 1 row of maize: 2 rows of kenaf
2M: 1K - 2 rows of maize: 1 row of kenaf

2M: 2K - 2 rows of maize: 2 rows of kenaf

Intra-row cropping (10 stands of kenaf between every two hills of maize).

All these arrangements gave different kenaf plant populations while the maize population remained constant. On per hectare basis, the various plant population of the treatments are presented in Table 1.

TABLE 1

Plant Population of the Seven Treatments

Crop arrangement	*Maize population*	*Kenaf population*
Sole maize	50000	-
Sole kenaf	-	1600000
IM : IK	50000	500000
IM : 2K	50000	100000
2M : 1K	50000	250000
2M : 2K	50000	500000
Intra-row	50000	432000

Sowing of seed started with the onset of rains in each year on 18 Jun 89 and 20 May 90. At sowing, a compound fertilizer (N:P:K.) 20:20:0 was broadcast on the plots at the rate of 100 kg/ha. Sulphate of Ammonia was applied as side dressing at the rate of 75 kg/ha to both maize and kenaf when plants were six weeks old. Weeding by hoeing was done twice during the growing period of the plants. Both the kenaf and the maize were harvested at the same time.

At harvest, the maize cobs were shelled and weighed. The harvested kenaf stalks were bundled and retted in water. After retting, they were washed, sun-dried and the resultant fibre was weighed. The yields per plot were recorded and the current cash values of the two crops at the time of harvest were used in evaluating and analysing the monetary returns per hectare.

The land equivalent ratio (LER) was calculated for all the crop mixtures, using the following formula.

$$LER = LA + LE = \frac{YA}{SA} + \frac{YB}{SB}$$

where LA and LB are the LERs for the individual crops. YA and YB are the individual crop yields in intercropping and SA and SB are their yields as sole crops (Mead & Willey, 1979).

LER may be defined as the proportional land area that would be required as sole crops to produce the yields achieved in intercropping (Narza Reddy, Ramamama Reddy & Reddy, 1987).

Results and discussions

Results of grain and fibre yields of the experiments are presented in Table 2.

TABLE 2

Maize and Kenaf Fibre Yields (kg/ha)

Treatments	*1989*		*1990*		*Mean (Estimated)*	
	Maize	*Fibre*	*Maize*	*Fibre*	*Maize*	*Fibre*
Sole	4680.70	796.73	6774.19	7145.73	5727.44	3970.94
IM : 1K	2708.33	464.23	3387.09	5758.06	3047.71	3111.14
IM : 2K	2812.51	350.69	3548.38	5274.10	3180.44	2812.44
2M : 1K	2968.75	265.80	2629.03	5161.29	2798.89	2713.54
2M : 2K	3385.15	255.56	2903.22	4725.80	3244.18	2618.46
Intra-row	3295.09	426.60	3822.58	6016.12	3558.83	3221.36
LSD 0.05	1207.77	141.46	703.70	808.64		
0.01	1613.71	188.97	938.27	1080.24		
CV (per cent)	25.71	23.00	19.97	33.42		

Grain yield

The sole crop stand of maize gave significantly (P=0.05) higher grain yield than all the crop mixtures in both years. It was realized that the pure culture of maize afforded efficient utilization of resources since it was free of competition from other crops. It was, therefore, evident to obtain higher yield from the pure stands than in the mixed cropping.

The lower grain yield in the crop mixtures might be attributed to the effect of intercropping and plant population pressure on maize plants, because the intercrops competed well with the maize for both light and soil nutrients. These effects might have caused reduction in the real grain yield.

Two rows of maize and two rows of kenaf gave the best grain yield among the mixtures in 1989. This might have been possible because kenaf plants have tap roots that draw nutrients from higher depth than maize and thus the crops did not compete for the soil nutrients.

In 1990, however, the intra-row arrangement gave the highest maize yield among the mixtures. The intra-row cropping might have facilitated efficient cultural practices like weeding to be carried out since no other crops were grown between the rows of maize as compared to other mixtures.

As component crops of the intercropping system differ in phenology, growth habit, rooting system, etc., both qualitative and/or quantitative effects of intercropping on productivity were likely to vary with the crops. Comparison of the effects of maize and kenaf has revealed different yield reductions due to intercropping.

Fibre yield

Differences in fibre yields between the pure stand of kenaf and the mixtures were significant (P=0.05) in both years. Of the mixtures, one row of maize and one row of kenaf produced highest fibre in 1989 and was followed by the intra-row arrangement. However, in 1990, the intra-row cropping gave the highest fibre of all the mixtures since kenaf plant population was not uniform in all the crop combinations; differences in fibre yield was, therefore, evident. Generally, fibre yields in 1990 were higher than the yields in 1989. The lower yields in 1989 might be attributed to heavier rainfall (Table 5) during the growing period of the crop (June - September) which might have caused poor plant growth, reduced plant stand and, subsequently, lower yields.

Two rows of maize and two rows of kenaf produced the lowest yield of fibre in both years. The low yields in this crop arrangement suggests some sort of competition among the crops for either light or soil nutrient since the two crops have different growth patterns. The competitive effect of maize on kenaf was drastic enough in this crop arrangement to cause low fibre yield. It should, however, be pointed out that the low fibre yield in this arrangement was compensated for by high grain yield. The low fibre yield obtained confirms the report by Samsri, Jatuporlunponobe & Murata (1987) who worked on intercropping of groundnut and roselle, a fibre crop, in Thailand and had

TABLE 3

Land Equivalents Ratios (LER) of Maize and Fibre Yields

Treatments	*1989*			*1990*			*Mean*		
	Maize	*Fibre*	*Total*	*Maize*	*Fibre*	*Total*	*Maize*	*Fibre*	*Total*
1M : 1K	0.58	0.58	1.16	0.50	0.80	1.30	0.54	0.69	1.23
1M : 2K	0.61	0.44	1.05	0.52	0.74	1.26	0.56	0.59	1.16
2M : 1K	0.64	0.33	0.97	0.38	0.72	1.10	0.51	0.52	1.04
2M : 2K	0.73	0.32	1.05	0.42	0.66	1.08	0.57	0.49	1.10
Intra-row	0.71	0.53	1.24	0.56	0.84	1.40	0.63	0.68	1.32

reduced yield of fibre by 4 - 18 per cent.

Combined performance iof both crops

Table 3 presents the land equivalent ratios (LERs) for the various crop arrangements. All the crop mixtures except one (2M:1K in 1989) gave mean yield advantages over the sole crops. In 1989, intra-row planting gave the highest land use efficiency of 24 per cent (LER 1.24) and was followed by one row of maize and one row of kenaf LER (1.16). With the exception of two rows of maize and row of kenaf which could not give any yield advantage (LER 0.97) in 1989, all other crop mixture gave yield advantages from 5 to 24 per cent.

In 1990, all the crop mixtures gave yield advantages ranging from 8 to 40 per cent. The intra-row crop arrangement gave the highest yield advantage (40 per cent) and was followed by one row of maize and one row of kenaf (30 per cent). The yield performance of both intra-row cropping and one row of maize and one row of kenaf might be due to less competition and better utilization of one or more growth resources as compared to plants in other crop mixtures. The yield advantages from the crop mixtures might have been achieved because, to a large extent, resource use by the component crops was more complementary than purely competitive. Complementarity of crops could have occurred because differences in plant heights and combinations of leaf canopy could have allowed better utilization of light. It could also be due to differences in the rooting depths and rooting patterns which allowed an improved utilization of the soil nutrients.

The mean LERs indicate that 4-32 per cent more land would have to have been planted to maize and kenaf as sole crops to produce the same amount of fibre and maize as were produced in the intercropping.

TABLE 4

Gross Monetary returns of Maize and Kenaf Intercropping in Cedis

Treatments	*1989*			*1990*		
	Maize	*Fibre*	*Total*	*Maize*	*Fibre*	*Total*
Sole	208066.96	114187.34		604838.39	1024044.33	
1M : 1K	120907.58	66533.44	187441.02	302418.75	825245.16	1127663.91
1M : 2K	125558.48	50260.89	175819.64	316819.64	755896.91	1072716.55
2M : 1K	132533.48	38094.45	170627.93	234734.82	739716.08	974450.90
2M : 2K	160051.33	36626.85	196678.18	359216.07	677301.65	977301.65
Intra-row	147102.23	61140.31	208242.54	341301.78	862230.32	1203532.10

Prices: Maize = ¢5000.00 (in 1989) per 112 kg: Ghana Food Distribution Corporation.
= ¢10,000.00 (in 1990) per 112 kg: Ghana Food Distribution Corporation.
Fibre = ¢143,320.00/ton: GIHOC Fibre Products (1989/90).

TABLE 5

Record of Rainfall Measured at 09 Hours GMT in mm at Nyankpala Agricultural Experiment Station

Year	*Month*												
	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total*
1989	0.0	0.0	35.7	51.4	74.2	419.6	189.0	297.4	418.2	115.9	0.0	0.0	1601.4
1990	0.0	33.7	-	57.9	101.9	77.0	74.6	86.2	259.9	72.3	11.1	13.9	788.5

Gross monetary return

Monetary returns from the various cropping patterns are presented in Table 4. In 1989, all crop mixtures gave better economic returns than the pure stand of kenaf. The intra-row cropping gave the highest cash return and was followed by pure stand of maize.

In 1990, all crop mixtures gave better cash returns than the pure stand of maize. The intra-row crop arrangement gave the highest monetary return in 1990 and was followed by one row of maize and one row of kenaf. Of all the crop mixtures, intra-row cropping gave the highest monetary return in both years.

The data for 2 years show that intercropping of maize and kenaf is better in terms of yield and cash return than monocropping. This suggests better utilization of resources under rainfed conditions.

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REFERENCES

Adetiloye, P. O. (1986) Effects of mixture plant population and two cropping patterns in the performance of cowpea-maize association. *N.J. Agron.* **1** (3), 73-77.

Adetiloye, P. O. & Adekunle, A. A. (1989) Concept of monetary equivalent ratio and its usefulness in the evaluation of intercropping advantages. *Trop. Agric. (Trin.)* **86** (4).

Dwivedi, R. N. & Awasthi, R. P. (1986) Studies on intercropping of soybean in maize under rainfed agroclimatic conditions of Nagaland. *Indian Agric.* **30** (4), 307-311.

Koli, S. E. (1975) Pure cropping and mixed cropping of maize and groundnut in Ghana. *Ghana Jnl agric. Sci.* **8**, 23-30.

Leihner, D. E. (1983) Management and evaluation of intercropping systems with cassava. CIAT, Calis, Colombia.

Mead, R. & Willey, R. W. (1979) The concept of a land equivalent ratio and advantages in yields from intercropping. *Exp. Agric.* **16**, 217-218.

Narza Reddy, S., Ramamama Reddy, E. V., & Reddy, V. M. (1989) Row arrangement in groundnut/pigeon pea intercropping. *Trop.Agri. (Trin.).* **66** (4).

Rees, D. J. (1986) Evaluation of yield stability in intercropping: Studies on sorghum/pigeon pea. *Exp. Agric.* **16**, 105-116.

Norman, D. W. (1972) An economic survey of three villages in Zaria Province. *Input-output relationships.* Sumaru, Nigeria: Ahmadu Bello University.

Rao, M. R. & Willey, R. W. (1980) Evaluation of yield stability in intercropping: Studies on sorghum/pigeon pea. *Exp. Agric.* **16**, 105-116.

Roy, A. R., Sasmal, B. C. & Bhattachrjee, A. K. (1990) Effect of intercropping roselle with blackgram cowpea, soyabean, groundnut and sesame. *Exp. Agric.* **26** (4). 407-411.

Samsri, N., Jatuporlunponobe, S. & Murata, Y. (1987) Studies on roselle (*Hibiscus sabdariffa*. Effect of row spacing in roselle peanut intercropping system. *Crop Science*, **56** (2), 204-209.

Shetaia, A. B. O. (1990) Inter and intra competition when intercropping faba bean with barley. *Anna agric. Sci.* **35** (1), 261 -278.

Singh, Y. P. & Sharma, A. (1987) Intercropping in rabi maize for higher production. *Seeds & Farms* **13** (12) 12 -14.

Sobhan, M. A. (1986) Mixed cropping and intercropping of mesta (*H. sabdariffa*) with mungbean (*Vigna radiata*). Bangladesh *J. Agric.* **11** (1) 1-9.