Neth. J. agric. Sci. 31 (1983) 13-25

New cultivation techniques for cashew (*Anacardium occidentale* L.)

C. L. M. van Eijnatten[1] and A. S. Abubaker[2]

[1] Department of Tropical Agriculture, Agricultural University, Wageningen, Netherlands
[2] Coast Agricultural Research Station, P.O. Box 16, Kikambala, Kenya

Received 4 May 1982; accepted 28 July 1982

Key-words: cashew, cultivation, hedgerow, gross margin, spacing requirements, rejuvenation

Summary

The cashew tree produces its fruits on new growth at the periphery of the canopy. Productivity of the crop should be maximized, therefore, by increasing canopy surface area.

Spacing experiments have shown that planting distances from 6 m to 15 m did not influence yields per ha, although wider distances led to increased yields per tree. It has been shown that productivity can be improved considerably by re-arranging the cashew orchard into hedgerows at 9 to 12 m from each other and planting distances of 2 to 3 m within the rows. Combination of hedgerowing and the use of a clonal cashew variety was shown to open perspectives in respect of greatly increased productivity and higher gross margins per ha.

Introduction

In several developing countries the cashew tree (*Anacardium occidentale* L.) is an important source of foreign exchange through the export of its nuts. As such the crop has been promoted by the agricultural services despite its low general level of yield. As is the case in Kenya the farmer often receives only around 20 % of the export value of the cashew kernels as processing costs are considerable. These two factors, low productivity and low price, make the crop unattractive to farmers, especially when and where alternative crops are much more remunerative.

Often mention is made of high yield levels reached by certain trees and for particular (favourable?) years. This is known from individual farmers and from the literature alike (Agnoloni & Giuliani, 1977; Ohler, 1979). Indications that outstanding trees should be utilized to improve yield levels of cashew orchards, either through clonal varieties or by the use of their seed, are common. However, little proof has so far been provided that high yields have actually been

achieved. It is suggested that this is partly due to the fact that cashew workers are still to develop a new, practical technology for the cultivation of the crop which ensures satisfactory benefits for the farmers. In this paper an attempt is made to provide such a new cultivation technique.

Development of the cashew tree in Kenya

The environment

In the cashew growing areas along Kenya's coastal strip rainfall varies from 900 to 1200 mm p.a. The variation over the years is considerable and has an important effect on productivity of the crop. At Mtwapa, situated right in the middle of the cashew producing area, rainfall averages 1111 mm but varied from 681 to 1478 mm in the period from 1970 to 1979. When rainfall was at levels below 1000 mm per annum cashew yields were 600 to 700 kg of nuts per ha. At higher rainfall levels yields proved to be much lower, at 158 to 434 kg per ha. Average yield levels in Kenya's Coastal Strip proved to be negatively correlated with annual rainfall: $r = -0.91$, $p = 0.05$ (van Eijnatten, 1979).

Temperatures in this lowland tropical area are on the average 25.8 °C, varying from 24 °C in August to 27.9 °C in February. Potential evaporation (Eo) is relatively low at 144 to 162 mm per month from May to August but reaches levels up to 221 mm in other months. Relative humidity particularly during the cool months of August and September, the flowering season of the cashew in Kenya, remains high also during the day (Agnoloni & Giuliani, 1980). A study of water availability, assuming a maximal storage of 150 mm water in 3 m of soil depth, shows that the flowering season (August, September) is in a period of sufficient water availability. Yields are, therefore, not restricted by the failure of flowers to develop due to drought as reported by Dag & Tapley in Tanzania (1967). Important water stress is likely to develop from December onwards, coinciding with the harvesting season (Table 1).

The soils which are supporting the cashew crop, are deep and well drained, sandy or loamy sands. The nutrient levels are usually low and water storage capacity is estimated at 150 mm over a depth of 300 cm (Michieka et al., 1978).

Current practices of cultivation

Cashew is planted, 3 seeds to a planting site, at a spacing of 6 m × 6 m giving 278 trees per ha. Depending on the growth of the trees the orchard is thinned to a spacing of 12 m × 12 m, some time between the fifth and the tenth year. This leaves a population of 69 trees per ha. During the first two or three years weeds are controlled around the young trees.

Later on, maintenance is reduced to clearing the farms prior to the harvesting period in order to allow the harvesters to locate any of the dropped, mature fruits. Harvesting is done by collecting the dropped fruits and separating the nuts from the apple. After paring the nuts to clean the point of attachment, they are dried prior to delivery to buying agents.

Table 1. Water balance for cashew at Mtwapa, Kenya.

Month	Average rainfall 1960-1979	Water budget								
		for cashew orchards with a closed canopy				for cashew planted at 15 m × 15 m and at 12 years of age, cashew covering 51 % of the soil and grass 49 %				
		E_t cashew	accumulated water stored in soil	drainage loss	water deficit	E_t cashew	E_t grass	accumulated water stored in soil	drainage loss	water deficit
January	25	141	–	–	116	72	0	3	–	–
February	22	136	–	–	114	69	0	–	–	44
March	54	147	–	–	93	75	0	–	–	21
April	152	120	32	–	–	61	59	32	–	–
May	265	101	150	46	–	51	50	150	46	–
June	155	99	150	56	–	50	49	150	56	–
July	99	96	150	3	–	49	47	150	3	–
August	73	108	115	–	–	55	53	115	–	–
September	75	121	69	–	–	62	0	128	–	–
October	27	132	–	–	36	67	0	88	–	–
November	106	133	–	–	27	68	65	61	–	–
December	58	136	–	–	78	69	0	50	–	–

A practice which is often followed is the removal of the lower limbs of the cashew tree. This is done to make the orchards accessible to harvesters, to cattle grazing under or between the trees or to tractors where maintenance of the orchards is mechanized. It has, however, been shown that this practice reduces yields with 10 % (Anon., 1979).

Elsewhere, recommendations are to plant at even wider spacings than pertains in Kenya, up to 18 m (Agnoloni & Giuliani, 1977; Ohler, 1979). As said by Ohler (1979) the ideal spacing would be one that could be adjusted to the growth of the trees, beginning with a high density that gradually could be reduced. So far the cashew is considered an extensively grown crop, receiving little care because of the low incomes generated by it.

The growth of the tree

The cashew tree develops rapidly a dome shaped canopy bearing its foliage on the outside, where also flowers and fruits are found. Data on the size of the canopy of cashew trees in relation to age were provided by Goldson (1973) and are listed in Table 2. Particularly the canopy diameter is of great importance when considering plant arrangements. Initial narrow spacings of 6 m prove to encumber tree growth already in the fourth year after establishment.

In respect of root growth it was observed that seedlings form a tap root reaching a depth of 1½ to 2 times the height of the plant during the first four months (Anon., 1979). Later on also an extensive system of lateral roots is formed, which in Tanzania proved to reach far beyond the canopy spread of the tree during the first years of growth (Tsakiris & Northwood, 1967). Observations on mature trees at Mtwapa, Kenya, showed that the 'sinker roots' were mainly arising from lateral roots within some three metres from the trunk. The main laterals thinned out rapidly beyond this distance from the trunk. Lateral roots emerging beyond the drip-line of the canopy at 6 m from the trunk were few and very thin. The rooting volume at Mtwapa seems to be confined to that below the canopy.

Yield levels

The overall yield levels of cashew in Coast Province have been estimated at 452

Table 2. Canopy measurements of cashew trees at Mtwapa, Kenya.

Age of tree (year)	Canopy measurements		Age of tree (year)	Canopy measurements		Age of tree (year)	Canopy measurements	
	diameter (m)	height (m)		diameter (m)	height (m)		diameter (m)	height (m)
1	1.8	1.1	6	7.8	5.8	11	10.3	7.2
2	3.3	2.2	7	8.5	6.1	12	10.5	7.3
3	4.9	3.3	8	9.2	6.3	13	10.8	7.4
4	6.2	4.2	9	9.6	6.8	14	11.0	7.4
5	7.2	5.1	10	10.0	7.0	15	11.3	7.5

kg per ha (van Eijnatten, 1979). This figure represents both young, higher-yielding cashew orchards and mature to over-aged, low-yielding orchards. Income generated by the crop is low, as best-quality raw nuts now realize 3.50 shs per kg, equivalent to US$ 0.34. The average gross margin over the economic life of the tree at 25 years, is only 530 shs or US$ 51 per ha and per year.

It has been possible to establish at Mtwapa the evolution of yields in relation to age of the trees. From the fifth to the ninth year after establishment (in 1958) 101 randomly chosen cashew trees spaced at 6 m × 12 m were observed individually. The average annual yield per tree proved to be 4.01 ± 0.31 kg of raw nuts. Observations were made again in this orchard during the 17th and 18th year on 161 trees remaining after thinning had been done in the 10th year, including 53 of those recorded earlier on. Since thinning the cashew trees had ample opportunity to adapt to the wider spacing of 12 m × 12 m, at the time of further observation. Averaged over the two years productivity proved to have increased to 5.33 ± 0.89 kg per tree (van Eijnatten, 1979). These cashew trees are presently in their 23rd year and loose much of their canopy by breakage of overgrown limbs. It is, therefore, suggested that economic life of the tree, according to current cultivation techniques, is at the most a 25-year period.

The low yield levels in Kenya's cashew growing areas are confirmed from other cashew orchards at Mtwapa, where 644 mature trees planted at 12 m × 12 m yielded on an average 3.3 kg raw nuts per year over a 3-year period and at Msambweni, where 10 000 trees at 12 m × 12 m gave 3.0 kg (van Eijnatten, 1979).

With the aid of these yield figures and taking into account the varying numbers of trees per ha due to thinning, a projection has been made of expected yields per ha under the current system of cultivation (Table 3). The gross margins realized have also been provided by dividing cash flow information by the number of years under consideration. Additional use of land was not considered in these calculations.

Constraints

Major contraints are the arrangement of the cashew trees in the orchards, the

Table 3. Average yields from cashew trees in Kenya, grown according to the traditional system.

Years after planting	Yields per tree (kg per year)	Yield per ha (kg per year)	Number of plants per ha	Average gross margin per ha and per year from year 1 to the end of the 5-year period
1 to 5	1.28	356	278	459 KShs (US$ 44)
6 to 10	4.01	557	139	709 KShs (US$ 69)
11 to 15	4.70	324	69	579 KShs (US$ 56)
16 to 20	5.32	367	69	548 KShs (US$ 53)
21 to 25	4.92	339	69	530 KShs (US$ 51)

[1] Price of cashew 3.25 KShs per kg; 1 KShs is equivalent to US$ 0.10.

adaptation of their number to the development of individual trees by thinning practices and the unselected nature of the plant material. These aspects will be discussed in detail. Of less importance are limitations imposed by various pests and diseases. One of the more important insect pests is the scale insect causing a serious defoliation in the period from May to July, especially in the drier years. The species concerned is probably that reported by Wheatley (1961): *Pseudoanidia trilobitiformis* Green. Other important pests are cashew nut weevil (*Mecocorynus loripes* Chevr.) and cashew stem girdler (*Paranaleptes reticulata* Thoms). *Helopeltis anacardi* Miller and *Pseudotheraptus wayi* Brown also do some damage. Primary damage by fungi or other pathogens does not seem to be of importance.

The number of trees per ha

From a spacing trial on cashew at Mtwapa planted in 1970 and testing populations of 44, 69, 111, 135 and 278 trees per ha, two years of data have been collected in 1979 and 1980, at 9 to 10 years from planting. The yields per ha varied from 314 to 600 kg of raw nuts (Table 4). The coefficient of variation was at 48 % and prevented the identification of real differences between yields per ha. The yields per tree responded very clearly to the various populations. More space per cashew tree, i.e. fewer trees per ha, was compensated by a better productivity per tree. However, the yields per ha were not improved by reducing the number of trees per ha.

Plant arrangement

The cashew tree has a dome-shaped canopy and forms its flowers and fruits from new flushes which are found in the surface layer of the canopy. Within the canopy little foliage is available and no flowers or fruits. It is, therefore, apparent that canopy surface is related to the productivity of the tree. This is supported by the better yields from widely spaced trees as compared to those estab-

Table 4. Average annual yield from cashew trees established at various populations per ha at Mtwapa, Kenya; observation in the 9th and 10th year (1979 and 1980).

Number of plants per ha	Yield (kg)	
	per tree	per ha
278	2.16	600
139	3.90	541
136	2.44	332
111	2.83	314
69	7.07	489
44	8.68	382
Standard error	0.87	86
Coefficient of variation	21 %	48 %
Significance of differences	$P < 0.01$	NS

lished at higher populations per ha. At higher populations canopies touch; this prevents development of young shoots and, hence, the formation of flowers and fruits. Very closely planted cashew trees, theoretically, would have a canopy surface of one ha per ha of land planted to cashew. Lower proportions occur. To avoid loss of fruiting surface per ha of land, two measures have been tested:
– an initial high-density planting at 6 m × 6 m (278 trees per ha), later reduced to 12 m × 12 m (69 trees per ha), i.e. the traditional system of cashew cultivation;
– establishment of a low number of trees per ha, at 12 m × 12 m or at 15 m × 15 m.

Neither of the two solutions haven proven satisfactory, although canopy surface and yield per tree increased at lower populations. These parameters did not lead to higher productivity per hectare.

It is suggested that establishment of cashew trees in closely planted rows and ample interrow spacing should provide more canopy surface per ha of orchard until the space between the rows is taken up by the developing canopies. From that moment onwards, also a hedgerowed cashew orchard will reduce its fruiting canopy surface to one ha per ha of land.

Plant material

As a rule, cashew orchards are planted from open pollinated seed and such trees have proven to rise to an average yield level of 7 to 9 kg per tree when established at low populations of 44 to 69 trees per ha (Table 4). When established at higher populations and later thinned to 69 trees per ha individual tree yields only reach 5 to 6 kg at mature age, as explained above ('yield levels'). Even lower yield levels of around 3 kg per tree have been recorded in Kenya.

Individual trees may exceed general performance. For example at Mtwapa ten out of 101 cashew trees of 5 to 9 years old with an average yield of 4.01 kg gave yields from 7.41 to 15.39 kg per tree and per year. Six of these trees yielded even 10 kg per tree at the age of 17 to 18 years, when the average yield had risen to 5.33 kg. With these outstanding trees clonal tests have been planted in 1980 and at the same time open pollinated progeny has been entered into a recurrent selection scheme.

The highest-yielding cashew tree (A 81) yielding 15.39 kg per year was used in 1968 as a source of graftwood to establish a clone on seedling rootstocks. Nine of these were planted in a straight line at intervals of 2 to 3 m to form a hedgerow. The plants now cover a land area of 26 m × 14 m and constitute a first, somewhat unorthodox, clonal test. The yields from this hedgerow were recorded in 1973/75 and again in 1979/81 (Table 5).

The major point illustrated is that yields were measured in thousands of kilograms per ha, no longer in hundreds. It should, of course, be realized that these figures have been obtained by extrapolation from a small area, as indicated above.

Table 5. Productivity of a hedgerow of nine grafted trees of cashew clone A81 at Mtwapa.

	Year of observation			
	1973/74	1974/75	1979/80	1980/81
Age of trees	5	6	11	12
Actual yield of hedgerow (length of 26 m) in kg	85.3	96.7	164.8	123.6
Estimated yields in kg per ha				
hedgerow at 9 m interrow	3644	4133	*	*
hedgerow at 12 m interrow	2733	3100	*	*
hedgerow at 15 m interrow	2187	2480	4227	3169

* In 1979 the hedgerow attained a width of 13 to 14 m and would no longer fit into 9-m or 12-m interrows.

Alternative cultivation techniques

Rejection of thinning

Thinning of cashew planted at 278 trees per ha to 69 trees per ha was shown to reduce yields from 557 kg in years 6 to 10, to 300-400 kg per ha in later years (Table 3). However, trees planted directly at 69 trees per ha proved to produce in their 9th and 10th years 489 (± 86) kg per ha, not different from trees planted and maintained at 278 trees per ha, which yielded 600 ± 86 kg per ha (Table 4). Therefore, there is no advantage in thinning cashew trees planted at 278 trees per ha. Moreover, thinning involves a considerable outlay of funds for labour and/or machinery and leads to higher maintenance costs due to increased weed growth. At the time of thinning a considerable reduction in yield is bound to occur, which may be up to 75 % initially as three quarters of the trees are removed. As shown above, yields then recover to 300-400 kg per ha.

On the other hand direct establishment of cashew trees at 12 m × 12 m (69 trees per ha) gives similar yields as narrower planted orchards at 9 to 10 years from planting. This, however, would be achieved at the cost of farmer's income since yields from 69 trees during the early years after establishment will be very low when expressed per hectare.

Rejuvenation of the orchard

Yields decline due to loss of canopy surface consequent upon intermingling of branches from neighbouring cashew trees and also to a drop in productivity per m^2 canopy surface as noted in trees beyond ten years of age in Kenya. The decline in yields is generally corroborated by farmers' complaints that older trees (15 to 20 years) drop in productivity. Beyond the age of 20 years, furthermore, trees begin to loose canopy by breakage of branches, which can no longer support their own weight. All these facts call for a rejuvenation of the orchard either by replacement of the old stands by new cashew trees or by rejuvenation of existing trees.

Replacement of trees by newly sown material would cause farmers to rescind income from the cashew orchard for at least a three year period. Income could be generated by the sale of firewood from trees removed or of charcoal prepared from these trees. It is estimated that per ha 450 bags (of around 20 kg) charcoal could be prepared if trees had been established at 278 trees per ha. Replacement could, of course, be effected in steps by removing alternate lines of trees with a two or three year interval.

The alternative method is to rejuvenate trees through removal of the canopies by cutting the main trunk, i.e. 'coppicing'. If this is done at heights of 30 to 150 cm from ground level, invariably a profuse regrowth of the trees occurs. If practiced during the dry season (February/March in Kenya) a good proportion of the coppiced trees is likely to flower and fruit in the same year. Again in this case 350 bags of charcoal could be obtained from the canopies removed.

Either replacement of trees or coppicing are extra expenses to the farmers. However, the quantity of charcoal which can be obtained covers the cost of removal or coppicing, and part of the loss in productivity if higher-yielding plant material would be used or if a more productive cultivation technique were practiced than pertains presently.

Hedgerowing

Canopy surface of cashew per ha of land is likely to be a determinant in the production of higher yields from cashew orchards. In traditionally planted orchards established at 6 m × 6 m, canopy surface develops up to 12000 m^2 per ha of orchard, in the fourth/fifth year. When trees are established in narrowly planted (2 to 3 m) rows to form hedgerows a more rapid build-up of fruit-bearing surface is realized depending on the distance allowed between the rows of trees.

Very narrowly planted hedgerows at less than 9 m from each other would be unattractive as they would meet across the interrows too soon. At 9 m interrow distances this is postponed until the ninth year and at 12 m until the fourteenth year. When hedgerows are established at 15 m distances canopies may not close in at all. However, wider interrows also lead to lower canopy surface per ha of orchard. As will be shown later, interrow distances of 9 m allow the highest levels of yield, and income, to be reached. This, however, could oblige the farmer to severely prune or rejuvenate through coppicing the hedgerows first at nine years of age and probably every fifth year thereafter. An alternative is to plant hedgerows at 12 m and accept somewhat lower fruit-bearing canopy surface in exchange for the postponement of a first rejuvenation after 14 years, probably to be repeated some eight years later.

Use of clonal varieties

The clonal variety A81 proved to retain the high productivity observed on the mother tree at 15.39 kg over a five-year period, i.e. 3.8 times the average of the plantation. The yield figures in Table 5 indicate very high yields per ha, but these cannot be related to individual trees since the plants formed a hedgerow. The effect of the clonal variety (factor of 3.8) and that of hedgerowing are irre-

trievably confounded. However, the yield level of the mature hedgerow over the two-year period 1979/81 averaged 3698 kg per ha. This is 7 to 9 times the average yields of cashew in Kenya. It is, therefore, conceivable that the effect of hedgerowing is, apparently, represented by a factor of 2.

A new technology

The proposed system of cultivation

Planting material. Establishment of any cashew orchard should be done with the most promising plant material available. Seeds should be obtained from the best trees, preferably those that have been tested; the seedling can be grafted or budded with outstanding clonal varieties. In Kenya, this is true in respect of clonal variety A81. The clonal variety has to be grafted or budded 'on site' because a suitable method of transplanting nursery-grown cashew trees into the field has not yet been developed. As a rule, it is advisable to establish the cashew orchard with several clonal varieties in order to prevent any difficulties which may arise through self- or cross-incompatibility. In the case that only one clonal variety is yet available, it is suggested that every tenth seedling should be left as such, not to be converted to a clonal plant.

Arrangement of the trees. In order to build up rapidly the required fruit-bearing canopy surface a large number of trees is required. However, closely planted trees 'on the square' will touch each other all around very soon. Much of the extra canopy surface obtained by planting high numbers of trees, would soon be lost. Hence high numbers of trees should be planted in rows spaced at 9 to 12 m from each other. Within the rows, planting distances should be 2 to 3 m. Arranging the trees in hedgerows allows a maximum area of canopy surface per metre length of row. Row distances of 9 m would allow a free development of the canopy up to the eighth year. At row distances of 12 m the canopies would begin to close around the 14th year. Whenever the canopies touch, canopy surface will be reduced and yields will drop to levels comparable to those from orchards planted 'on the square' with the same plant material. The advantages of the specific hedgerow effect would be lost, but that of the planting material retained.

Hedgerows established at 9 m distances would accommodate 370 trees per ha when planted at 3 m within the row or 556 trees per ha at 2 m within the row. Hedgerows established at 12 m distances would comprise 278 or 417 trees respectively.

Rejuvenation. When canopies of neighbouring hedgerows are closing in, the orchard should be rejuvenated in order to form a new canopy. This can be done by severe pruning or coppicing of the existing hedgerows and by allowing a new canopy to be formed. This is a major undertaking and it may be wise to spread this over a period of two or more years by first removing alternating rows of canopies and then, when the coppiced or pruned rows are back in production, the alternative hedgerows.

When more productive or otherwise more outstanding varieties have been identified, rejuvenation of the orchard could be effected by replacement, i.e. by the establishment of seedlings in alternating interrows after opening these sufficiently to allow the development of young cashew trees. The alternative interrows can similarly be dealt with at a later date after removal of the original hedgerows.

Additional uses of the land. During the early years after establishing the cashew orchard, a considerable part of the land is available for intercropping. Annual crops interplanted between the rows of cashew would not interfere with the main crop providing they are not planted closer than 2 m to the centre of the hedgerows or 1 m to the periphery of the cashew canopy. Several years of intercropping can again be realized after rejuvenation of the hedgerows of after replacement with new planting material.

It is, however, suggested that the development of a cashew/dairy system of farming (Goldson, 1973) would not be attractive when very high yielding cashew plant material is used. The presence of cattle would require the removal of the lower limbs from the cashew hedgerows. This is likely to remove ten per cent from the production of cashew nuts (Anon., 1979). This is unlikely to be offset by the extra income from cattle.

Development of the hedgerowed cashew orchard. During the first year cashew seeds will be planted in rows, which will form the central lines of the future hedgerows. At the same time around 80 % of the area can be interplanted to annual crops as maize, cowpea, and simsim. After some five or six months the young cashew seedlings will be budded or grafted with the desired clonal variety. Depending on the success in budding or grafting, this operation may have to be carried out two to four times before all young trees will have been budded satisfactorily. When only one clonal variety is used, every tenth cashew plant should be allowed to develop as a seedling, without being budded or grafted. When outstanding seed material is available, it may be advisable to omit budding and grafting altogether.

During the next two years some yield is expected to be realized but income from intercrops, covering 60 or 45 % of the land respectively, still plays an important role. Over the third to the sixth years yields from cashew will rise to levels of 2 to 3 tonnes of raw cashews nuts, and intercrops are unlikely to be of much interest. In any case, space for intercrops decreases rapidly, i.e. to 30 % of the land in the third year, and 15 % in the fourth year.

The annual harvesting operations from November to March will require a considerable input of labour since all nuts need to be gathered and removed from the attached 'cashew apple' manually. To prevent the need for pruning the lower part of the canopy, fruits dropped to the ground at the lower end of the canopy must be gathered with the aid of rakes.

Depending on the distance between the hedgerows major rejuvenation through severe pruning or coppicing will take place after nine to fourteen years.

Table 6. Average gross margins in KShs per ha and per year for traditional cashew orchards with or without the preparation of charcoal, and hedgerowed cashew at 9 m or 12 m, including the preparation of charcoal.[1]

Period in years[2]	Traditional system of cultivation		New system of cultivation	
	without preparation of charcoal (current system)	with preparation of charcoal (innovation)	hedgerows at 9 m	hedgerows at 12 m
1 to 5	459	519	2827	2244
1 to 10	709	1066	5806	5394
1 to 15	579	1155	7870	6692
1 to 20	548	980	8464	7550
1 to 25	530	875	9089	7685

[1] Average price of cashews at farm gate 3.25 KShs per kg; 1 KShs is equivalent to $ 0.10.
[2] Year 0 is the year of establishment.

If carried out in March after completion of the harvest and prior to the onset of the rains, some yield can already be obtained from the new growth within the same year. The cycle of rejuvenation by coppicing is likely to have to be repeated every five to eight years depending on the distance between the hedgerows. The alternative to coppicing is the replacement of the trees when they are 9 to 14 years old with newly selected seed or clonal varieties.

The economics of the new technology. Cashew being a perennial crop requires investments which during the first years will not be balanced by the gross output in the form of payments for harvested cashew nuts, for produce from intercrops or for charcoal prepared from branches and logs at the time of rejuvenation or replacement. This period lasts three or four years. The costs of establishment, of the maintenance procedures including special activities as thinning or rejuvenation and of harvesting and 'on the farm' processing make up the variable costs. Deduction of these variable costs from the gross output provides a gross margin or gross return per ha for the year under consideration. By accumulating the gross return over consecutive years 'a cash flow' is obtained which indicates the profitability of the enterprise over the years. By division of the cash flow level reached in the *n*th year by that number of years an average gross margin is obtained for that period. This can be compared with data for annual crops. Average gross margins per ha and per year have thus been calculated for the current system of cashew cultivation and for this same system but complemented with the preparation of charcoal from 'thinned trees' (an innovation!). The average gross margins were also calculated for hedgerowed cashew orchards with 9 m or with 12 m interrow widths (Table 6).

Conclusion

Observations recorded over a considerble period of time have allowed the development of a system of cashew cultivation which could raise the farmer's income with a wide margin. The use of hedgerowed cashew orchards planted with selected plant material, either seed or clonal varieties, would at least double productivity, but an eight-fold increase was realized in Kenya. The cultivation system proposed represents a more intensive system of farming and allows for a more efficient use of the land in areas where rainfall is not a limiting factor.

Acknowledgement

Appreciation is expressed for the efforts of field workers at the Coast Agricultural Research Station, Mtwapa, thanks to whose dedication the recorded information became available. The studies were made possible by permission of the Director of Agricultural Research, Ministry of Agriculture, Nairobi.

References

Agnoloni, M. & F. Giuliani, 1977. Cashew cultivation Library of Tropical Agriculture, Ministry of Foreign Affairs, Italy.

Anonymous, 1979. Annual Report, Coast Agricultural Research Station, Mtwapa, Kenya.

Dag, M. & R. Tapley, 1967. Cashew nut production in Southern Tanzania V, water balance of cashew trees in relation to spacing. *East Afr. agric. For. J.* 33: 88–94.

Eijnatten, C. L. M. van, 1979a. Cashew productivity in relation to rainfall in Coast Province, Kenya Coast Agricultural Research Station, Kenya, Communication 7, pp 7.

Eijnatten, C. L. M. van, 1979b. A review of information on cashew in Kenya and suggestions for its further development as a cash crop in Coast Province. Coast Agricultural Research Station, Kenya, Communication 3, 26 pp.

Goldson, J. R., 1973. The effect and contribution of the cashew tree in a cashew pasture-dairy cattle association at the Kenyan Coast. Ph. D. thesis, University of Reading.

Michieka, D. O., B. J. A. van der Pouw & J. J. Vleeshouwer, 1978. Soils of the Kwale-Mombassa-Lunga lunga area: Kenya Soil Survey, Ministry of Agriculture, Kenya, Reconnaissance Soil Survey Report R3 Vol. I.

Ohler, J. G., 1979. Cashew. Department of Agricultural Research, Royal Tropical Institute, Amsterdam, Communication 71.

Tsakiris, A. & P. J. Northwood, 1967. Cashew nut produktion in Southern Tanzania IV, the root systems of the cashew nut tree. *East Afr. agric. For. J.* 33: 83–87.

Wheatley, P. E. 1961: The insect pests of Agriculture in the Coast Province of Kenya II, cashew *East Afr. agric. For. J.* 26: 178–181.