INTERCROPPING WITH SUGARCANE

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Abstract

In response to requests by small scale cane growers of KwaZulu-Natal for advice on improving their system of crop production, a Joint Project between SASEX and the KwaZulu-Natal Department of Agriculture was started in 1996. Trials were initiated to investigate the practicalities of intercropping rainfed and irrigated cane with food crops. Results from the first two years of trials are discussed. They clearly indicate that provided good management is practised, including the application of the full fertiliser requirement to each crop grown, crops such as cabbage and maize (green mealies) can be economically produced in the plant cane crop. These crops provide food and/or an alternative source of cash within 120 days of planting. The practice of intercropping in plant cane should improve the viability of many small scale cane growers.

Introduction

Joint Project

In October 1995, representatives of the small scale sugarcane growers in KwaZulu-Natal approached the South African Sugar Experiment Station (SASEX), to request an improvement in access to information to enable them to:

- improve their average cane yields
- intensify agricultural production by intercropping cane with food crops
- improve food security.

As the latter two topics were not solely concerned with sugarcane research, they could not be funded from the cane levies, which thus required the close involvement of the KwaZulu-Natal Department of Agriculture (KZNDA). After much discussion, a Joint Project between SASEX and KZNDA was initiated in August 1996 to run for five years, to address the needs of the small scale cane growers. The KZNDA agreed to research the potential for intercropping sugarcane with food crops chosen by the farmers to produce extension recommendations for the efficient and economic production of food crops grown within/adjacent to cane.

Intercropping principles

Intercropping implies that two or more crops are grown on the same piece of land at the same time. Intercropping is one of the most important features of farming in developing countries, with 50 to 80% of rainfed crops being planted in intercrop mixtures. The usefulness of the intercropping system has often been condemned as inherently primitive and without any scientific basis. About 20 years ago, researchers in many countries became aware that this system does, in fact, have scientific merit, and is one of the best-suited to the African environment, particularly with regard to the nutritional requirements of the farm family (Kass, 1978). Small farmers show a preference for intercropping because the system provides a greater stability of production by minimising climatic risks, and it allows for a more equal distribution of labour through the season, thus encouraging the farmer to stay on the land. Intercropping can provide a higher productivity per unit area of land, and it tends to provide a greater diversity of food and income sources (Temple, 1976). However, as a result of researchers ignoring the potential of intercropping for many years, all high yielding crop varieties have been bred for a sole cropping situation.

Intercropping with cane

In theory, sugarcane is a crop that offers unique possibilities for intercropping. The plant cane crop takes two to three months to become established, during which time food crops can be planted in the interline spaces, to make better use of incident solar energy and rainfall. The food crops selected must mature, and be harvested, before the cane canopies at three to four months after planting. The major limitations are that of insufficient rainfall, and a lack of availabile soil nutrients.

Intercropping research

Most countries where cane is produced by small scale farmers have considered the intercropping of cane as a means to improve home food security. The largest volume of scientific papers originate from India, where extensive intercropping research has been done on a total of 84 different crops in the four northern-most States where climatic conditions are similar to those found in KwaZulu-Natal. The other centres of research include Pakistan, Brazil, West Indies, Fiji, Phillipines, Indonesia, Egypt, Kenya and Mauritius. The two countries where intercropping of cane is practised widely on a commercial scale are India and Mauritius.

Mauritius has been growing cane since 1639, having been self-sufficient in sugar since 1755. Now more than 87% of the arable land of the island is planted to cane, and there is no new land available for the intensification of food production, which has caused a considerable problem for the adequate production of food crops to support the island's large population (Nicolin, 1986). Mauritius started investigating the economics of intercropping cane as long ago as the early 1950s (Rouillard, 1956), but the main effort was initated in

1984 (Govinden *et al.*, 1984). By 1990, 55% of the groundnut crop, 80% of the potatoes and 59% of the maize crop of Mauritius were being commercially produced within the sugarcane interlines (Govinden, 1990). Since 1984, cane intercropping research has been under the direction of Govinden and his team, who have developed detailed recommendations for intercropping cane with maize, groundnuts, potatoes, beans and vegetables. As these crops coincide with those selected by the small scale cane growers in KwaZulu-Natal following an official visit to Mauritius in 1996, the author decided to test the Mauritian recommendations under South African conditions.

In KwaZulu-Natal there are estimated to be a total of over 52 000 small scale cane growers, of which over 50% are concentrated into the areas served by the mills of Amatikulu, Felixton, Sezela and Eston, so these were the areas selected for the siting of the cane intercropping trials. Many farmers in KwaZulu used to intercrop their cane on an *ad hoc* basis, but the mill extension services strongly discouraged this practice on the grounds that it would interfere with mechanisation of the crop, and would prevent the use of residual herbicides, leading to unacceptable weed levels. Intercropping by Indian farmers near to Durban markets is still practised on a very small scale, and is mainly used for the production of Indian vegetables. However, none of these practices has been well documented, and there are no extension recommendations in existence for intercropping cane in South Africa.

Prior to the start of the Joint Project, there was almost no research data originating from South Africa concerning the intercropping of cane. In 1984, the effect of inter-specific competition between cane and dry beans on the growth of the two crops was investigated (Leclezio *et al.*, 1984). They found the competition very severe as there was a pronounced drought throughout the trial period, which resulted in a significant reduction in all cane growth parameters due to competition from the intercrop of beans. However, the effects of the severe drought rendered the research inconclusive.

Methods and Materials

Due to the high concentration of dryland small scale producers in the Amatikulu mill area, (28% of the total for KwaZulu-Natal), the first trials were initiated on a Tongaat-Hulett farm near the mill, at an altitude of 100 m above sea level, on a heavy black Dwyka soil. The soil was analysed at Cedara (KZNDA) and SASEX, and fertilisers were applied separately to each and every crop at planting, according to the recommendations for a sole crop. The spring trial was planted in October 1996 and, adjacent to it, the summer trial in February 1997. Both trials had a split plot design, the main treatment being the food crop, with the N16 cane occupying half of each main treatment plot, enabling a direct comparison between the yields of food crop + cane, and sole food crop. The plots were randomised in blocks, with four replicates of all treatments. The food crops tested were those identified by farmers to be of paramount importance to them, V13 maize, cabbage, potatoes, groundnuts and beans. The cultivars selected were PAN 6363, Hercules, Mnandi, Anel, and Kranskop, respectively, each selected for high yield, short maturity, and disease resistance. To reduce the period of risk, and to maximise the profit potential, the maize was grown for the production of green mealies, not for dry grain.

As some of the small scale cane growers have access to irrigation, and a new dam near Pongola has the potential to provide irrigation for cane, the trial design described above was repeated under irrigation during the winter at Makhathini at an altitude of 65 m above sea level, in the extreme NE of KwaZulu-Natal, where planting took place in May 1997. The same crops and cultivars were planted, although the available cane variety was N19, rather than N16. Fertilisers were applied to each crop as recommended for sole crops, based on soil analysis. The trial was situated on a heavy red Hutton soil, and irrigation from the river was provided through overhead sprinklers and draglines.

In the first trial (October 1996), cabbages were planted at 40 cm between seedlings in the row for all plots, and other food crops were planted at varying spacing within the row, depending on whether they were in sole stand, or intercropped (in *italics* in brackets), because it was anticipated that the cane crop would compete with the food crops to reduce their yields. Thus maize: 30 cm (*45 cm*); potato: 30 cm (*45 cm*); groundnuts: 8 cm (*12 cm*); and beans: 6 cm (*9 cm*). As all the cane was planted in 1,2 m rows, the single row of food intercrop was also effectively planted at 1,2 m. In sole stand, all the food crops were planted in rows 90 cm apart, except for cabbage which was planted at 60 cm. This meant that all intercrops had 50% of the sole crop stand per plot. Except for cabbage, it was observed that the food crop plants within the cane under-utilised the space available, and there was no evidence that any food crops suffered from inter-specific competition from the cane, so in the summer (February 1997), and winter (May 1997) trials, all the food crops were planted within the row at spacings similar to the first trial, whether they were intercropped or sole: maize at 30 cm, cabbage at 40 cm, potatoes at 30 cm, groundnuts at 8 cm and beans at 6 cm. This meant that the relationship changed so that all intercrop plots had 75% of the sole crop stand, except for cabbage, which maintained the 50% level. This relationship of food crop stand between sole and intercropped plots is important when considering the relative yields presented in Table 3.

The seedcane was planted first, at a double stick seeding rate, in rows 1,2 m apart. The seedcane was covered with soil and, in the plots where the cane was intercropped, a single row of the food crop was planted in the centre of the interline space within three days of planting the seedcane. Cane plot size: gross 6 rows x 8 m long, net 4 rows x 6 m long; sole food crop plot size: gross 6 rows (or 8 rows for cabbage) x 8 m long, net 4 rows (or 6 rows for cabbage) x 6 m long.

For all three trials described in this paper, the day after planting the food crops, all plots received a herbicide application of 2,5 L/ha Lasso Micro Tech (alachlor), and an insecticide application of 3 L/ha Ambush (permethrin) against cutworms. All post-emergent weeding was done by hand labour, as there were no chemicals which could be used safely on all the crops grown, and most small scale farmers would be unable to afford the agrochemicals required. Stalk borer granules were placed in the funnels of the maize plants when the plants were 60 cm tall, and caterpillar and bollworm damage to the cabbages and beans was controlled with three mid-season sprays of Ambush at 100 ml/ha. A foliar spray of 150 g/ha sodium molybdate was applied to the cabbages, beans and groundnuts three weeks after planting to ensure no molybdenum deficiency occurred. The cane, cabbage, maize and potato crops all received a top-dressing of LAN nitrogen fertiliser at the recommended rates and times according to soil analysis. Fungicides and other agrochemicals were not used to control diseases.

Results and Discussion

Spring trial at Amatikulu – Cane

The N16 cane took 28 days to emerge from the ground, and then grew slowly for the first 60 days, minimising the competition between cane and food plants in the intercropped plots. However, by 108 days from planting, a clear effect of the intercrop could be seen on cane performance ([1]personal communication).

The early reduction in growth of the spring-planted cane (Table 1) caused by the intercrops of cabbage, potato, groundnuts and beans, and the reduction in tillering (stalk count in thousands/ha) where the cane was intercropped by maize, potato, groundnuts and beans, agrees with the results obtained by a number of researchers. Jayabal and Sankaran (1991) found that a number of legumes reduced early tillering in cane in Tamil Nadu, S. India. In Uttar Pradesh, N. India, Verma and Yadav (1988) found that most intercrops reduced early tillering, except where high levels of fertiliser had been applied, which might explain why the cabbage intercrop in Table 1 had increased tillering, due to the early application of 480 kg/ha LAN top-dressing on the intercrop. Harlapur *et al.* (1995) found maize to significantly reduce tillering and stick height, whereas at Amatikulu stick height was increased as the cane competed for light between tall maize plants. Govinden and Ramsamy (1995) in Mauritius, found that maize reduced stalk counts of the cane. Table 2 shows that all intercrops tested tended to reduce all three parameters listed including cane yields, which agrees with the findings of most researchers on cane intercropping, including those quoted above. The yield of sole cane, at 82,6 t/ha was considered reasonable for the area, based on the 51 week total rainfall of only 829 mm. From the statistical analysis of data presented in Table 2, it can be seen that only the groundnut crop significantly reduced all three parameters ($p < 0,05$), but in addition, potato significantly reduced both stick height and stalk count, and cabbage significantly reduced stick height and cane yields (both to $p < 0,05$).

Table 1. Effect of intercrop on cane growth at 108 days after planting.

Crop system	Stick height (cm)	Stalk count (000/ha)
Sole cane	51	105
Cane + maize	62	90
Cane + cabbage	47	110
Cane + potato	49	72
Cane + groundnuts	41	100
Cane + beans	49	101

Spring trial at Amatikulu – Food crops

PAN 6363 maize grew rapidly, tasselling at 57 days, silking at 63 days, and being ready for harvest at 84 days after planting, when the plants reached a height of 1,8 m. Despite having received only 268 mm rainfall from planting to harvest, a good seed set was achieved, and no diseases affected the plants. When cane intercropped with maize was harvested, competition between the two crops had reduced stick height and stalk count by only 5%, and the yield of cane by 12,3%. Green mealie cobs are sold singly, not by weight, thus Table 3 presents the yields in terms of both the number of cobs/ha, and the tons of cobs/ha. The table shows that, for this spring trial, there was no significant difference between yields in tons/ha from the intercropped and sole plots, despite the former having only 50% of the plant stand of the latter. This implies that the individual maize plants growing between the cane each produced a higher yield of cobs than in the sole stand of maize. This was confirmed by the data that the intercropped plants bore 1,4 cobs/plant, against 1,0 cobs/plant in sole stand, which meant that per hectare the total number of cobs harvested from the intercrop plots was 64% of that of the sole crops, despite the stand being only 50%.

Table 2. Effect of intercrop on cane growth and yield, at harvesting 358 days after planting.

Crop system	Stick height (cm)	Stalk count (000/ha)	Cane yield (t/ha)	% loss of yield due to intercrop
Sole cane	192	124	82,6	–
Cane + maize	182	118	72,4	12,3
Cane + cabbage	166	107	64,0	22,5
Cane + potato	177	97	68,2	17,4
Cane + Groundnut	159	101	54,4	34,1
Cane + beans	185	115	74,7	9,6
LSD 5%	14,9	17,4	16,2	
CV%	5,6	10,5	15,5	

[1] Mr PET Tutner, Head, Agronomy Department, SASEX (1997). Current: Sugarcane Research Services, PO Box 1443, Forest Hills, Kloof, 3610.

The spring planted Hercules (a heat tolerant cultivar) cabbages developed well, but suffered early diamond-back caterpillar damage which resulted in a number of multiple-head cabbages, which were unsaleable. The crop was harvested on the same date as the green mealies. A number of heads suffered symptoms of tip burn caused by an insufficiency of calcium inside the plant at the time of head expansion, typical of cabbage produced under hot conditions. Cabbages were found to be in high demand in the Gingindlovu area in January, where they retailed at R1,00 to R2,50 per head, depending on size. The cabbage intercrop had a much greater competitive effect upon the cane than had maize, so that stick height and stalk count were reduced by an average of 13,5%, and cane yields by 22,5%. Cabbages are sold as single heads, or in pockets, for both of which large heads sell for more than small heads. The pattern seen in Table 3 for maize was repeated for cabbage, whereby the yields from the intercrop plots in tons/ha were considerably more than 50% of the sole stand yield, and the individual cabbage head weights were significantly heavier in the intercrop plots. Thus the inter-specific competition between cane and cabbage, or cane and maize, was actually less than the intra-specific competition between food crop plants in sole stands.

The potato cultivar, Mnandi, was chosen for its resistance to blight, and no other diseases caused any problems, but throughout its growing season, the crop suffered severely from heat and water stress. At 112 days from planting, the crop had received a total of 365 mm of rainfall, which proved totally inadequate, and fewer tubers were harvested than had been planted. It was evident that this crop cannot be expected to produce any economic yield when growing at low altitudes during the summer where irrigation is not available. Despite an inability to produce an economic tuber yield, the plants nevertheless competed with the cane, to produce an 8% reduction in stick height, a 22% decrease in stalk count, and a 17,4% loss in cane yield. The low yields in Table 3 show that the intercrop yield was greater than expected from the 50% sole crop stand.

The groundnut cultivar Anel was chosen for its ability to yield well under hot, dry conditions. Its compact, upright habit should have made it compatible as an intercrop in cane. Due to the isolation of this crop at Amatikulu, the crop suffered none of the normal groundnut diseases. As shown in Table 3, a good yield of nuts was produced when the crop was harvested 120 days from planting, having received a total of 370 mm of rainfall. As seen for the other food crops, the yield of 1,03 tons/ha nuts from the intercrop was considerably higher than 50% of the sole crop yields, once again indicating a higher productivity from intercropped groundnut plants. However, for some unknown reason, the groundnut plants competed very heavily with the cane throughout the season. In the field, all the cane where groundnuts were interplanted was stunted and yellow. At cane harvest, the

Table 3. Comparison of food crop yields in sole stand with the food crop yields when intercropped with cane, for three field trials.

Crop	Yield parameter (units)	Trial		Intercrop stand as % of sole	Sole stand	Intercrop	#Significance of difference
Maize for green mealies	Fresh cobs (t/ha)	Spring	Oct 1996	50	8,8	6,7	NS
		Summer	Feb 1997	75	10,1	7,6	*
		Winter	May 1997	75	19,4	16,8	*
	Number of saleable cobs/ha	Spring	Oct 1996	50	35 100	22 500	*
		Summer	Feb 1997	75	34 725	24 540	*
		Winter	May 1997	75	39 355	33 683	NS
	Number of cobs per plant	Spring	Oct 1996	50	1,00	1,40	**
		Summer	Feb 1997	75	1,04	1,07	NS
		Winter	May 1997	75	1,85	1,99	NS
Cabbage	Saleable heads (t/ha)	Spring	Oct 1996	50	41,1	26,0	*
		Summer	Feb 1997	50	71,4	33,5	**
		Winter	May 1997	50	103,0	81,8	**
	Number of saleable heads/ha	Spring	Oct 1996	50	37 040	17 120	**
		Summer	Feb 1997	50	41 670	20 800	**
		Winter	May 1997	50	42 596	21 760	**
	Mean weight per head (kg)	Spring	Oct 1996	50	1,11	1,51	*
		Summer	Feb 1997	50	2,00	1,90	NS
		Winter	May 1997	50	2,42	3,76	**
Potato	Total yield of tubers (t/ha)	Spring	Oct 1996	50	6,71	3,94	NS
		Summer	Feb 1997	75	nil	nil	–
		Winter	May 1997	75	32,16	23,17	**
Groundnuts	Total yield of shelled nuts (t/ha)	Spring	Oct 1996	50	1,76	1,03	**
		Summer	Feb 1997	75	0,71	0,32	NS
		Winter	May 1997	75	nil	nil	–
Dry beans	Total yield of dry bean seeds (t/ha)	Spring	Oct 1996	50	nil	nil	–
		Summer	Feb 1997	75	1,82	1,15	*
		Winter	May 1997	75	nil	nil	–

#Significance of difference column: NS = non-significant * = Sig at p <0,05 ** = Sig at p <0,01 groundnuts had reduced the stick height by 17%, the stalk count by 18,5% and the cane yield by an unacceptably high 34,1%. No reference could be found in the literature to explain this high degree of competition.

The dry beans suffered from windburn at the beginning of the season, and flowered 51 days after planting. This coincided with a period of very high temperatures, which caused many flowers to abort, and young pods to fall off. There were no problems of pests or diseases, but by 64 days most plants were severely wilted, and there was no crop to harvest. Due to the very short time this crop was actively growing, it was not surprising that it competed least with the cane, causing only a 9,6% reduction in cane yields.

Spring trial at Amatikulu – intercrop costs and profits: combined data for cane and food crops (Table 4)

To enable a comparison between intercrop combinations, and because the farmer, who is the end-user of the research findings, will need to know how to improve the profitability of his farming system, it was decided to convert the yields of the various crops to the common denominator of financial value (R/ha). This technique has been used by a large number of research workers. In India, Sinha *et al.* (1994), Shivay and Rathi (1996) and Singh *et al.* (1997) all compared the benefits of intercropping with a variety of food crops, on a financial basis. The same technique was followed by Miah *et al.*(1995) in Bangladesh, by El-Gergawi and Abou-Salama (1994) in Egypt, and by Ismael and Govinden (1990) in Mauritius.

Table 4 shows the combined economic data calculated for the yields of the sole cane and intercrops for the spring trial at Amatikulu. It is immediately evident that the intercrops of cane + maize (for green mealies) and cane + cabbage produced a profit far exceeding that produced by sole cane, despite the reduction in cane yields caused by both crops. This is the reason why many countries consider that the intercropping of cane is worthwhile on a commercial basis for selected crops. In all the papers quoted in the paragraph above, research workers showed that, although the inter-specific competition between food intercrop and cane was greater than the intra-specific competition between cane plants, which caused cane yield reductions, the loss in cane revenue was more than compensated for by the value of some of the intercrops tested. In the spring trial, the loss in income due to the decrease in cane yield caused by competition from the intercrop, was far lower than the value of the intercrop, even for cabbages, which reduced both the cane yield and the sucrose percentage. The food value of the intercrop, or the revenue raised from its sale only three to four months after planting, has the potential to uplift the cash flow for the farming family, yet allows a profit to be made from the cane later in the year. However, Table 4 also shows that, due to poor yields, intercropping with potatoes, groundnuts or beans would seriously reduce the profits of the farmer, who would be better off planting sole cane rather than selecting any of these three crops.

Summer trial at Amatikulu

A late summer trial was planted at Amatikulu, to determine whether the food crops would be better able to survive under dryland conditions if they were planted in February, so that they would mature when the season was cooling down.

Cane

It had been intended that the N16 plant cane from this trial should be ratooned in September 1998, and replanted with food intercrops to determine their ability to compete with the faster growing first ratoon. However, the degree to which the cane became infected with smut meant that an unacceptably high number of stools would have been lost, thus the trial was instead harvested in June 1998 after 16 months, to enable the land to be cleared in time for planting new trials with more resistant cane varieties in spring 1998. During the 16 months, the trial received a total of 1 152,6 mm of rainfall, and produced a massive yield of almost 150 tons

Table 4. Intercrop costs and profits: combined data for cane and food crops for dryland spring trial at Amatikulu, planted 7/10/96, ratooned 1/10/97.

Treatment	Cane yield (t/ha)	Prod. cost cane (R/ha) *	Sucrose (%)	Value sucrose (R/ha) **	Food crop yield (t/ha)	Prod. cost food crop (R/ha)	Value food crop (R/ha) #	Net profit (R/ha)
Sole cane	82,6	6 550	10,7	8 425	nil	nil	nil	1 875
Cane + maize	72,4	6 000	10,3	7 452	6,7	2 200	11 725	(10 978
Cane + cabbage	64,0	5 803	9,5	5 794	26,0	6 800	15 600	(8 791
Cane + potato	68,2	5 900	10,8	6 694	4,0	8 800	2 400	-5 606
Cane + groundnuts	54,4	5 578	10,7	5 547	1,0	1 800	2 050	219
Cane + beans	74,7	6 053	10,7	7 617	Nil	1 520	nil	44

* Production costs of cane are reduced in intercrop because no residual cane herbicides applied, saving R320/ha, and due to cane yield reduction which affects transport (R0 ,67/ton km x 30 km) and levy.

** Sucrose value: R953/ton

\# Food crop values based on minimum prices during year - actual values likely to be higher (i.e. green mealies = R0,70/cob or R1 750/ton; cabbage = R0,90-R1,50/head or R600/ton; potatoes = R600/ton; groundnuts = R2 050/ton; beans = R2 300/ton).

(Indicates that intercrop combination gave significantly higher profits than sole cane.

Table 5. Intercrop costs and profits: combined data for cane and food crops for dryland summer trial at Amatikulu, planted 6/2/97, harvested 30/6/98.

Treatment	Cane yield (t/ha)	Prod. cost cane (R/ha) *	Sucrose (%)	Value sucrose (R/ha) **	Food crop yield (t/ha)	Prod. cost food crop (R/ha)	Value food crop (R/ha) #	Net profit (R/ha)
Sole cane	149,6	8 648	13,2	18 264	nil	nil	nil	9 616
Cane + maize	142,7	8 115	13,3	17 526	7,6	2 220	13 300	(20 491
Cane + cabbage	144,8	8 179	13,6	18 172	33,5	7 420	20 100	(22 673
Cane + potato	125,4	7 580	13,0	15 035	nil	8 500	nil	-1 045
Cane + groundnuts	127,4	7 642	13,2	15 497	0,3	2 100	615	6 370
Cane + beans	129,2	7 697	12,9	15 404	1,2	2 750	2 760	7 717

* Production costs of cane are reduced in intercrop because no residual cane herbicides applied, saving R320/ha, and due to cane yield reduction which affects transport (R0,75/ton km x 30 km) and levy.
** Sucrose value: R922.41/ton.
\# Food crop values based on minimum prices during year - actual values likely to be higher (i.e. green mealies = R0,70/cob or R1 750/ton; cabbage = R0,90-R1,50/head or R600/ton; potatoes = R600/ton; groundnuts = R2 050/ton; beans = R2 300/ton).
(Indicates that intercrop combination gave significantly higher profits than sole cane.

cane/ha in the sole plots. Even when converted to a 12 month figure, a yield of 112,2 tons cane/ha was considered very good for the area. No doubt due to the longer period between the harvest of food crops and the harvest of cane, the cane was better able to recover from the inter-specific competition it suffered in the first four months after planting, so the reduction in cane yield caused by the intercrops was far less than in the October trial, as shown in Table 5.

Food crops

Initially high temperatures put a lot of stress on the food crop seedlings, but the excellent rains of April and May 1997, together with the more favourable temperatures in autumn, ensured cabbage and green mealie yields far in excess of those harvested from the October 1996 trial. After 92 days, and only 194 mm of rain, PAN 6363 green mealies and Hercules cabbages were harvested. The mealies produced much heavier cobs than from the previous trial, and only decreased cane yields by 4,6%. The cabbages were also significantly heavier than those of the previous trial, and reduced cane yields by only 3,2%. Table 3 shows the yields achieved by the sole and intercropped food crops. The pattern of a heavier crop per plant in the intercrop demonstrated by the data for the spring trial was not seen in this trial for any of the food crops.

As in the October 1996 trial, the potatoes performed very badly, proving their unsuitability as a dryland crop at the coast. The seed potatoes suffered badly from the very hot planting conditions, so that many tubers rotted in the wet soil, resulting in very poor stands of stunted stems, which produced no tubers at all. Despite this poor growth, the potato intercrop succeeded in reducing cane yields by 16%. The groundnuts were infected by a number of serious fungal diseases (*Cercospora, Phoma* and rust), and yields were further reduced by rabbits. After 134 days and 240 mm of rainfall, they produced very uneconomic yields, even in the sole plots. Once again, the intercrop competed heavily with the cane to produce a 15% yield reduction. The beans suffered from a late infestation by red spider mite, and also from severe rust, but when they were harvested after 126 days and 230 mm of rainfall, they produced reasonable yields of 1,8 t/ha in sole stand, and 1,2 t/ha in cane. The beans caused a 13,6% decrease in cane yields.

Summer trial at Amatikulu – intercrop costs and profits: combined data for cane and food crops (Table 5)

Table 5 shows a massive increase in sole cane yields over that of the previous trial, partly due to the 16 month cut instead of a 12 month cut and to the greater total rainfall, hence a greatly improved level of profitability from sole cane. It was interesting that the sucrose percentage was also much higher when cutting cane in June as opposed to October. Once again, the pattern seen from the spring trial was repeated in the summer trial, in that the two intercrops, cane + maize and cane + cabbage, gave the highest increase in profits, except this time cabbage had a slight edge over maize, despite the higher costs for transport. Due to poor yields and the degree of competition, which seriously reduced the cane yields, the intercrops of potatoes, groundnuts and beans reduced the profitability level well below that achieved by sole cane.

Winter irrigated plant cane trial at Makhathini – Cane

Due to the cool conditions, the cane took eight weeks to emerge from the soil and remained very short throughout the growth cycle of the food crops, so little competition for light was evident. The cane was harvested exactly 365 days after planting, during which time the crop received 570 mm of irrigation plus 828 mm of rainfall, to give a sole crop yield of 122,7 t/ha. Table 6 summarises the yields of cane and intercrops, from which it can be seen that, as water was not limiting, planting potatoes between the cane rows actually increased the cane yield to 155,6 t/ha (26,8% increase). This finding agrees with Imam *et al.* (1990), working in Bangladesh, who suggest that this increase in cane yield resulted from high levels of P and K left over from the potato crop, which is an inefficient feeder. Verma and Yadav (1988) found similar results in India, provided the water supply was not limiting, and Govinden (1990) explains that this is one of the reasons that so much of the commercial potato crop in Mauritius is produced in sugarcane in high rainfall areas.

Makhathini – Food crops

The trial was planted during the winter of 1997 as the summer was considered too hot for the intercrops on the Makhathini Flats. The winter was much cooler and wetter than normal. This resulted in waterlogging of the heavy red soils causing the death of the groundnut and dry bean plants before seeds were produced. Due to far fewer heat units during the winter, the green mealie crop took 50% longer than in the summer trials to reach maturity, so that it was harvested after 125 days, having received 369 mm of irrigation plus 181 mm of rainfall. Good yields of food crops were produced both in sole stand and where intercropped with cane, as shown in Table 3. There was a return to the pattern exhibited by the spring trial at Amatikulu in that, although the intercrop had 75% of the sole stand, the cob yield in tons/ha was 87%, cob number per plant 107%, and number of saleable cobs 87%. Thus the maize plants grown in the interline spaces have a higher productivity per plant than when grown in pure stand. Competition with the cane plants caused a significant reduction in cane yield (38,3%).

The cabbages took 105 days to reach maturity, during which time they received 324 mm of irrigation plus 111 mm of rainfall. The very wet conditions caused many of the cabbages to be infected with black rot. Even so, excellent yields were produced from sole and intercropped plots. Table 3 shows, once again, that the intercrop cabbages produced much more than 50% of the yield of the sole crops. In fact, the data for individual head size shows a significantly heavier mean head size in the intercrop ($p < 0,01$), and the competition from these larger plants caused a 21,5% loss in cane yield.

Due to the extended period of waterlogging of the soil the potato yields were low but still much better than had been produced in the summer trials. Table 3 shows that the productivity of plants in sole and intercropped plots was similar. The potato crop was harvested on the same day as the green mealies (125 days, with 369 mm irrigation and 181 mm rainfall), and for the economics of irrigation calculations the maize, beans, groundnuts and potatoes were all considered to have received the same amount of irrigation.

Winter trial at Makhathini – intercrop costs and profits: combined data for cane and food crops (Table 6)

Despite the 38,3 and 21,5% reductions in cane yields caused by competition from the intercrops of maize and cabbage respectively, Table 6 gives a convincing message that using these intercrops considerably increases the profitability of growing cane during the winter under irrigation at Makhathini. As shown in the summer trial at Amatikulu, the profit from the cabbage + cane intercrop was greater than from cane + maize, but the advantage of the maize + cane system was the lower outlay required to produce the intercrop. Table 6 also shows that where the potato intercrop increased the cane yield it decreased the sucrose percentage (i.e. there was a dilution of sucrose in the larger cane sticks), but not to such a degree that this crop mixture did not have the highest sucrose yield of any treatment tested. Although the Net Profit column shows that cane + potato gave a bet-

Table 6. Intercrop costs and profits: combined data for cane and food crops for irrigated winter trial at Makhathini, planted 27/5/97, harvested 26/5/98.

Treatment	Cane yield (t/ha)	Prod. cost cane (R/ha) *	Sucrose (%)	Value sucrose (R/ha) **	Food crop yield (t/ha)	Prod. cost food crop (R/ha)	Value food crop (R/ha) #	Net profit (R/ha)
Sole cane	122,7	7 816	12,9	14 506	nil	nil	nil	6 690
Cane + maize	75,7	6 044	13,1	9 154	13,3	3 415	23 275	(22 970
Cane + cabbage	96,3	6 681	12,6	11 148	81,8	13 580	49 080	(39 967
Cane + potato	155,6	8 513	11,4	16 290	21,4	12 450	12 840	8 167
Cane + groundnuts	128,6	7 679	12,2	14 519	nil	2 350	nil	4 490
Cane + beans	127,7	7 651	12,2	14 335	nil	2 550	nil	4 134

* Production costs of cane are reduced in intercrop because no residual cane herbicides applied, saving R320/ha, and due to cane yield reduction which affects transport (R0 ,75/ton km x 30 km) and levy.
** Sucrose value: R922.41/ton.
\# Food crop values based on minimum prices during year - actual values likely to be higher (i.e. green mealies = R0,70/cob or R1 750/ton; cabbage = R0,90-R1,50/head or R600/ton; potatoes = R600/ton; groundnuts = R2 050/ton; beans = R2 300/ton).
(Indicates that intercrop combination gave significantly higher profits than sole cane.

Costs of production include cost of irrigation calculated as follows (figures from Combud Crop Budget 1997, produced annually by Economics Section of KZN Department of Agriculture, Cedara): Irrigation power @ R1,00/mm/ha, irrigation labour @ R0,62/mm/ha, irrigation repairs @ R0,05/mm/ha. Each food crop received a different total of irrigation due to varying times to maturity.

ter profit than sole cane, the outlay of capital to establish the potato intercrop would not have been justified. As expected from the nil yields caused by a waterlogged soil, neither legume planted justified their inclusion into cane, even where they tended to increase cane yields.

Conclusions

The three intercropping trials clearly showed that the inclusion of an intercrop of cabbages, or of maize grown for green mealies, has the potential to increase the profitability of plant cane, under both dryland and irrigated conditions, despite the competitive effect of the food crop reducing cane yields. There is a strong tendency for the intercrop plants between the cane rows to have a higher individual productivity than when planted in sole stand. This means that for crops such as green mealies and cabbages, where market price is closely linked to the size of the product per plant, small scale cane growers who wish to produce these food crops should plant them between the cane lines of their plant cane, rather than cultivating extra land to plant a sole stand of food crop.

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