The effects of weed competition and row spacings in Sugarcane Production.

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DECLARATION BY THE CANDIDATE

This thesis is my original work and has not been presented for a degree in any other University.

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SUMMARY

Sugarcane has been grown at the Coast of Kenya for a long time. The Ramisi factory is one of the oldest in the country. It produces a mill-white sugar and has an annual production potential of 30,000 tons. The factory has the largest nucleus estate in the country that has an area of 45,000 acres with 12,000 acres actually under cane. The estate supplies about 75% of the cane to the factory, the rest is provided by the outgrowers. At the Coast, normally, three harvests in a three-year period are obtained. After the second ratoon the fields are ploughed and replanted.

Very few trials on the effect of weeds on the production of sugarcane have been done in Kenya. In this thesis, work on the effect of weeding and row spacing in sugarcane is reported. The objects of the experiment were to determine:

(i) the effects of weed competition on the yields of cane and sugar,

(ii) the influence of row spacing on weed growth and cane yields,

(iii) the period of growth the cane crop is likely to suffer most from neglected weed control.

A factorial experiment was laid out in May, 1976 in plant cane of the cultivar CO421 at Famoni estate of the Associated Sugar Company, Ramisi. The soil is sandy clay loam that was deficient in phosphorus and nitrogen and was acidic.

The field was ploughed and harrowed during the major rainfall season. The rains were favourable for germination of cane. Three noded setts were planted end to end in the base of the furrow, after dipping into a bath containing Aretan (an organo-mercurial

chemical) to protect the seedcane against soil-inhabiting fungi. Double superphosphate at the rate of 250 kg per hectare was applied before planting in the base of furrows and covered with a little soil. Half the nitrogenous fertilizer (250 kg/ha of C.A.N.) was applied four weeks after planting and the rest half dose was top dressed four weeks later. Rainfall in 1976 was over 100 cm. The only crop grown at the site, which has been cropped for several years, is sugarcane. On the experimental plots there were both perennial and annual grass and broad-leaved weeds.

The trial consisted the following treatments:-

Spacings: S_1 - 100 cm
S_2 - 125 cm
S_3 - 150 cm

Weeding:

A - Control = free from weeds up to time of harvest

B - Free of weeds for the first 120 days and weed infested until harvest

C - Free of weeds for the first 90 days and weed infested until harvest

D - Free of weeds for the first 60 days and weed infested until harvest

E - Free of weeds for the first 30 days and weed infested until harvest

F - Free of weeds for the first 15 days and weed infested until harvest

G - Control = weed infested up to time of harvest

H - Weed infested for the first 120 days and free up to time of harvest

I - Weed infested for the first 90 days and free up to time of harvest

J - Weed infested for the first 60 days and free up to time of harvest

K - Weed infested for the first 30 days and free up to time of harvest

L - Weed infested for the first 15 days and free up to time of harvest.

The following data was collected at harvest and during the experiment:

a) yields of cane

b) Sucrose content

c) Number of millable canes

d) Number of tillers per stool

e) Germination percentage

f) Height and diameter of the stalks

g) Number and fresh weight of weeds

h) Weed cover of the plots.

The results showed that cane yields were substantially reduced due to the presence of weeds particularly during the early stages of cane growth. The percentage losses in yield due to unchecked weed growth were about 70%.

The trial gave a definite indication that weeds adversely affect the development of crop at early stage of growth but extent of damage decreases at an advanced stage after the crop closes over and shades the surrounding areas.

The presence of weeds for the first 60 days depressed production by about 50% and there was no advantage in controlling after 90 and 120 days or only for the first 15 days. The yields from these treatments were the same as those obtained from the unweeded control plots. But as the number of days in which the crop was unweeded decreased, yields progressively increased. Weed free conditions for the first 120 days after planting gave the same yields as the plots that were free from weeds up to time of harvest. Considering the number of weedings involved, it becomes even better in terms of net profit. It is suggested that the unexpected drop in yields in the plots that suffered weed-infestation for the first 15 and 30 days was due to the unavoidable delay in planting after the land had been ploughed. It is obvious from the results that weed competition between 30 and 90 days reduced the yield significantly.

The sucrose percentage in cane for the various treatments was the same and Brix readings showed no definite trend in the juice quality of the cane.

Reductions in yield due to weeds were brought about mainly by the effect of weeds on the number of millable canes and their height. Weeds had no effect on the diameter of canes.

The results clearly indicate that weed-free conditions are necessary between 30 and 90 days for optimum production of millable canes. Any weed competition during this period adversely affects the number of canes produced. Longer periods of weed-free conditions produced larger number of canes and resulted in high yields. Weed-free control produced an average of 68,130 millable canes per hectare as against 24,020 canes produced where there was no weed control - a reduction of about 65%. As the number of days when the crop was kept weed-free increased there was a progressive increase in the production of millable canes. Weed competition for the first 15 days only gave the same yields as the plots kept weed free till harvest. Similarly weed-infestation after 90 days from planting did not reduce the number of millable canes produced. As the number of days when the crop experiences weed competition increases, a substantial drop in the production of millable canes is seen in the results.

Weeds did not affect the number of tillers per stool produced and had no adverse effect on the germination of cane under the conditions prevailing.

Stalk length is another important component of cane yield and where canes were shorter the yields were lower. The results clearly show that weed-infestation adversely affects the height of cane. Weed infestation throughout the cane growing period reduced the height of cane by over 30% compared to the weed free conditions. Similarly weed competition for 120 days and 90 days reduced the height of cane substantially (25% and 22% respectively). Weeding the crop for only 15 days reduced the height by over 20% compared to the weed-free control.

The results also show that weed infestations at the initial stages causes a setback that could not be recouped even at later stages, resulting in significant reduction in the final height.

From the results it appears that, in a normal rainfall season, weed control measures should be taken immediately after planting and to continue for the first 120 days, or when the canopy closes. With a clean seedbed at planting initial weed control could be delayed until 15 days from planting or even 30 days during a dry season. During the rains it is important to plant the cane as quickly as possible to avoid the growth of weeds and their subsequent competition at early stages of cane growth.

Therefore the indications are that at Ramisi sugarcane need only be kept weed free for the first 120 days. This is the time when the canopy of the plants closes and weed competition ceases.

Weed management in sugarcane may involve cultural operations and the use of herbicides. As there is no single method which is effective under all farming situations, a combined use of all the available techniques is needed to tackle the weed management problems of the complex weed flora in sugarcane.

In this study, reduction of row spacing from 150 to 125 or 100 cm did not affect the yield of sugarcane. Although the number of millable canes in the closer spacing treatments was significantly higher than in the standard 150 cm between rows, the differences in cane and sugar yields were not significant. The individual cane weight was lower at narrow row spacings. It can thus be seen that by reducing spacing 150 cm downwards, we are not going to increase yield. Wide spacing, however, provide favourable conditions for weeds to grow and compete with the crop in the unshaded row intervals.

CHAPTER I

1. INTRODUCTION

1.1. Importance of Sugarcane crop in Kenya

The demand for sugar in Kenya is high, in fact the highest in East Africa and the country is unable to meet this demand and has to import sugar each year from other countries.' However, the local production is set to raise from 240,000 to 270,000 tons between next year and 1980, thereby making the country self-sufficient in sugar by that year (The Standard, May 30, 1978).

Since independence, Kenya has placed tremendous effort in increasing sugar production. Sugar milling factories rose from two before independence to five factories now. Production of sugar has subsequently sharply risen from 38,000 metric tons in 1963 (Economic Review of Agric, March 1975) to 181,207 tons in 1977 (The Standard, May 30, 1978).

However, despite such a steep rise in sugar production, Kenya's home consumption of sugar has outstripped its production rising from 98,000 tons in 1963 to 240,000 tons in 1977 (Economic Review of Agriculture, April-June, 1977). Consequently the Government spends a lot of money in terms of foreign currency in importing sugar to satisfy the increasing needs of the nation. In 1977,,320 million shillings were to be spent for this purpose (Daily Nation, 19/5/1977).

Plans are at hand to further reduce the import of sugar and eventually cut it off when more new factories come into operation between now and end of 1980. In fact with the tempo and speed of cane plantation expansion, Kenya is set to become a major exporter of sugar after 1982.

The present acreage under sugarcane is estimated at 124,500 acres with an additional 41,000 acres available in the zones in which cane could profitably be grown (Economic Review of Agriculture, Jan. - March, 1975). With the establishment of new factories the area under sugarcane in the country will substantially increase.

1.2. Sugarcane at the Coast

The Ramisi Factory (Associated Sugar Company) is one of the oldest factories in the country. At present the factory has a daily cane crushing capacity of 1,600 tons with an annual production potential of 30,000 tons of sugar.

The factory produces a mill-white sugar, which is yellow-white in colour and can be used instead of refined sugar for most of household purposes.

The main source of cane to the factory at Ramisi is the 'nucleus estate' which supplies about 75% of the cane. This is the largest nucleus estate in the country and has an area of 45,000 acres with 12,000 acres actually under cane. The rest of the cane (25%) is provided by the outgrowers.

In Ramisi nucleus estate yields are twenty tons per annum per acre, while the outgrowers with poorer management practices (e.g. poor or no weed control) obtain even lower yields. Normally, the plant crop and two ratoons are harvested, giving a crop cycle of three years.

In general terms it takes 12.5 to 15 tons of cane to produce one ton of sugar at the Coast. This is more than in the sugar belt where the average range is 10 to 10.5 tons of cane, while at Mumias the range is 8.5 to 9 tons to produce a ton of sugar (Economic Review of Agriculture, January-March, 1975).

1.3. The sugarcane plant and its use

Sugarcane (Saccharum officinarum) is a giant and specialized member of the grass family (Gramineae). It is one of the few plants that stores its carbohydrate in the form of sucrose (Muller 1960). It is grown throughout the tropics and provides more than half of the World's sugar (Mcllroy, 1963), which is an economical source of food energy. It is harvested on more than 11 million hectares each year, with a production exceeding 580 million tons of cane or 51 tons per hectare (Martin et al, 1976).

Sugarcane is typically a crop of the tropical and subtropical regions, and requires temperatures above 20^{o}C in order to thrive (Purseglove,1972). It is a perennial, that requires eight to twenty four months of growth to produce a crop, depending on prevailing temperatures. At the Coast of Kenya the growing period to maturity is 13 to 14 months while in parts of Nyanza and Western Province it requires 21 to 22 months to produce a crop. After harvesting the cane, the old stools regenerate rapidly, producing a 'ratoon crop'. In Kenya only two ratoon crops are taken.

The most commonly grown sugarcane cultivars at the Coast are Co421, Co331,Nco376 and B41227.

Sugarcane is reported to be able to thrive in a wide range of soil moistures, and certain varieties can withstand extreme drought, (Humbert, 1968). At the Coast, rainfall is normally deficient and severe damage by drought is quite common.

Sugarcane grows well on a wide variety of soils ranging from sandy soils to heavy clays. It can give good yields in sandy soils provided that nutrient deficiencies are rectified by the application of fertilizers or manures and provided that there is an adequate water supply. It does not make any special demands regarding soil pH.

1.4. Weed problems in sugarcane production

Out of the many problems confronting the sugarcane growers in Kenya, the one and by far the more important is the eradication of weeds from the cane fields. Weeds make precisely the same demand from the soil as the crop does, deprive the cane plants from water and nutrients, shade them from light and harbour the harmful insect pests and diseases. The eradication of weeds, therefore, is absolutely essential for obtaining high yields in this crop.

A weed has been defined as a plant that is useless, undesirable, or detrimental, or simply as a 'plant out of place'. More than 3,000 species of herbaceous and woody plants of the world are regarded as weeds.

In all probability weeds are a more limiting factor in tropical crop production than they are in temperate climates. They grow very rapidly and luxuriantly in the rainy season causing great loss to the plant crops. In sugarcane, losses in yields due to unchecked weed competition could easily amount to 50% or more (Lall, 1977 and Millholon, 1970).

Weeding is an important operation in the plant crop, which grows more slowly in the early stages than the ratoon crops. After the closure of the canopy weed competition is no longer of importance.

The timing of the weeding operations is very important to the effectiveness and efficiency of the weed control methods. Weeding costs could be greatly reduced by keeping the crop free only during the critical weed competition period.

1.5. Row spacing effects on sugarcane yields and weed growth

Although there has been considerable research comparing yields from various row widths in sugarcane, much of it has involved spacings that permit mechanical cultivation for weed control. Reports over the years have shown that yields do not vary significantly over a wide range of plant populations. In fact, careful consideration must be given to factors other than optimum yield in deciding upon the best spacing to adopt. One of these is the balance between the value of the enhanced yields obtained from close planting and the cost of the extra plants needed in planting.

The stress from weed competition is greatly influenced by the spatial arrangement of sugarcane. A close spacing takes more planting material, but forms a canopy more quickly, thus surpressing weeds and saving on cultivation cost. Wide spacing provides favourable conditions for weeds to grow and compete with the crop.

The choice of correct spacing should, however, be determined by exact field trials because it can vary with soil, climate and economic factors.

1.6. Objectives

This experiment was to determine

(i) The effects of weed competition on the yields of cane and sugar.

(ii) The influence of row spacing on weed growth and yields of cane and sugar.

(iii) The period of growth the cane crop is likely to suffer most from neglected weed control.

CHAPTER 2

2. LITERATURE REVIEW

2.1. Sugarcane and its production in Kenya

The sugarcane is one of the oldest cultivated plants (Muller, 1960). Its native home-land cannot be determined with any certainly, although New Guinea is considered to be the centre of its origin (Daniels J. et al, 1975).

The dispersal of cultivated forms of sugarcane is closely related to the migration in ancient times which brought about the introduction of Saccharum officinarum to northern India (Barnes, 1964). It was probably in India, where there was a tradition of making jaggery from palm sap, that sugarcane was first used for making sugar (Purseglove, 1972). From India the cane was introduced to Persia, Arabia and Egypt (Barnes, 1974).

As early as 1857, the exploratory journey of Burton and Speke discovered sugarcane being widely grown in Tanganyika and four years later, the expedition of Speke and Grant found sugarcane throughout Uganda (Hill, 1963). It is likely that the Indian type of cane was introduced by the Arabs (Muller, 1960), who were established in trading centres along the whole East Coast of Africa as early as the tenth century.

Commercial sugar production in Kenya has been practised for more than 50 years (Kerr, 1967), but it is only in recent years that positive plans have been formulated for a production drive which will enable the country to be self-sufficient in this commodity (Economic Review of Agriculture, March, 1975).

Assisted by an increasing population with purchasing capacity, sugar consumption in Kenya is growing at an estimated rate of 8% (Kerr, 1967).

2.2. Weeds and their effects on sugarcane production

One of the chief problems in sugarcane production is the control of weeds. Among the several factors responsible for low yield of sugarcane, negligence of weed management is the most important one (Lall, 1977). Weed control takes up a large proportion of the efforts needed to produce a crop, and this directly affects the cost of crop production (Soerjani and others, 1969). It is a time consuming and considering the physical effort involved in pulling out the weeds it is far too laborius (Panje, 1968).

Weeds, as we know, are those plants which are unwanted, useless and out of place (King et al, 1965). They cause losses to farmers from reduced yields and lowered quality of crops, increased cost of farm operations insect and diseases harboured by weeds, and depreciation of land values (ABC of Weed Control, 1957). Of some 30,000 weed species in the world, over 18,000 cause serious economic losses (Durnham, 1973).

Reduced crop yield results from competition between crops and weeds for water, light, nutrients (Kasasian, 1971 and Parihar and Mukerji, 1969) or just for space (Zweep, 1971). Weeds also absorb a certain proportion of fertilizers applied to the crop (Soerjani et al, 1969). Competition occurs when any or all of these essentials is inadequate for the optimum growth of both crop and weed (Durnham, 1973). It has been found that every ton of weed removes 3in (76.2 mm) of rainfall from the soil, and this is sufficient, in a dry period, to stunt the crop permanently so that it never becomes a healthy plant (ABC of Weed Control, 1957). In fact more water and nutrients are required to raise a ton of weeds than to raise a ton of most crops (Muzik, 1970). The very conditions which are ideal for cane growth also favour weed growth (Cox, 1959), and if we realise that 80% of the sugarcane roots are actually confined to the top 20 cm (Hill, 1963), it can be seen how serious weed competition must be.

The effect of weeds is greatest when the root systems are actively competing with the crop for nutrients and moisture (Singh and Verma, 1969) and when the weeds are large enough to compete for light (Sugarcane Production in South Africa, April, 1977). The intensity of competition varies with the stage of growth of the crop (Gordon, 1960), and is greater in plant cane which is slower to canopy than ratoon cane (Sugarcane Production in S. Africa, April, 1977). Weeds should be controlled until the formation of a full canopy by the cane crop, which then effectively shades out any further weed growth (Cox, 1959).

Weeds reduce the yield of both cane and sugar. The losses in yield due to weeds in sugarcane are appreciable (Mani et al, 1968), and vary from 10 to 70 percent depending on the weed flora and its intensity (Lall, 1977). Though the losses are not known accurately, infestations of sorghum helepense, for example, have reduced yields by 25-50% compared with a hand-weeding control (Millholon, 1970). Weeds like nutgrass look quite inocuous; yet, neglecting them, especially in the early stages of the crop, can bring down the yield of the crop substantially (Panje, 1968), ranging between 5 to 80% (Singh and Verma, 1969). For instance, in an experiment conducted in a field liable to infestation by nutgrass and Johnsongrass, the unweeded plots gave only 20% the yield of normally-weeded plots (Panje, 1968). Drops in yield of such a magnitude shows clearly that something has to be done to keep the plant cane clean (Gordon, 1960).

Potential losses due to weeds in crops have been recognized to be at least equivalent (averaging 10%) and frequently higher then those caused by other pests (Zweep, 1971). Such losses, however, are not nearly as striking as those due to disease and insect pests and are too often taken for granted (Soerjani et al, 1969). Usually the terrific influence on the final crop yield of just a little weed growth in the early stages of crop development is hardly if at all appreciated (Zweep, 1971).

Besides the losses in sugar and cane yields, weeds also act as host plants for many pests and diseases which in turn adversely affects the crop yield, thereby, affecting an increase in the cost of production (Parihar and Mukerji, 1969). In addition they may even be poisonous (King, Mungomery and Hughes, 1965).

Weeds increase production costs because they add to or interfere with farm operations (Rochecouste, 1967) Fifty to 60% of the tillage in seedbed preparation, cultivation of row crops, and after-harvest cultivation is done to control weeds (Dunham, 1973). If chemicals are not used, sugarcane generally is cultivated 3 or 4 times at 3 to 4 weeks interval (Lall, 1977).

The increased yields secured from adoption of weed control measures (Arevalo and Mariotti, 1970) leaves no room for doubting the magnitude of the yield losses due to unchecked weed growth (Ashby and Pfeiffer, 1956) Control of weeds is, therefore, a must for the well-being of the crops, soil and water (Mani et al, 1968).

Weed competition seriously reduces crop yields in the tropics (Wrigley, 1971), and Ashby and Pfeiffer (1956) estimated that such losses are 2 to 3 times as great as in temperate zones. Weeds in the tropics are very tough, fast growing and well adopted to local ecological conditions (Kasasian, 1971), that are conducive to a rapid and heavy growth of weed (Ochse et al, 1961).

Most territories have their own particular problem weeds which have developed by a combination of climatic factors and cultural practices (Wrigley, 1971). In Argentina, for example, 191 species were identified during the last 10 years, representing only a part of the 300 species that are considered to be troublesome in cane growing (Arevalo, 1975). Each weed is arbitrarily identified as noxious, secondary noxious or common, and as very abundant, frequent, infrequent or rare (Blanco, 1975).

Cyperus rotundus and the related sedge species which are referred to as 'nutgrass' are a problem in the sugarcane growing areas of Ramisi. The weed is now recognised as the most serious species in world agriculture (Hammerton, 1974). It is well adapted to survive the adverse condition and the effect of cultivation, due to its tuberous storage organs (nuts), which lie about 6in (15 cm) below the surface of the ground (Wrigley, 1962). Apart from competitive effects, substances toxic to other plants may be produced by decay of dead residues of Cyperus rotundus (Friedman and Harowitz, 1970). Growth characteristics of the nutgrass and the damage it can and does cause to various crops have been studied (Cyperus rotundus - the world's worst weed, 1963), and experiments have shown that germination of the tubers could be influenced, so that there is a possibility of conditioning the axillary buds into sprouting and then subjecting them to herbicidal or cultivation operations (Nyahoza, 1974).

Another common weed at Ramisi is Commelina benghalensis, commonly known as 'Wandering Jew'. It is difficult to control by cultivation, partly because broken pieces of stem readily take root again and partly because underground stems are often produced (Ivens, 1967).

2.3. Weed Control Methods in Sugarcane

Weed control in Ramisi is being carried out mainly by using tractors and contract labour. This practice of hand-weeding is made possible by the large population providing cheap labour. The days of cheap labour, however, are passing with the rapid rise during recent years in the standard of living of the people. As labour costs rise, and with the decrease in the cost of chemicals (Cox, 1959), alternative methods to hand-weeding are being examined, and several herbicides have given most promising results (Hill, 1963).

There are a number of reasons why the use of herbicides in tropical crops has not developed as fast as in temperate climate. The main explanation for this slow development is that weeds can be pulled by hand and any money available for crop protection is used to buy insecticides and fungicides before herbicides (Almond and King, 1955) and the cash returns per acre from crops in the tropics are low and cannot support the expensive chemicals to replace manual work (Wrigley, 1968). In some experiments hand-weeding was found more economical where maximum net return is aimed at (Panje, 1968). However, hand-weeding standards are generally low (Harahap et al, 1974)

The cash return from perennial crops such as sugarcane is much greater than from annual crops (Sugarcane Production in South Africa, April 1977) and these perennial crops are frequently grown by estates who face high labour costs (Wrigley,1968). Moreover, even on estates with a normally adequate labour supply, there is a problem at planting time, due to the conflicting demands of weeding and planting operations (Harap et al, 1974). These perennial crops have, therefore, been the first where herbicides have been used (Wrigley, 1968).

Many workers have investigated different chemicals that could be used in controlling the many types of weeds in sugarcane (Agrawal and Jain, 1971; Garrucho, 1970; Ethirajan et al, 1976; Kar and others, 1972; Orsenigo, 1970; Patro and Tosh, 1972; Sinha and Thakur, 1970; and Spry, 1974) and further investigation on these lines is continuing. In East Africa, recommendations are made with application details, susceptible weeds and crop tolerance (Terry, 1969).

Chemical weed control is desirable in many sugarcane estates not only because of an increasing scarcity of estate labour for hand weeding (Harahap et al, 1974), but because chemical weeding causes no physical soil disturbance and thus no crop-root damage, improves moisture conservation and soil structure, and has a long lasting effect (Cochrane and Procter, 1970). Cultivation, however, is still the major method of controlling weeds since it is necessary on most cane soils to prevent crusting (MacQueen and Parker, 1975, and Pembroke 1970) and because some chemicals have been shown to bring about an adverse effect on the cane plant (Sheng-yang, 1972).

Therefore, weed control by chemicals should be considered as a supplement to but not a substitute for good tillage and farming practices (Helgeson, 1957).

2.4. Critical period of infestation

One of the chief omissions of research workers in their studies of weed control is ignorance of the critical period for competition (Nieto et al, 1968) The precise time and duration of maximum competition depends on many factors, such as the relative rate of growth of the crop and weeds. the density of planting, the variety grown, the time of moisture and nutrient stress etc (Kasasian, 1971). The point is that there are periods when weeds must be removed and other periods when some may be allowed to grow because they do not cause the slightest harm to the crop (Nieto et al, 1968). Any large scale project to control weeds should begin with a thorough study in determining the most vulnerable stages in the life cycles of the weeds (Chandra Singh and Narayana Rao, 1973).

One of the most important development of recent years in the study of crop-weed interactions has been the determination of the period during which damaging interspecific competition, as measured by crop yield reduction, takes place (Chancellor and Peters, 1974). The length of the critical period, during which weed competition must be absent to avoid crop loss, varies with, among other things, the crop grown. Several experiments showed that the critical period for weed competition in a 6-month onion crop was 6 to 8 weeks (Hewson and Roberts, 1971). Other results indicate that weeds commence to compete with rice at early stage (Swain et al, 1975) Weeding for the first four weeks adequately controlled weeds in soya beans (Gurnah, 1976) In other places the period between 20 and 50 days after planting was the only critical one during which weeding was necessary (Sistachs and Leon, 1975). In cotton all season competition from yellow

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For sugarcane it is suggested that a proportion of a crop's life (i.e. the first 25-33%) is critical (Kasasian and Seeyave, 1969). However, it is evident that only 4 months of weed control is not sufficient for satisfactory yields (Azzi and Fernandes, 1968). Many experiments have shown that weeds have their most serious effect between the emergence of primary shoots and the beginning of the stalk elongation (Lall, 1977) and that weed infestation during the first 12 weeks after planting reduces the yield of cane significantly but those that germinate after that seem to have little effect (Lamusse, 1965).

Weed competition depends on development stage, infestation rate, weed species and moisture stress (Azzi and Fernandes, 1971). Increasing periods of weed competition progressively reduced the total number of stalks and number of millable stalks, and stalk diameter and cane yields (Singh and Verma, 1967). Under dry climatic conditions competition during the first 3 months did not affect the yields (Azzi and Fernandes, 1971).

Time from planting cannot be taken as a standard and the condition of growth of the cane must be the guide to tell one when weeds must be eradicated (Gordon, 1960). During tillering phase the problem of weeds becomes most serious as they compete with crop for water, nutrient supply and sunlight causing an adverse effect on tiller formation (Singh and Verma, 1969). When the grand growth phase of the sugarcane commences the weed growth is practically checked due to smothering effect (Lall, 1977 and Panje, 1968), and no serious loss is caused due to weed infestation (Singh and Verma, 1969).

Results of a weeding experiment indicated that weed infestations which began 3, 6 and 9 weeks after planting significantly reduced the yield of cane and sugar, while one starting at 12 weeks caused a reduction that was not significant (Lamusse, 1965). This is most useful information since it means that one can plan weed control cheaply and rationally, (Nieto et al, 1968), while, in addition, one may employ herbicides in a way geared to the needs of the crop (Harper, 1960).

2.5. The effect of row spacing on weeds and cane yields

Weed competition in sugarcane ceases when a canopy which covers the rows is formed (Verma and Bhardwaj, 1958). With normal germination and growth, this takes place in about 3 months (Barnes, 1974), but is greatly determined by the distance between rows (Hill, 1963).

A given spacing is chosen to suit the cultivator's needs, and depends upon several factors but usually varies from 1.0 to 2.5 m (Ochse, 1961).

Wider spacing encourages greater weed growth (Gurnah, 1976) needing more work and expense to control, because of the longer time required for the cane to cover down the inter-row space (Barnes, 1964). Closer spacing takes more planting material, but forms a canopy more quickly, thus suppressing weeds and saving on cultivation costs (Hill, 1963). Anyway, the cost of the additional seed cane that would be required and of adopting present cultivation implements to narrow spacing may not be justified (Herbert et al, 1965).

Recent experiments have shown that the mortality of shoots and stalks to be mainly a consequence of a moisture stress in the closely planted crops (Singh and Verma, 1969). Stalks were smaller in diameter and shorter on the narrow rows (Matherne, 1972), but results showed that the tiller population was higher in the closer spacings (kanwar and Shärma, 1974).

Field trials showed thatcane yields obtained from row spacings at 90 and 105 cm were significantly higher than those obtained from a row spacing at 180 cm (Matherne, 1974). Becaause of the need of mechanization of field operations, however, a 90 cm interrow spacing can not be recommended (Ramos, 1975). The highest average yields were achieved at 100 cm interrow spacing, a increase of 15-20 tons/acre compared with the standard 180 cm rows (Matherne, 1973). This would be economical in view of the minimum seed material involved (Nour et al, 1972).

Row spacings had no significant influence on the percentage of juice extracted or brix of the juice (Freeman', 1968), though wider spacing tend to show slightly better juice quality (Ajaib Singh, 1960).

The superiority of close row spacing in increasing yields and suppressing weeds is recognised. But in choosing an optimum density of planting, it is important to keep in mind the limitation imposed on mechanical, animal or manual work in cane fields (Barnes, 1964). The choice of correct spacing can only be determined by exact field trials (Muller, 1960), and the exploitation of increased productivity due to reduced spacing should involve breeding and selection at the row spacing adopted (Bull, 1975).

Based on yield trends in several spacing trials at Ramisi, it would appear safe to recommend planting sugarcane at 1.25 m where machinery permits inter-row cultivation (Unpublished Report, Coast Agricultural Research Station, Kikambala).

CHAPTER 3

3. MATERIALS AND METHODS

3.1. Location of site

The experiment was situated at Famoni estate of the Associated Sugar Company, Ramisi in the Coast Province of Kenya.

Famoni estates is between longitudes 39^{0} 24' to 39^{0} 27' East and latitude 4^{0} 25' to 4^{0} 27' South.

3.2. Soil Characteristics

A very dark grey sandy clay loam underlain by dark grey brown sandy clay loam.

The soil is acidic. It is deficient in Calcium, Magnesium, Phosphorus and Nitrogen. The analytical data are provided in Appendix I.

The problems that appear to be associated with these soils are nutrient deficiencies, low water retention, impeded drainage and seasonal high water table.

3.3. Rainfall and Irrigation

This region has two rainfall seasons, a major and minor rainfall seasons. The trial was planted during the major rainfall season in May, 1976.

The rainfall data and the amount of water given through irrigation are shown in Appendix IIB.

3.4. Vegetation

The site is in the lowland rain forest belt of the Coast Province. The land has been cropped for several years and the only crop grown at the site is sugarcane.

3.5. Cultural Operations

3.5.1. Land Preparation

The field was ploughed and harrowed before the furrows were open on 28th and 29th of April, 1976.

3.5.2. Planting

Planting was done on the 2nd and 3rd of May, 1976. The cultivar of sugarcane planted was Co421.

Three noded sets were planted end to end in the base of the furrow and covered with about 2 inches of soil. The cut ends of the sets were dipped in an organo-mercurial dip (Aretan) before planting.

3.5.3. Fertilizer Application

Double superphosphate at the rate of 250 kg per hectare was applied before planting in the base of furrows and covered with a little soil.

The first application of Calcium Ammonium Nitrate was done four weeks after planting and the second four weeks later, at the rate of 250 kg/ha in each application.

3.6. Design of experiment

This is a factorial experiment with three intervals of spacing and twelve weeding treatments (frequencies). There were four replicates on 54 sq m plots. The layout of the experiment is given in Appendix .III.

3.6.1. Treatments

3.6.1.1. Spacing between rows

S_1 - 1.00 m
S_2 - 1.25 m
S_3 - 1.50 m

3.6.1.2. Weeding Frequencies

A - Clean during the whole season
B - Clean weeded for 120 days after planting

C - Clean weeded for 90 days after planting
D - Clean weeded for 60 days after planting
E - Clean weeded for 30 days after planting
F - Clean weeded for 15 days after planting
G - Unweeded during the whole season.
H - Weeded after 120 days from planting
I - Weeded after 90 days from planting
J - Weeded after 60 days from planting
K - Weeded after 30 days from planting
L - Weeded after 15 days from planting

N.B. The weeding was done be means of a fork jembe between rows and hand-pulling of weeds within the rows.

3.7. Data Collected:

The following data were collected at harvest and during the experiment:

3.7.1. Yields of cane

3.7.2. Sucrose content

3.7.3. Number of millable canes

3.7.4. Number of tillers per stool

3.7.5. Germination

3.7.6. Height and diameter of the stalks every month

3.7.7. Weed population per 50 cm x 50 cm quadrant before weeding.

3.7.8. Fresh weight of weeds per 50 cm x 50 cm quadrant during the removal of weeds.

3.7.9. Weed score in each plot every 30 days in 0-5 scale:

0 - none,
1 - one or two isolated plants,
2 - some scattered plants,
3 - in patches
4 - in large patches
5 - plots fully covered

3.8. Weed Flora

On the experimental plots, there were both perennial and annual grass and broad-leaved weeds. Some of these are:

Ageratum spp.

Portulaca oleracea L.

Eragrostis ciliaris (L) R. Br.

Tridax Procumbens L

Commelina benghalensis

Cyperus rotundus L

Chloris virgata Sw.

Dactyloctenium aegypticum (L) Beauv.

Brachiaria brizanthe (A. Rich) Stapf.

Digitaria adscendens (B.B.K.) Hens

Echinochloa colonum (L) Link

Eriochloa spp.

Rottboellia exaltata L.f.

PLATE (1) Unweeded Plot

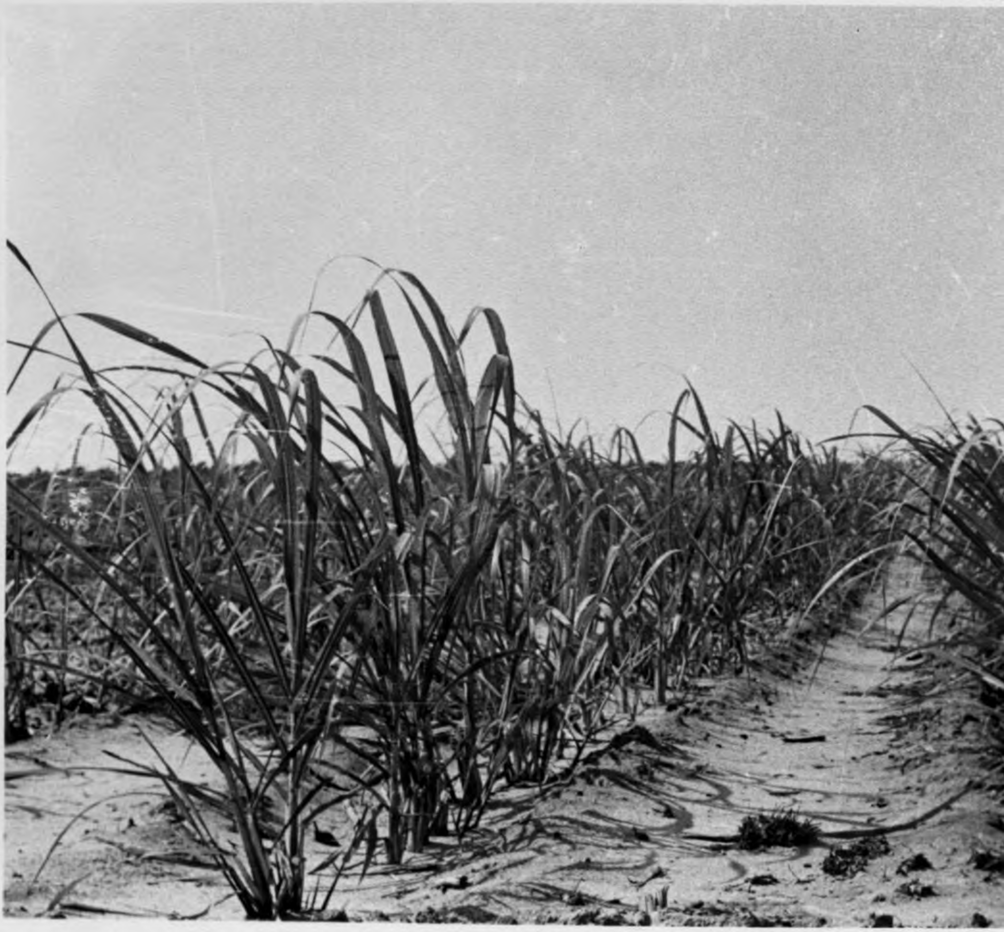


PLATE (2) Weedfree Plot

CHAPTER 4

4. RESULTS

4.1. Yield of cane

Yields of cane in tons per hectare are presented in Table 1-A

4.1.1. Weeding treatments

The last column of the table (weeding means) shows that the highest yields were obtained from the weed-free control (A) and in the plots where the crop was kept weed free for 120 days (B). But as the number of days the crop was kept weedfree decreased, there was a progressive decrease in yields. The yields in plots which suffered weed competition from planting to harvest (G) were the lowest. The differences between these plots and those which were kept weedfree during the same period (A) were highly significant ($P<0.001$). Similarly, plots that were kept weedfree for only 15 and 30 days (F and E) produced low yields of cane. Those with no weeds for 60 and 90 days (D and C) gave considerably higher yields than the plots with a shorter period of weed free conditions (F and E) and the unweeded control (G).

On the other hand, as the number of days in which the crop was unweeded increased, yields progressively decreased. Here again the lowest yields were obtained from the plots that suffered weed competition from planting to harvest (G). Plots which were unweeded for 60, 90 and 120 days (J, I and H) also gave low yields of cane. The yields in these plots were lower ($P<0.001$) than those obtained from plots which had weeds for only 15 and 30 days (K and L) or no weed competition at all (A).

Now, comparing the effects of weed competition during different periods with the absence of the competition during the same period, the results show that plots with weed competition for only 15 and 30 days (L and K) gave higher ($P<0.001$) yields than plots with weedfree conditions during the same period (F and E). Weed competition for 60, 90 and 120 days (J, I and H) gave lower ($P<0.001$) yields than no competition during the same time (D, C and B).

4.1.2. Spacing treatments

The last line of the table (spacing means) and the table of ANOVA (Table 12) shows that there were no differences in yields between the three row spacing treatments.

TABLE 1.A. YIELD OF CANE - MEAN TONS CANE PER HECTARE

Spacing / Weeding	S_1 (1.00 m)	S_2 (1.25 m)	S_3 (1.50 m)	Weeding mean
A - WF control	61.82	62.79	69.14	64.58 a
B - WF for 120 days	61.73	61.22	68.22	63.72 ab
C - " " 90 days	56.78	57.89	64.24	59.64 b
D - " " 60 "	51.51	53.27	46.62	50.47 c
E - " " 30 "	43.84	39.21	29.62	37.58
F - " " 15 "	25.20	19.60	18.68	21.16 de
G - UW control	22.56	20.76	15.45	19.59 e
H - UW for 120 days	23.54	23.49	21.37	22.80 de
I - " " 90 "	28.90	26.73	17.57	24.40 d
J - " " 60 "	26.54	35.10	35.38	32.34
K - " " 30 "	51.88	51.05	52.82	51.92 e
L - " " 15 "	48.50	56.23	58.04	54.26 c
Spacing Mean	41.90	42.28	41.43	G.M. 41.87

WF - weed free
UW - unweeded

SE (Spacing) = 1.095
SE (weeding) = 2.190

CV = 18.12%

Means followed by the same letter are not significantly different according to Duncan's multiple range test at 5% level.

TABLE 1-B. YIELD OF CANE

PERCENT REDUCTION BELOW WEED-FREE

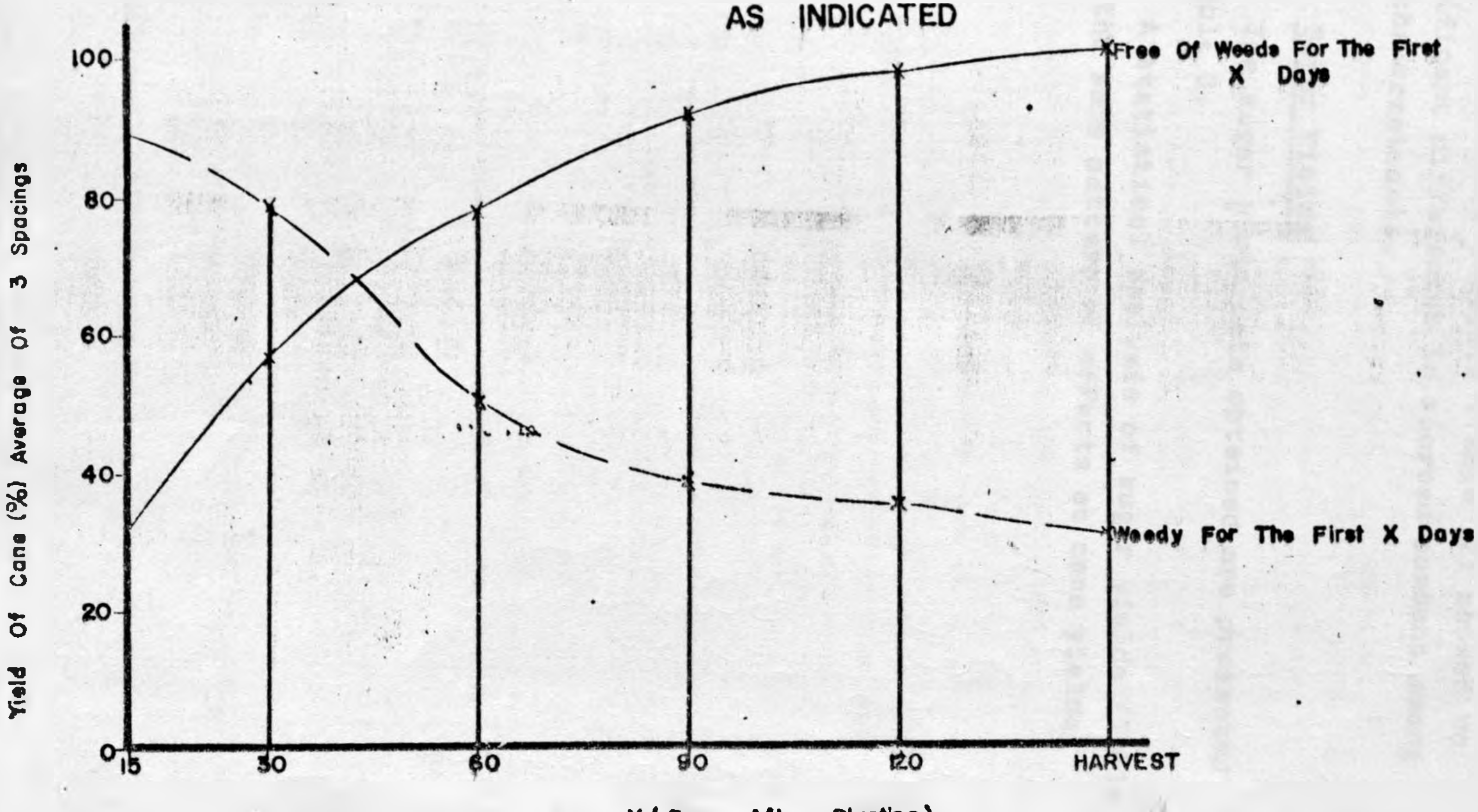
CONTROL - A

SPACING / WEEDING	S_1	S_2	S_3	Mean
A - WF Control	-	-	-	-
B - WF for 120 days	0.15	2.50	1.33	1.33
C - " " 90 "	8.15	7.80	7.09	7.65
D - " " 60 "	16.68	15.16	32.57	21.85
E - " 30 "	29.08	37.55	57.16	41.81
F - " 15 "	59.24	68.78	72.98	67.23
G - UW Control	63.51	66.94	77.65	69.66
H - UW for 120 days	61.92	62.59	69.09	64.69
I - " " 90 "	53.25	57.43	74.59	62.22
J - " " 60 "	57.07	44.10	48.82	49.92
K - " " 30 "	16.08	18.70	23.60	19.60
L - " " 15 "	21.55	10.45	16.05	15.98

WF - Weed free

UW - Unweeded

Fig1 CANE YIELD FOR VARIOUS TREATMENTS, AS PERCENTAGE OF MAXIMUM OBTAINED, FOR PLOTS WEED-INFESTED OR WEED-FREE AT PERIODS OF CROP GROWTH CYCLE, AS INDICATED



Cartographic Unit / Range Management JULY 1978

4.2. Sucrose Content

Table 2 gives the percent sucrose content of canes.

Statistical analysis (Table 12) showed no significant differences in sucrose content among all the treatments.

4.3. Sugar Yields

The sugar yield data obtained are presented in Table 3.

A statistical analysis of sugar yields (Table 12) gave the same pattern of effects as cane yields.

TABLE 2.

SUCROSE CONTENT

MEAN PERCENT SUCROSE CONTENT

SPACING / WEEDING	S_1 (1.00 m)	S_2 (1.25 m)	S_3 (1.50 m)	Weeding Mean
A - WF Control	14.12	13.83	14.58	14.17
B - WF for 120 days	12.64	13.68	12.64	12.99
C - " " 90 "	12.92	12.08	12.81	12.60
D - " " 60 "	13.00	13.34	13.04	13.13
E - " " 30 "	13.27	13.17	12.72	13.05
F - " " 15 "	12.62	12.42	11.91	12.32
G - UW Control	12.54	12.53	12.31	12.46
H - UW for 120 days	12.89	12.66	13.53	13.02
I - " " 90 days	13.56	12.39	12.33	12.76
J - " " 60 "	13.40	12.75	13.26	13.13
K - " " 30 "	12.76	12.95	13.10	12.94
L - " " 15 "	13.19	13.30	13.30	13.28
Spacing Mean	13.08	12.96	12.96	G.M. 12.99

WF - weed free

UW - unweeded

SE - spacing = 0.2354
weeding = 0.4708

CV = 12.55%

TABLE 3.A

SUGAR YIELDS

- MEAN TONS SUGAR PER HECTARE

SPACING / WEEDING	S_1 (1.00 m)	S_2 (1.25 m)	S_3 (1.50 m)	Weeding means
A - WF control	8.74	8.59	10.03	9.12
B - WF for 120 days	7.82	8.42	8.65	8.30
C - " " 90 "	7.35	7.04	8.12	7.50
D - " " 60 "	6.77	7.04	6.01	6.61
E - " " 30 "	5.81	5.12	3.75	4.89
F - " " 15 "	3.14	2.46	2.22	2.61
G - UW control	2.81	2.63	1.87	2.44
H - UW for 120 days	3.05	2.92	2.89	2.95
I - " " 90 "	3.88	3.30	2.17	3.12
J - " " 60 "	3.54	4.39	4.62	4.19
K - " " 30 "	6.67	6.60	6.95	6.74
L - " " 15 "	6.39	7.56	7.54	7.16
Spacing Means	5.50	5.51	5.40	G.M. 5.47

WF - weed-free
UW - unweeded
SE - spacing = 0.1639
weeding = 0.3279

CV = 20.76%

TABLE 3.B. SUGAR YIELDS

PERCENT REDUCTION BELOW WEED-FREE CONTROL

SPACING	S_1	S_2	S_3	Mean
A - WF Control	-	-	-	-
B - WF for 120 days	10.53	1.98	13.76	8.99
C - " " 90 days	15.90	18.04	19.04	17.76
D - " " 60 "	22.54	18.04	40.08	27.52
E - " " 30 "	33.52	40.40	62.61	46.38
F - " " 15 "	64.07	71.36	77.87	71.38
G - UW Control	67.85	69.38	81.36	73.25
H - UW for 120 days	65.10	66.01	71.19	67.65
I - " " 90 "	55.61	61.58	78.36	65.79
J - " " 60 "	59.50	48.89	53.94	54.06
K - " " 30 "	23.68	23.17	30.71	21.49
L - " " 15 "	26.89	11.99	24.82	21.49

4.4. Number of Millable Canes

The number of millable canes in thousands per hectare is presented in Table 4 - A.

4.4.1. Weeding Treatments

From the data in the last column of the table (Weeding means) it can be seen that the weed free control (A) plots produced the highest number of millable canes. However, the same number was obtained in plots that were kept weed free for 120 days and 90 days (B and C). With the decrease of the period the crop was kept weed free there was a progressive decrease in the number of canes produced. The lowest was in the plots that suffered weed competition from planting to harvesting (G). The number of canes in the plots with weed infestation after 15, 30 and 60 days (F, E and D) were lower ($P<0.001$) than in the plots that had weed competition after 90 and 120 days (C and B) or no competition at all (A).

The length of the period in which the crop was unweeded affected the production of millable canes. There was a progressive reduction as the number of days increased. Where weeding was not done at all (G), the plots gave the lowest number of canes. Plots that experienced weed infestation for 90 and 120 days (I and H) gave the same yields, which were lower than in the plots that were unweeded for 60 days (J). The highest number of canes were obtained from the plots that were unweeded for only 15 days (L). In fact, the number of canes here were the same as in the weed free control (A). Plots with 30 days of weed infestation (K) produced the same number of canes as those with 15 days of weed competition (L) but lower ($P<0.05$) than that from weed free control (A).

Weed infestation after 15 and 30 days (F and E) gave less canes (P<0.001) than weed-free conditions during the same time (L and K). Whereas weed competition after 60 days (D) gave more canes than when the crop is unweeded for the first 60 days after planting (J). The latter gave the same number of canes as the plots that were kept weed-free for 30 days (E).

Weed competition after the first 15 days (F) had the same effect as competition during 90 and 120 days (I and H) but gave higher (P<0.05) number of canes than the unweeded control (G).

4.4.2. Spacing Treatments

Closer row spacings of 1.00 m and 1.25 m (S_1 and S_2) gave higher (P<0.05) number of canes per ha than the wider spacing of 1.50 m (S_3).

TABLE 4.A. NUMBER OF MILLABLE CANES

TREATMENT MEANS (THOUSANDS PER HECTARE)

SPACING / WEEDING	S_1 (1.00 m)	S_2 (1.25 m)	S_3 (1.50 m)	Weedirg Means
A - WF Control	68.15	70.24	65.99	68.13 a
B - WF for 120 days	70.09	64.59	67.52	67.40 a
C - " " 90 "	69.91	64.59	65.67	66.73 a
D - " " 60 "	61.68	60.67	56.42	59.59 b
E - " " 30 "	55.91	43.32	38.57	45.94 c
F - " " 15 "	35.66	30.20	24.19	30.01 d
G - UW Control	28.35	24.18	19.51	24.02
H - UW for 120 days	29.92	34.22	23.03	29.06 d
I - " " 90 "	33.90	33.90	21.87	29.89 d
J - " " 60 "	37.74	43.32	45.83	42.30 c
K - " " 30 "	64.27	59.47	60.72	61.49 b
L - " " 15 "	62.93	63.91	65.21	64.02 ab
Spacing Means	51.54g	49.39g	46.21h	G.M. 49.05

WF - weed-fre
UW - unweeded
SE - spacing = 1.268
- weeding = 2.537

Means followed by the same letter are not significantly different according to Duncan's multiple range test at 5% level.

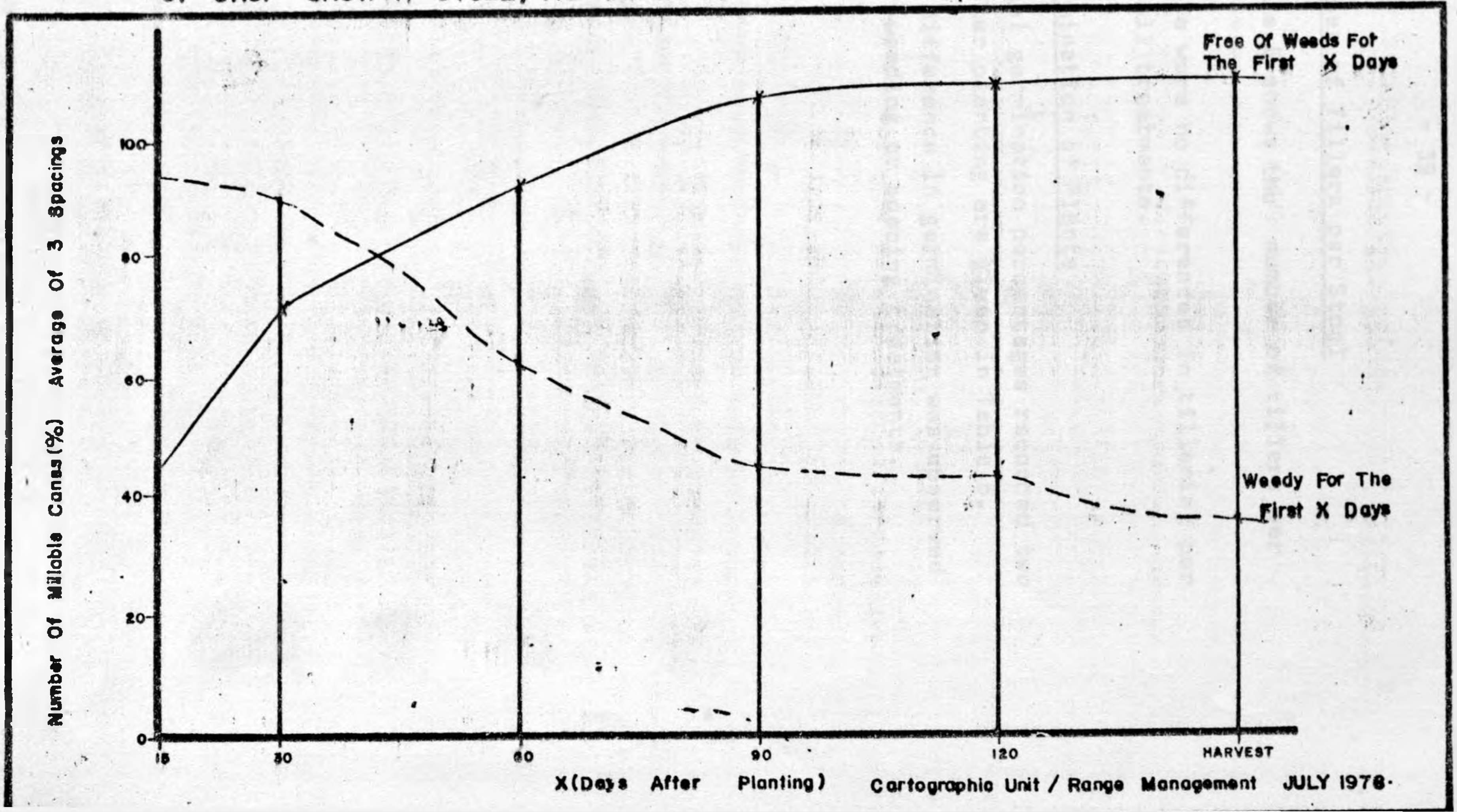
CV = 17.92%

TABLE 4.8. NUMBER OF MILLABLE CANES

PERCENT INCREASE OVER S_3 (1.5 m) ROW SPACING

SPACING	S_1 (1.00 m)	S_2 (1.25 m)
A - WF Control	3.27	6.44
B - WF for 120 days	3.81	-
C - " " 90 "	6.46	-
D - " " 60 "	9.32	7.53
E - " " 30 "	44.96	12.31
F - " " 15 "	47.41	24.84
G - UW Control	45.31	23.94
H - UW for 120 days	29.92	48.59
I - " " 90 "	55.01	55.01
J - " " 60 "	-	-
K - " " 30 "	5.85	-
L - " " 15 "	-	-

Fig 2. NUMBER OF MILLABLE CANES FOR VARIOUS TREATMENTS AS PERCENTAGE OF MAXIMUM OBTAINED, FOR PLOTS WEED-INFESTED OR WEED-FREE AT PERIODS OF CROP GROWTH CYCLE, AS INDICATED.



4.5. Number of Tillers per Stool

Table 5 shows the number of tillers per stool.

There were no differences in tillering per plant in all treatments.

4.6. Germination of Plants

Final germination percentages recorded two months after planting are given in Table 6.

No difference in germination was observed in either weeding or spacing treatments.

TABLE 5. NUMBER OF TILLERS PER STOOL

SPACING / WEEDING	S_1 (1.00 m)	S_2 (1.25 m)	S_3 (1.50 m)	Weeding Mean
A - WF Control	4.75	4.25	4.00	4.33
B - WF for 120 days	4.75	4.75	4.25	4.58
C - " " 90 "	4.25	3.75	4.50	4.17
D - " " 60 "	3.50	3.50	4.25	3.75
E - " " 30 "	3.50	3.25	3.25	3.33
F - " " 15 "	3.75	4.00	3.00	3.58
G - UW Control	3.50	3.25	3.50	3.42
H - UW for 120 days	3.50	4.50	3.50	3.83
I - " " 90 "	4.00	4.25	4.00	4.08
J - " " 60 "	4.75	4.50	3.80	4.25
K - " " 30 "	4.50	4.50	4.75	4.58
L - " " 15 "	4.50	4.25	4.00	4.25
Spacing Means	4.10	4.06	3.87	G.M. 4.01

WF - weed-free
UW - Unweeded
SE - spacing = 0.2626
weeding = 0.5252

CV = 25.92%

TABLE 6. GERMINATION PERCENTAGE TREATMENT MEANS

SPACING / WEEDING	S_1 (1.00 m)	S_2 (1.25 m)	S_3 (1.50 m)	Weeding Mean
A - WF Control	63.75	61.25	61.25	62.08
B - WF for 120 days	65.00	57.50	61.25	61.25
C - " " 90 "	67.50	57.50	62.50	62.50
D - " " 60 "	58.75	61.25	62.50	60.83
E - " " 30 "	62.50	53.75	60.00	58.75
F - " " 15 "	58.75	47.50	61.25	55.83
G - UW Control	46.25	55.00	57.50	52.92
H - UW for 120 days	50.00	51.25	50.00	50.42
I - " " 90 "	53.75	42.50	58.75	51.67
J - " " 60 "	57.50	53.75	55.00	55.42
K - " " 30 "	57.50	53.75	57.50	56.25
L - " " 15 "	60.00	56.25	57.50	57.92
Spacing Mean	58.44	54.27	58.75	G.M. 57.15

WF - Weed-free
UW - unweeded
SE - spacing = 1,3624
weeding = 2,7247

CV = 18.96%

4.7. Height of Cane

4.7.1. Height of Cane at Harvest

Mean height data of canes at harvest are presented in Table 7.

4.7.1.1. Weeding Treatments

Longer periods of weed infestations particularly at early stages of canc growth adversely affected the height of cane. The shortest plants were observed in the treatments that were unweeded till harvest (Treatment G). But as the number of days with weed infestation decreased the height of millable canes progressively increased. Treatment L with weed infestation for only 15 days gave canes of the same length as the plots that did not suffer weed competition at all (Treatment A) or suffered only after 120 days (Treatment B).

Weed-free conditions for only 15 days after planting (Treatment F) gave shorter ($P<0.001$) plants compared to treatments that had longer periods of weeding (Treatments E and D). Increased number of days when the crop was weeded (C) gave better ($P<0.05$) canes than the treatments that had less period of weed free conditions. (E.E.& F), but they were inferior ($P<0.01$) to treatment B (weed competition after 120 days).

4.7.1.2. Spacing

There were no differences in the length of millable canes among the spacing treatments.

4.7.2. Monthly increase in height of canes

The data of the monthly increase in cane height is shown in Table 7-B.

The t-test (Table 7-C) shows differences in growth between treatments that were weed-free for the first and second month on one side, and those that had no weeding during this period.

There were no differences in the spacing treatments.

TABLE 7.A.

HEIGHT OF CANE

HEIGHT OF CANE AT HARVEST

MEAN HEIGHT IN METERS

SPACING / WEEDING	S_1 (1.00 m)	S_2 (1.25 m)	S_3 (1.50 m)	Weeding Mean
A - WF Control	2.18	2.29	2.20	2.23 a
B - WF for 120 days	2.10	2.22	2.16	2.16 b
C - " " 90 "	2.03	2.09	2.09	2.07
D - " " 60 "	2.01	2.01	1.99	2.00 c
E - " " 30 "	1.87	2.08	1.89	1.95 c
F - " " 15 "	1.79	1.70	1.77	1.75 d
G - UW Control	1.46	1.59	1.54	1.53
H - UW for 120 days	1.61	1.65	1.77	1.67
I - " " 90 "	1.79	1.81	1.87	1.74 d
J - " " 60 "	1.96	2.00	1.99	1.98 c
K - " " 30 "	2.01	1.96	1.97	1.98 c
L - " " 15 "	2.19	2.12	2.23	2.18 ab
Spacing mean	1.92	1.96	1.96	G.M. 1.94

WF - weed-fre
UW - unweeded
SE - spacing = 0.0158
weeding = 0.0316

CV = 5.65%

Means followed by the same letter are not significantly different according to Duncan's multiple range test at 5% level.

B - MONTHLY GROWTH OF CANE

GROWTH WHEN WEEDED

FREE OF WEEDS							
FOR THE FIRST	n	$\bar{X}$			S		
		S1	S2	S3	S1	S2	S3
1 MONTH	5	30.62	30.80	30.82	1.073	0.617	0.544
2 MONTHS	4	28.22	32.75	29.91	3.150	4.018	5.606
3 MONTHS	3	23.08	21.25	23.25	1.090	4.418	2.291
4 MONTHS	2	26.75	32.25	26.37	0.707	2.122	3.359
5-8 "	1	77.25	78.75	72.00	-	-	-
DURING THE							
2nd MONTH	2	35.37	19.87	22.50	4.419	0.884	0.353
3rd MONTH	3	31.92	32.58	31.67	4.390	4.215	3.214
4th to 8th MONTHS	5	68.25	68.00	71.90	11.779	4.694	9.310

GROWTH WHEN UNWEEDED

WEED-INFESTED

FOR THE FIRST	n	$\bar{X}$			S		
		S_1	S_2	S_3	S_1	S_2	S_3
1 MONTH	5	26.72	26.07	26.75	0.863	0.617	1.625
2 MONTHS	4	10.41	10.28	11.34	2.717	4.018	3.642
3 "	3	19.83	20.33	19.25	4.003	4.418	2.250
4 "	2	26.12	25.25	27.12	2.298	2.122	5.834
5-8 "	1	36.25	45.00	52.75	-	-	-
DURING THE [illegible]							
2nd MONTH	2	21.13	17.25	15.25	1.591	1.414	4.243
3rd MONTH	3	24.50	26.58	27.08	4.265	2.363	1.627
4th to 8th MONTHS	5	65.35	67.50	64.80	3.324	8.725	3.689

C - INCREASE IN HEIGHT OF CANE

COMPARISONS BETWEEN WEEDED AND UNWEEDED TREATMENTS USING THE T-TEST

WEEDED VS UNWEEDED	d_f	S_1	S_2	S_3
FOR THE FIRST				
ONE MONTH	8	5.472*	8.545*	5.311*
2 MONTHS	6	5.010*	8.802*	5.555*
3 MONTHS	4	0.350	0.349	1.159
4 MONTHS	2	0.146	4.426	0.158
DURING THE				
2nd MONTH ONLY	2	1.277	2.222	2.408
3rd MONTH ONLY	4	2.095	2.145	1.056
4th to 8th MONTH ONLY	8	0.530	0.113	1.585

Fig 7· HEIGHT OF CANE AT HARVEST FOR VARIOUS TREATMENTS AS PERCENTAGE OF MAXIMUM OBTAINED, FOR PLOTS WEED-INFESTED OR WEED-FREE AT PERIODS OF CROP GROWTH CYCLE, AS INDICATED

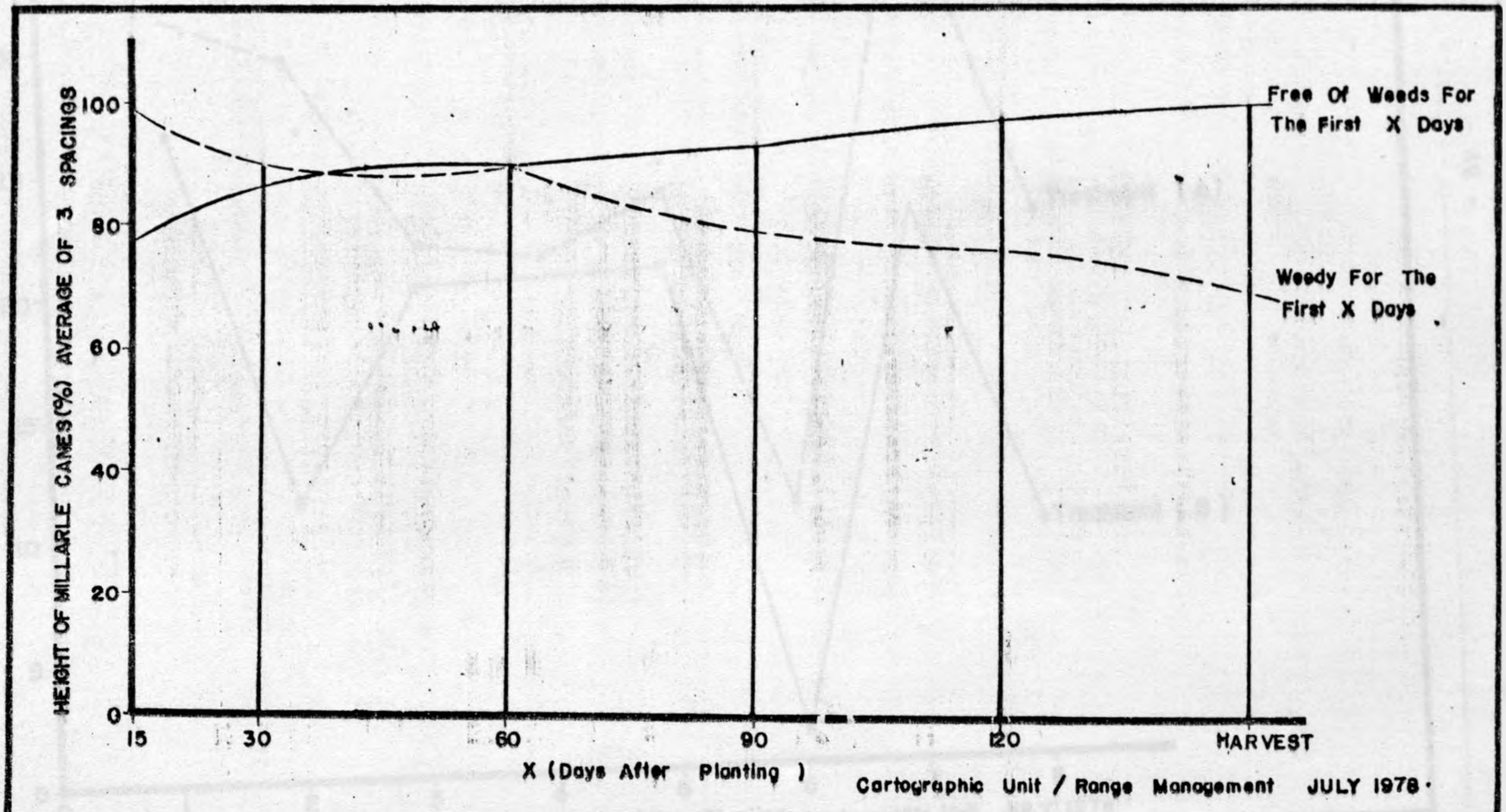
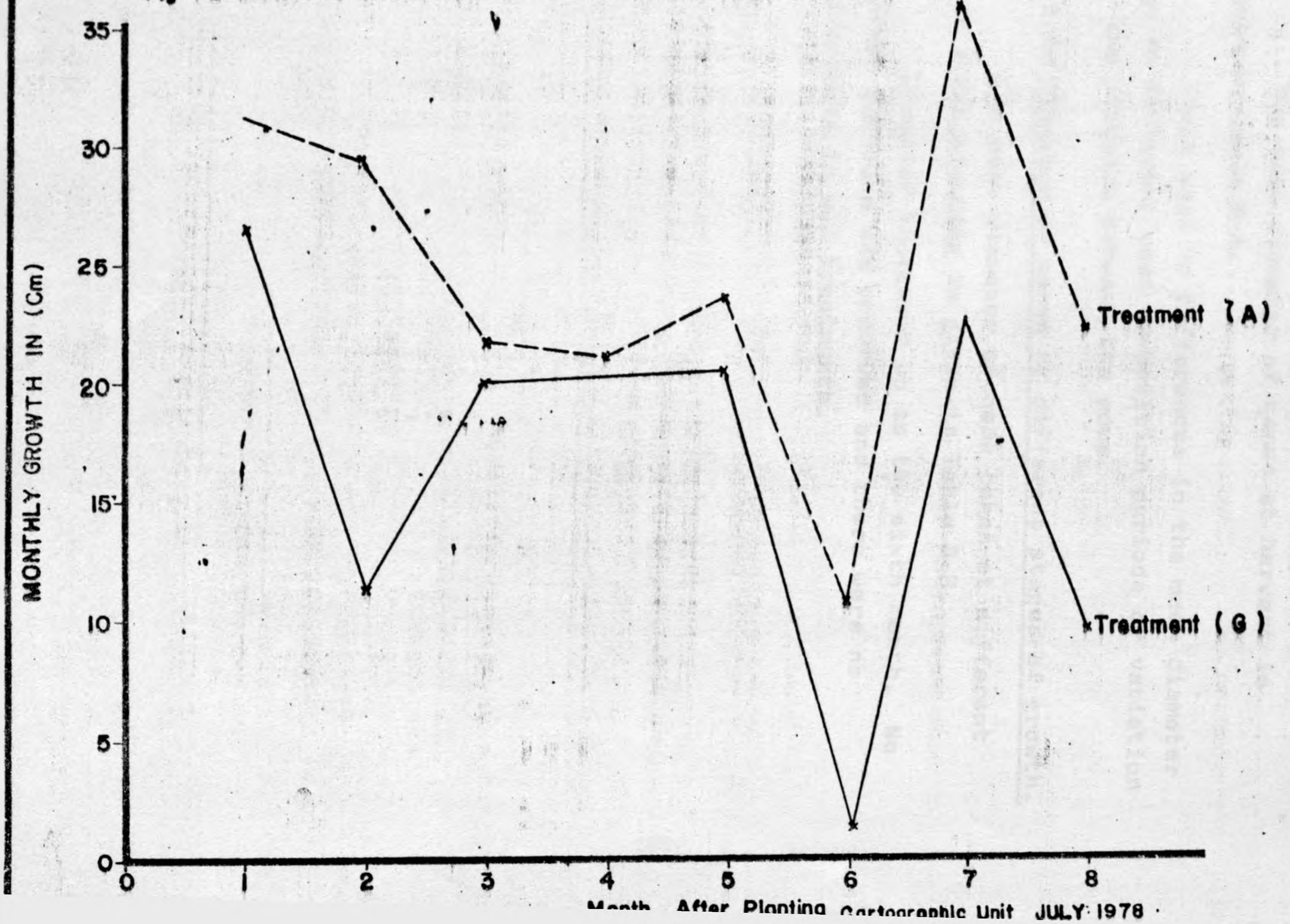


Fig 7B MONTHLY INCREASE IN CANE HEIGHT (CM) FOR PLOT WEED-FREE (A) & WEED-INFESTED (G).



4.8. Diameter of Cane

4.8.1. Diameter of cane at harvest

The mean diameter of canes at harvest is given in Table 8-A.

There were no differences in the mean diameter due to different weed competition periods or variation in the distance between the rows.

4.8.2. Diameter of canes at different stages of growth.

The mean diameter of cane taken at different days after planting is given in Table 8-B.

Diameter increased up to the sixth month. No further increase was observed and there were no differences in all treatments.

TABLE 8.A DIAMETER OF CANE

DIAMETER OF CANE AT HARVEST

MEAN DIAMETER IN CENTIMETERS

SPACING / WEEDING	S_1 (1.00 m)	S_2 (1.25 m)	S_3 (1.50 m)	Weeding Mean
A - WF Control	10.12	10.00	10.12	10.17
B - WF for 120 days	10.12	10.12	9.87	10.12
C - " " 90 "	9.87	10.12	10.00	10.00
D - " " 60 "	10.00	10.25	10.00	10.08
E - " " 30 "	10.12	9.87	10.25	10.08
F - " " 15 "	10.12	9.75	9.62	9.83
G - UW Control	9.87	10.12	9.75	9.92
H - UW for 120 days	9.87	9.75	9.50	9.71
I - " " 90 "	9.75	9.75	9.62	9.71
J - " " 60 "	9.87	9.87	9.75	9.83
K - " " 30 "	9.62	9.87	10.00	9.83
L - " " 15 "	10.25	10.00	10.50	10.25
Spacing Mean	9.97	9.96	9.94	G.M. 9.95

WF - weed-free
UW - unweeded
SE - spacing = 0.0722
weeding = 0.1443

CV = 5.02%

B - MEAN DIAMETER OF CANES AT DIFFERENT STAGES OF GROWTH

DAYS AFTER PLANTING	DIAMETER (CM)	INCREASE IN DIAMETER (%)
30	6.52	-
60	7.84	20.24
90	8.65	10.33
120	9.28	7.28
150	9.43	1.62
180	9.62	2.01
AT HARVEST	9.95	3.43

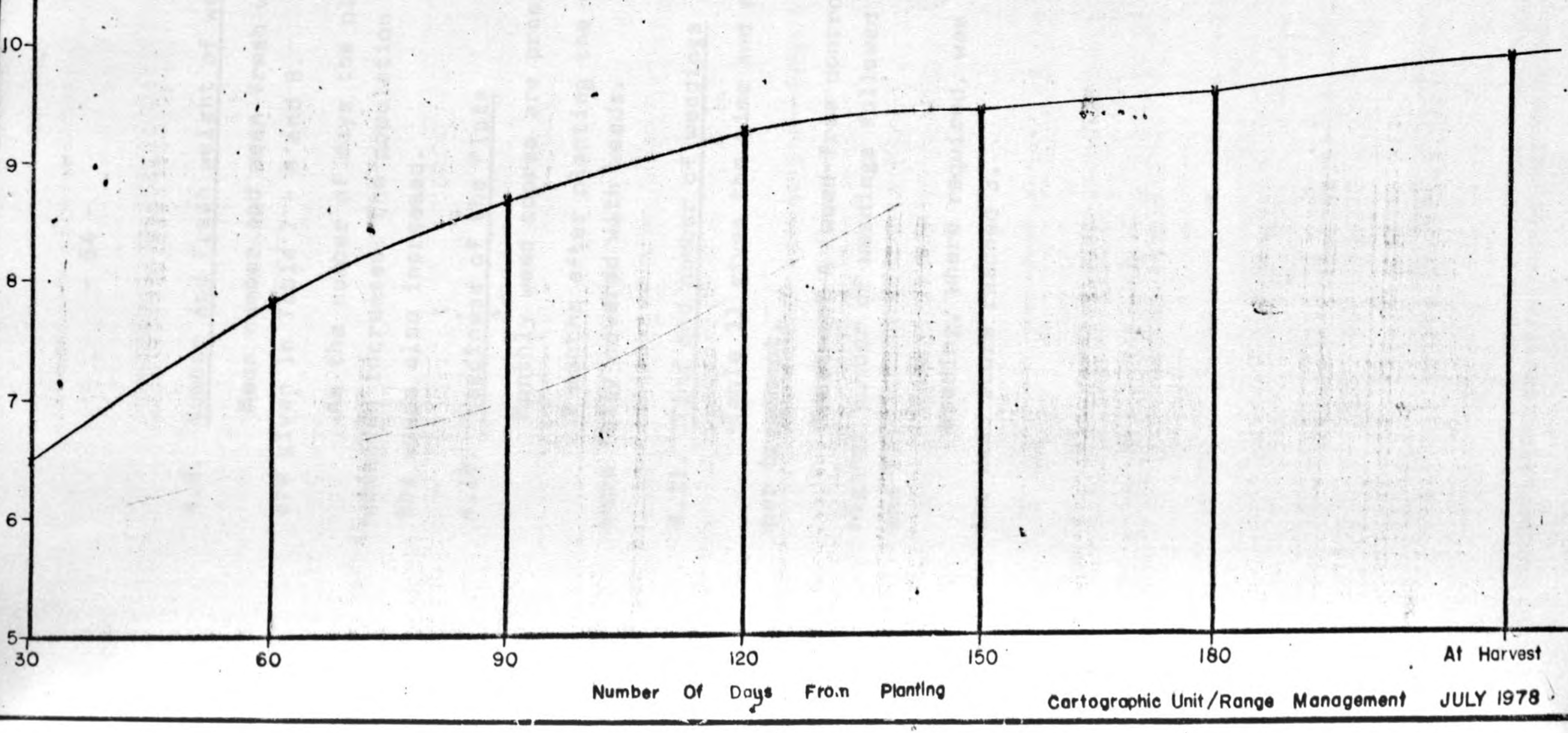


Fig 8 MEAN DIAMETER OF CANES IN CM. AT DIFFERENT PERIODS FROM PLANTING

4.9. Number and Fresh weight of weeds

Mean number and mean fresh weight of weeds are given in Table 7 - A and B.

As the number of days the plots remained unweeded increased, the population and weight of the weeds also increased.

4.10. Weediness of the Plots

Monthly weed scores are presented in Table 10.

2 months after planting the unweeded plots were fully covered with weeds.

4.11. Time and number of weedings

Table 11 gives the time and number of weedings per treatment.

Treatment A (weed-free control) had the highest number of weedings followed by L, J, K, H and I.

Weeding, where required, was carried out before the weed score reached 3.

4.12 Economics of weeding treatments

Comparative economics of treatments are presented in Table 13.

The economics of weeding operations was worked out by deducting the cost of weeding operations from the money value of additional cane yield produced by the treatments. Weeding for the first 120 days gave the highest income in all the treatments. Higher profit in this treatment as compared to the weed-free control is quite important from economics point of view.

TABLE 9. NUMBER AND FRESH WEIGHT OF WEEDS

A - MEAN NUMBER OF WEEDS PER 50 CM X 50 CM QUADRANT

SPACING	DAYS AFTER PLANTING				
	15	30	60	90	120
S_1 (1.00 m)	26.25	42.75	54.25	168.00	176.50
S_2 (1.25 m)	27.50	46.25	70.75	175.00	184.50
S_3 (1.50 m)	29.00	49.00	78.75	180.25	185.50

B - MEAN FRESH WEIGHT OF WEED (IN GRAMS) FROM 50CM X 50 CM QUADRANT

SPACING	DAYS AFTER PLANTING				
	15	30	60	90	120
S_1 (1.00 m)	125.75	217.50	430.75	1147.50	1393.75
S_2 (1.25 m)	129.00	233.00	461.25	1132.25	1296.25
S_3 (1.50 m)	136.75	248.25	567.50	1296.25	1548.75

TABLE 10. MONTHLY WEED SCORE IN 0 - 5 SCALE

TREATMENT / MONTH AFTER PLANTING	A	B	C	D	E	F	G	H	I	J	K	L
1	2	2	2	2	1	3	3	3	3	3	3	1
2	3	3	3	2	4	5	5	5	5	5	3	3
3	2	2	1	3	5	5	5	5	5	2	2	2
4	1	0	2	3	5	5	5	5	2	1	1	1
5	1	1	2	4	5	5	5	2	3	3	3	3
6	1	1	3	5	5	5	5	2	2	2	1	1
7	1	2	3	5	5	5	5	1	1	1	1	1
8	1	2	3	5	5	5	5	1	1	1	1	1
9	1	2	3	5	5	5	5	1	1	1	1	1
10	1	2	3	5	5	5	5	2	2	2	1	1
11	1	2	3	5	5	5	5	2	2	2	1	1
12	1	1	3	5	5	5	5	3	3	3	1	1
13	1	1	3	5	5	5	5	4	3	3	1	1
14	1	1	2	5	5	5	5	4	3	3	2	1

TABLE 11. TIME AND NUMBER OF WEEDINGS PER TREATMENT

TREATMENT / DATE OF WEEDING.	A	B	C	D	E	F	G	H	I	J	K	L
10/5/76	W	W	W	W	W	W						
17/5/76												W
25/5/76					W							
3/6/76	W	W	W	W							W	W
18/6/76				W								
2/7/76	W	W	W							W	W	W
22/7/76			W									
2/8/76	W	W							W	W	W	W
25/8/76		W										
2/9/76	W							W				
4/10/76	W							W	W	W	W	W
20/11/76	W							W	W	W	W	W
10/12/76	W							W	W	W	W	W
4/1/77								W	W	W		
10/2/77								W	W	W		
TOTAL WEEDINGS	8	5	4	3	2	1	0	6	6	7	6	7

TABLE 12: <u>ANALYSIS OF VARIANCE</u>

CHARACTERS	VARIANCE DUE TO				
	TREATMENT DF = 35	WEEDING DF = 11	SPACING DF = 2	INTERACTION DF = 22	ERROR DF = 105
1. Yield of Cane (tons/ha)	1197.20**	3644.43**	8,66	81,63	57.56
2. Sucrose Content (%)	1,26	-	-	-	2.66
3. Sugar yields (tons/ha)	22.45**	68.13**	0,15	1.63	1.29
4. Number of millable canes (thousands/ha)	1196,98**	3685,46**	345,17*	30,17	77.24
5. Number of tillers (per stool)	1.08	-	-	-	3.31
6. Germination (%)	117,36	-	-	-	89.09
7. Height of canes at harvest (metres)	0.18**	0,54**	0.02	0.01	0.01
8. Diameter of canes at harvest (cm)	0.20	-	-	-	0.25

TABLE 13. COMPARATIVE ECONOMICS OF TREATMENTS

TREATMENT	Increase in gross income per ha above unweeded control (G) (shs)	Cost of weeding per ha (shs)	Increase in income per ha above unweeded control (G) (shs)
A	5983.67	810.00	5173.67
B	5869.29	506.25	5363.04
C	5326.65	405.00	4921.65
D	4107.04	303.75	3803.29
E	2392.67	202.50	2190.17
F	208.81	101.25	107.56
G	-	-	-
H	426.93	607.50	-180.57
I	637.73	607.50	32.23
J	1695.75	708.75	987.00
K	4299.89	607.50	3692.39
L	4611.11	708.75	3902.36

N.B. Cost was calculated on sale price of sugarcane at 133 shilling per ton and cost of one weeding at 101.25 shilling per hectare.

TABLE 14. WEIGHT OF INDIVIDUAL CANES

MEAN WEIGHT OF CANES IN GRAMS

SPACING / WEEDING	S_1	S_2	S_3	Weeding mean
A - WF Control	907.12	893.93	1047.73	947.89
B - WF for 120 days	880.72	947.82	1010.37	945.40
C - " " 90 "	812.19	896.27	978.22	893.75
D - " " 60 "	835.12	878.03	826.30	846.95
E - " " 30 "	784.12	905.12	767.95	818.02
F - " " 15 "	706.67	649.01	772.22	705.10
G - UW Control	795.77	858.56	791.90	815.57
H - UW for 120 days	786.76	686.44	927.92	784.58
I - " " 90 "	852.51	788.49	803.38	816.33
J - " " 60 "	703.23	810.25	771.98	764.54
K - " " 30 "	807.22	858.42	869.89	844.36
L - " " 15 "	770.70	879.83	890.05	847.55
Spacing Mean	812.96	856.28	896.56	C.M.853.62

WF - Weed-fre

UW - Unweeded

CHAPTER 5

DISCUSSION AND CONCLUSIONS

5.1. The effects of weeds and weed competition

It appears from the results that the losses in yield due to weeds in sugarcane are appreciable and where no weeding was done, the yield of the crop was substantially reduced - about 70% (Table 1-B). In India it was found that the losses to the crop due to weeds vary from 10 to 70 percent in terms of yield reduction depending on the weed flora and its intensity (Lall, 1977). In U.S.A. weed infestation reduced sugarcane yields by 25-50% compared with a hand-weeded control (Millholon, 1979).

The percentage losses in yield due to unchecked weed growth in the other crops are also appreciable. In some crops such as rice, maize, onion and cotton, the yield may be reduced more than 50% due to weed competition (Mani, et al, 1968). Crops with poor competing ability such as groundnut and rainy season crops such as maize and cotton suffer more from unchecked weed growth. The ample moisture in rainy months help the weeds to flourish and unless they are controlled well in time, the crop may be smothered out of existence by the aggressive weed growth.

Although it is not usual to leave weeds uncontrolled throughout the growing periods of a crop, small growers who sometimes plant more land than they can cultivate, when they see that they cannot carry out weeding tasks for lack of help or because the rains are too heavy, generally decide to leave their crop weed-infested, and accordingly find yields decidedly lower, even when they have used improved cultivars and fertilizers. Such reductions in yield of cane and sugar shows clearly that good husbandry is not complete without weed control.

On the other hand, keeping the crop weed-free throughout the growing period is rather expensive and might not be all that useful (Table 13). Weed-free conditions for the first 120 days after planting produced almost the same yields as the weed-free control and was better in terms of net profit because of the less number of weedings involved.

Surprisingly there was a big drop in yields in the plots that suffered weed-infestation for the first 15 and 30 days. Experiments in other places showed that weed competition did not affect the yields of cane during the first 20 to 40 days (Lamusse , 1965), and under dry climatic conditions, even 3 months of weed-infestation did not reduce the yields (Azzi and Fernandes, 1971). The cause of this reduction in yields could probably be attributed to the delay in planting after the land had been ploughed. Due to a shortage of labour it took several days to open the furrows and apply the fertilizers, Normally, tractors are used to make the furrows but because we had different row spacings in the experiment, only hand labour could be used to do this job. By the time planting was started, weeds had grown considerably. This emphasizes the importance of having a clean field at planting because weed competition at this stage will adversely affect the yield of the crop.

The results gave a definite indication that cane yield may markedly be decreased by not controlling weed infesting the plots during the early stages of crop growth. Thus the presence of weeds during the first 60 days (J) depressed production by about 50%, while weed competition starting 60 days after planting was less detrimental to the yields of cane - the reduction below weed-free control was about 22%.

There was no advantage in controlling weeds after 90 or 120 days (Treatments I and H) or only for the first 15 days (Treatment F). These plots gave same yields as the unweeded control (Treatment G) or just slightly more.

The presence of weeds for the first 60 days gave 20 tons per hectare of cane less than the presence of weeds for only 15 or 30 days. Furthermore controlling weeds after the first 60 days did not improve yields very much. This again empasizes the importance of controlling weeds in the early growth periods of the cane.

It is obvious from the results that weed competition between 30 and 90 days reduced the yield significantly (Fig. 1). Experimental evidence from Trinidad (Lamusse, 1965) showed that weed-free conditions were necessary between the third and the twelfth week. In South Africa, it was found that with wet weather, the first hand weeding was necessary not later than 28 days after planting, while when conditions were dry, the first weeding could be delayed till 42 days without detrimental effects on the cane yield (Gordon, 1960).

The sucrose percentage in cane for the various treatments was the same and no definite trend was found in the juice quality. Similar results were obtained by Parihar and Mukerji (1969) and Verma (1961). This would give more support to the theory that the sucrose content of cane is mainly a varietal character (Ajaib Singh, 1969).

In the present work, however, there was some indication that there was a decrease in the sucrose where weeds were left unchecked throughout (Treatment G) or where weed control was for only 15 days (Treatment F). Comparing with the weed-free control, these treatments showed about 12% decrease in the sucrose content. Almond and King (1955) also found that with bad weed control there is a loss not only in yield but also in sucrose.

Brix taken using the hand-refractometer did not show any difference in the juice quality of cane.

Weed infestation for 60 days (Treatment J) reduced the number of canes produced by over 30% compared to the plots with weeds for only 15 days or after 90 days. A longer period of weed infestation (Treatments F, I & H) gave much less - over 50% decrease in the number of canes produced.

The results clearly indicate that weed-free conditions are necessary between 30 and 90 days for optimum production of millable canes. (Fig. 2) Any weed competition during this period adversely affects the number of canes produced. It must be remembered, however, that sugarcane grown under different conditions might need a different weed-free period.

The number of canes are an important component of cane yield per unit area (Jamer, 1971). Any effect on the number of millable canes will certainly influence the final yields.

The reduction in yield as a result of weed infestation was therefore primarily due to reduction in millable cane produotion. These were influenced possibly due to inadequate supply of water and nutrients to the crop plants as the weeds themselves utilized considerable quantities of these for their own growth and development. Therefore, while these noxious plants were removed from the plots and water and nutrients which should otherwise have been utilized by them were made available to the cane plants, they produced larger number of canes and resulted in high yields.

Weed-free control (Treatment A) produced the highest number of millable canes. An average of 68130 canes per hectare were produced in these plots as against 24020 canes produced where there was no weed control (Treatment G). There was thus a decrease of about 65% in the production of millable canes in the unweeded plots. Comparing the normal cultivation practices with control (no hoeings) Singh and Verma (1969) found that the former gave an increase of 30.5 percent.

The results showed a progressive decrease in the production of canes as the number of days when the crop was kept weed-free decreased. A similar trend was found to be caused by the increase in the number of days the crop was left unweeded. In fact, weed competition for the first 15 days only or after 90 days from planting gave similar results as the plots that were kept weed-free till harvest (Treatment A). There was a small decrease in the number of canes in the plots with weed infestation for the first 30 days only (Treatment K) and when weeds were allowed to grow after 60 days from planting (Treatment D). But as the number of days when the crop experiences weed competition increases, a substantial drop in the production of millable cane is seen in the results.

During the period of tillering the problem of weeds was most serious, as they infested the field heavily and created serious competition with cane seedlings for water, nutrient supply and sunlight. Where the weeds were allowed to grow, tillering was adversely affected.

The results showed that simply by eradicating the weeds during this period tillering was greatly enhanced. As against 3.42 tillers per plant in the unweeded control (Treatment G), 4.33 tillers were obtained under weed-free conditions (Treatment A) - an increase of over 26%. As the number of days the crop was kept weeded increase there was an increase in number of tillers per plant. A weed-free condition of only 15 days (F) produced about 22% tillers compared to treatment B that had longer period of weedfree conditions. Similar results were obtained by Singh and Verma, 1969.

Weed infestation for only 15 and 30 days (L and K) did not have an adverse effect on the number of tillers produced by plants. They had the same number as the plots that did not suffer weed competition at all (A). But as the number of days with weed infestation increased there was a decrease in the tillering of the plants. Plots unweeded for 120 days produced about 10% less tillers than those unweeded for 15 days only.

The number of tillers greatly and directly affects the number of millable canes which is an important factor in determining the yields of cane. Therefore any effect on the tillering of the plant will influence the final yields of cane.

Stalk length is another important component of cane yield (James, 1971) and the results confirm that where canes were shorter the yields were lower i.e. treatments with short canes had lower average weight of individual cane (Table 14.   ).

The plant height at the time of harvest was maximum in all the treatments. Plants that suffered weed infestation for only 15 days or after 120 days (L and B) had the highest cane length. The height in these treatments was similar to that of plants in the weed-free plots (A). The results clearly show that weed infestation adversely affects the height of cane. Parihar and Mukerji (1960) found no significant differences in the length of millable canes due to weeds.

In the present work weed infestation throughout the cane growing period reduced the height to 1.53 meters as against 2.23 meters in the weed-free control i.e. a reduction of over 30%. Similarly weed infestation for 120 days and 90 days reduced the height of cane substantially (25% and 22% respectively). There was no advantage in weeding the crop for the first 15 days. These plots had shorter plants. The reduction in height compared to the weed-free control was over 20%.

In the analysis of cane growth (i.e. monthly increase in height) it was found that in plots with weed infestations at the initial stages, the crop received a setback in growth. This setback could not be recouped even at later stages, resulting in significant reduction in the final height.

The middle internode was measured in estimating the average diameter of each stalk at 30 days interval from planting. Statistical analysis showed no differences in the diameter of canes in all the measurements.

At 30 days after planting the average diameter was 6.52 cm. For the next 30 days (at 2 months after planting) there was an increase of 1.32 cm (about 20%). The growth in the thickness of cane became slower and the diameter remained almost constant after 120 days from planting (Figure 8).

According to Muller (1960) the thickness of the stems varies with the individual cane variety.

The results show that weeds create a serious problem in sugarcane cultivation at Ramisi. The presence of weeds in the first 90 days reduced the yields considerably. This reduction is brought about by the adverse effect on the production in the number of millable canes and their height, which caused a reduction in individual cane weight. The differences in sucrose content and diameter of cane were not significant.

In all plots germination was fair and the results indicate that weeds or variation in spacings had no effect on the germination of cane under the conditions prevailing. The germination commenced in a few days time and within about 30 days after planting the development of shoots were noticeable.

Singh and Verma (1969) observed no marked differences in germination between the unweeded control and the normal cultivation plots. Similarly Patro and Tosh (1971) and Parihar and Mukerji (1969) found that the differences in germination percentage were not significant.

Gordon (1960) explains that in the race to get established, the primary shoot of cane elongates rapidly and early to take a lead over competing weeds. It is in the later stages that life of the plants is seriously handicapped by the presence of weeds.

There was always a heavy weed infestation following rains or irrigation. In plots where the infestation was high, the growth of sugarcane was depressed and their leaves showed a yellowish colour. Plots that had weed control at early stages had less weeds later because the cane became more competitive and smothered the weeds.

5.2. The effects of row spacings

In general, no difference in cane yields were observed among the three row spacings. A similar observation was made at Kibos (Hill, 1963). Although statistically not significant, weed control for the first 60 days gave higher yields in the plots with row spacings at 100 cm and 125 cm than those obtained from a row spacing at 150 cm. Weed competition ceases when a canopy which covers the rows is formed (Verma and Bhardwaj, 1958) and the canopy in closer spacings forms more quickly.

The results indicate that longer periods of weed control are more beneficial to cane grown at wider spacings. The weed free control and the plots that were kept weed-free for 120 days gave over 10% in yields at the standard 150 cm rows compared with the interrow spacings of 100 cm and 125 cm. This would seem economical in view of the amount of seed material involved.

Previous trials at Ramisi (Unpublished report) showed that a row spacing of 125 cm was superior to the wider spacing of 150 cm. Such a spacing is, however, not practicable as the present machinery can only be used in the fields with rows 150 cm apart.

Contrary to the findings of Ajaib Singh (1969) that wider spacing tend to show slightly better juice quality, the results show that row spacings had no influence on the percentage of juice extracted or brix of the juice. In Georgia, U.S.A. Freeman (1968), studying the influence of row spacings on quality of sugarcane, also found that variation in the spacing did not affect the sucrose content of the cane.

Experimental evidence in Nyanza (Hill, 1963) and in other countries (Kanwar and Sharma, 1974) showed that cane population was higher in closer spacings.

Results presented in the foregoing pages reveal that closer spacings (S_1 and S_2)gave larger number of canes than the standard 150 cm spacing, particularly in the treatments with longer period of weed competition (Table 4-B). An average of 46210 canes per hectare were produced in the S_3 treatment plots (150 cm) as against 51540 and 49390 canes produced in the S_1 (100 cm) and S_2 (125 cm) treatments. There was thus an increase of about 10% in the production of millable canes in the closer spacings.

It is interesting here to note the effect of cane population or rather the lack of any effect on the final yields of cane. Results have shown that there were no differences in yields regardless of variation in the row spacings. Now, if 125 cm spacing gives the same overall yield as 150 cm spacing, then the larger number of canes in the 125 cm spacing must have given a lower weight per cane (Table 14). As the cane at harvest is mature in both cases, the canes have given their maximum potential yield under the conditions prevailing. The reduction in yield per cane from one spacing to another must be due to agronomic considerations, the most likely being competition due to the close spacing.

A similar trend is observed with the still closer spacing of 100 cm. Though the number of canes per hectare is larger than the other spacings, this treatment gives the same overall yield. The still lower individual yield of the higher number of canes indicate even greater competition.

Though statistically not significant, there was some increase in the number of tillers per stool in the closer spacing - about 6% over the wider spacing. Kanwar and Sharma (1974) also found that the tiller population was higher in the closer spacings but some experiments (Singh and Verma, 1969) have shown that moisture stress causes the mortality of stalks in the narrow spacings.

The two close spacings (S_1 and S_2) gave almost the same number of tillers per stool.

The differences in the length and thickness of millable cane in the three row spacing treatments were found not significant. Other experiments have shown that stalks were shorter and smaller in diameter on the narrow rows (Matherne, 1972).

Wider spacings gave a higher weed population and weight. As the number of days the crop was kept unweeded increased, the number and fresh weight of weeds increased. The biggest increase was between 60 and 90 days after planting. This is probably due to the high rainfall and the fact that some weeds had outgrown the cane plants.

5.3. Conclusion

Weeds are a sore problem in sugarcane fields. The losses from reduced yields due to competition are enormous. When weeds are left unchecked from planting to harvest, they may cause almost a complete loss of crop (Table 1). The infestation of weeds starts early and continues for about three months. Afterwards the fast growing canes smother the weeds and no serious loss is caused to the crop due to their presence in the field.

It appears that, in a normal rainfall season, sugarcane at Ramisi should be weeded immediately after planting and that it is no longer necessary to weed 120 days after planting (Figure 1). Therefore the indications are that sugarcane need only be kept weed-free for the first 120 days. However, initial weed control could be delayed until 15 days from planting or even 30 days during a dry season and when the cane is planted in a clean field. Caution should be excercised in applying this finding, as the rate of growth of sugarcane plant varies widely from year to year with weather and soil conditions, cultivation practices and the cultivars grown. During the rainy season it is important to plant the cane as quickly as possible to avoid the growth of weeds and their subsequent competition at early stages of cane growth.

It is necessary to correlate the days after planting with the different phases in the growth of the sugarcane plant (Lamusse, 1965), because time from planting can hardly be used to determine the most appropriate period to control the weeds in sugarcane fields (Gordon, 1960).

The results show that a weed infestation starting as late as 120 days after planting seems to have no adverse effect on the yield of cane or its important components, namely, the number of millable canes and the height of the stalks. Weed infestation starting at 15 and 30 days after planting was very detrimental to cane yields.

This finding applies to the plant crop of the cultivar CO421. For ratoon crops, which grow more rapidly, and for other cultivars, the results could be different. It is therefore necessary to carry out experiments with the ratoons and different sugarcane cultivars, and for several years to determine if the above findings are of general application.

In the present work, the superiority of narrow rows in increasing yields was not established.

APPENDIX I

SOIL TEST DATA

	1st Block	2nd Block	3rd Block	4th Block
pH	5.7	5.7	5.4	5.7
Na m.e. %	0.04	0.13	0.07	0.15
K m.e. %	0.27	0.28	0.25	0.26
Ca m.e. %	1.7	1.8	1.6	1.8
Mg m.e. %	0.2	0.5	0.6	0.6
Mu m.e. %	0.8	0.8	0.7	0.7
P p.p.m.	18	31	11	9
N %	0.04	0.04	0.04	0.04
C %	0.40	0.38	0.36	0.50
Cat. exch. cap. (m.e. %)	4.6	4.9	4.9	4.7
Sand %	79	80	80	78
Silt %	11	10	11	11
Clay %	10	10	9	11

N.B. Deficincies underlined

The soil sample was taken before planting and the application of fertilizers.

APPENDIX II

RAIN CHART (FAMONI)

A - MONTHLY RECORDS: JAN 1976 - JULY 1977

RAINFALL IN MM

MONTH	1976	1977
JAN.	-	23.90
FEB.	19.00	37.10
MARCH	80.00	116.60
APRIL	191.80	242.80
MAY	179.30	180.60
JUNE	362.50	55.10
JULY	130.30	230.40
AUGUST	25.40	-
SEPTEMBER	63.20	-
OCTOBER	8.60	-
NOVEMBER	16.80	-
DECEMBER	50.50	-
	1127.40	886.50

TOTAL = 2013.90

IRRIGATION

A total of four rounds were applied during the following months:

NOVEMBER	1976
DECEMBER	1976
JANUARY	1977
FEBRUARY	1977.

A round of irrigation supplies 50.8 mm of water.

N.B. The rainfall and irrigation data were supplied by the management of Sugar Company at Ramisi.

B - YEARLY RECORDS: 1970 - 1976

YEAR	RAINFALL IN MM
1970	1017.78
1971	966.47
1972	1657.60
1973	1439.16
1974	855.73
1975	1009.40
1976	1127.40

APPENDIX III EXPERIMENTAL LAYOUT.

<———————— ROAD ————————>

S_1A^{1}	S_2L^{2}	S_3G^{3}	S_1B^{4}	S_2K^{5}	S_3H^{6}	S_1F^{7}	S_3D^{8}	S_2G^{9}	S_1D^{10}	S_2F^{11}	S_3K^{12}
S_2J^{13}	S_1H^{14}	S_3E^{15}	S_2D^{16}	S_2I^{17}	S_1E^{18}	S_3A^{19}	S_2H^{20}	S_1L^{21}	S_1C^{22}	S_3B^{23}	S_3L^{24}
S_2A^{25}	S_1G^{26}	S_3I^{27}	S_1J^{28}	S_2C^{29}	S_3J^{30}	S_2B^{31}	S_1I^{32}	S_3F^{33}	S_3C^{34}	S_2E^{35}	S_1K^{36}

S_1F^{37}	S_2K^{38}	S_3G^{39}	S_1D^{40}	S_3F^{41}	S_3F^{42}	S_2B^{43}	S_3Z^{44}	S_1E^{45}	S_3S^{46}	S_3H^{47}	S_1J^{48}
S_1L^{49}	S_2E^{50}	S_2H^{51}	S_2F^{52}	S_1B^{53}	S_3L^{54}	S_2A^{55}	S_2J^{56}	S_1A^{57}	S_3E^{58}	S_2D^{59}	S_1K^{60}
S_2G^{61}	S_3A^{62}	S_1H^{63}	S_3K^{64}	S_3D^{65}	S_1G^{66}	S_3B^{67}	S_2C^{68}	S_1I^{69}	S_2I^{70}	S_2L^{71}	S_1C^{72}

S_1E^{73}	S_3E^{74}	S_1B^{75}	S_2J^{76}	S_1L^{77}	S_3B^{78}	S_2A^{79}	S_3D^{80}	S_2D^{81}	S_3A^{82}	S_1K^{83}	S_2H^{84}
S_1D^{85}	S_2L^{86}	S_3C^{87}	S_3I^{88}	S_1G^{89}	S_1A^{90}	S_3J^{91}	S_1I^{92}	S_2B^{93}	S_2K^{94}	S_2C^{95}	S_2G^{96}
S_1H^{97}	S_3K^{98}	S_1C^{99}	S_3L^{100}	S_1F^{101}	S_2L^{102}	S_2F^{103}	S_3G^{104}	S_3F^{105}	S_2E^{106}	S_3H^{107}	S_1J^{108}

APPENDIX III (Contd......)

S_2I^{109}	S_3F^{110}	S_1H^{111}	S_1E^{112}	S_2D^{113}	S_3E^{114}	S_1L^{115}	S_1D^{116}	S_3A^{117}	S_2A^{118}	S_2L^{119}	S_1A^{120}
S_3H^{121}	S_2K^{122}	S_2G^{123}	S_2B^{124}	S_2H^{125}	S_3K^{126}	S_3D^{127}	S_1J^{128}	S_2F^{129}	S_2C^{130}	S_1K^{131}	S_3I^{132}
S_3F^{133}	S_3J^{134}	S_2L^{135}	S_3L^{136}	S_1B^{137}	S_2J^{138}	S_1C^{139}	S_1G^{140}	S_1I^{141}	S_3B^{142}	S_1F^{143}	S_3G^{144}

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