A SURVEY OF CHEMICAL WEED CONTROL IN SUGARCANE

By M. J. STEWART

Introduction

OBJECT OF SURVEY

The object of this survey is to give an outline of the chemical methods of weed control employed in cane-growing countries, with special reference to South Africa.

HISTORY OF CHEMICAL WEED CONTROL

Chemical weed control in crops is a comparatively young branch of agriculture and has only been actively pursued for about fifty years, during which time a large number of chemicals were brought onto the market as herbicides, however, many of the materials were either damaging to crops, corrosive to machinery, poisonous, or expensive.

However, in 1940 Dr. Templeman[1] of the Imperial Chemical Industries, discovered a synthetic plant hormone which possessed a selective action of being able to kill some plants and leave others unharmed. This hormone weed killer was 2 methyl, 4 chloro-phen-oxyacetic acid (Methoxone or M.C.P.). Later in 1942 Zimmerman and Hitchcock[2] reported the herbicidal effect of a similar synthetic plant hormone, namely 2.4–dichloro phenoxyacetic acid. The action of both these hormones is to over-stimulate the growth of susceptable plants, cause serious internal abnormalities, and results in the eventual death of the plant.

Only since the discovery of the phenoxyacetic acid compounds has the use of chemical weed control in sugarcane been widely accepted. In South Africa most of the present methods and techniques are based on the experience of Illovo Sugar Estates and the two articles written by Dr. McMartin[3] in 1949 and 1950.

SOME RECENT ADVANCES IN CHEMICAL WEED CONTROL

Phenoxy acetic acids have proved very satisfactory as pre-emergent herbicides in plant and ratoon cane, when used correctly against susceptible weeds. Post-emergent applications of emulsified aromatic oils, activated by penta-chloro-phenol, are used less extensively and have not been entirely satisfactory in the control of perennial grasses. Thus the success of any new herbicide will depend largely on its ability to give an effective suppression of perennial grasses and nut grass at economical rates. To mention but a few that may prove valuable to the cane grower:—

T.C.A. (Trichloro-acetic acid)

T.C.A. is classed as a root poisoning herbicide for the control of grasses, and the best results are obtained when the chemical is absorbed through the roots of the plant, consequently moisture is essential for its absorption and dry conditions are often responsible for the slow and sometimes unsatisfactory results. This material is used extensively overseas, especially in Louisiana, to control Johnson grass (Sorghum halepense). In South Africa, it has been the subject of exploratory work for use only in sugarcane fields, but it could be used profitably where a particular grass problem exists.

2-2-Dichloro Propionic Acid

This compound is similar to T.C.A. in its selective effect against grasses, but in this case it can be absorbed and translocated more readily by the foliage. Although the toxic effects are slow in developing, it appears to have a higher phytotoxicity than T.C.A. and can be used at lower rates in selective weed control. In Hawaii it has been noted that 2 lb. of this material is equivalent to 15 lb. of T.C.A. in the control of Couch Grass (Agropyron repens).

Substituted Ureas

C.M.U. [3(p-chlorophenyl) 1.1 dimethyl urea] and P.D.U. (phenyl dimethyl urea) both possess most of the desirable properties of a herbicide. They are highly phytotoxic and are therefore effective at low dosages against a wide range of weeds, furthermore, the stability of these compounds enables them to resist decomposition in the soil, thus extending the period of weed control. The substituted ureas are primarily pre-emergent herbicides, but due to the insolubility of these compounds their action is much slower than many other weed-killers. The effects on the growing plant are first exhibited by a wilting and chlorosis of the leaves, followed by a progressive

die-back and finally death of the plant itself. Although light applications of up to 8 lb. per acre can be used for selective weed control in sugarcane, heavy rates of 40-80 lb. per acre can eradicate all vegetation for a long time. When water is used as the diluent for applying substituted ureas, continual agitation is required to keep the insoluble material in suspension. This necessitates the inclusion of a special agitating mechanism, which is an important practical limitation.

More recently amino triazole has shown promise in the control of nut grass (Cyperus rotundus) in the U.S.A. The compound induces a chlorosis of the leaves, especially the young growth, but the water grass is not eradicated and may recover eventually. However, more research is still required to determine the full value of this chemical.

The amides of chloro acetic acid are still another range of compounds which have not yet been fully tested, but have already shown promise in the control of certain grasses.

LIMITATIONS OF CHEMICAL WEED CONTROL

It is important to bear in mind that chemical methods of weed control are only supplementary to cultural practices and as far as one can safely predict chemicals will never replace cultural methods.

Selective herbicides will invariably fail to kill some weeds and furthermore some herbicides will damage some crops because the protoplasm of desirable plants is similar to that of undesirable plants we call weeds. It follows that continuous and injudicious use of a particular selective herbicide will encourage a resistant type of weed to flourish and predominate. For example injudicious use of 2.4–D may control broad leaf weeds, but cause resistant grass weeds to predominate and create a more serious problem.

There has been much speculation as to the effect of herbicides on the soil micro-organisms and experiments are being conducted at this station to investigate this possibility. Overseas investigations have shown that neither 2.4–D nor P.C.P. reduce the microbial activity in the soil when used at recommended rates, i.e. below 4 and 2 lb. respectively. These results are supported by two papers, one written by Krotochvil[4] and another written by Hoover and Colman.[5]

In other countries harmful effects on cane have been observed from applying 2.4–D at certain stages of the cane's growth, but in South Africa there has been no definite evidence of such harmful effects when recommended quantities of 2.4–D are used.

APPLICATION OF CHEMICAL WEED CONTROL IN CANE

SOUTH AFRICA

Sugarcane is a hardy crop and less susceptable to the effects of herbicides than most weeds, consequently the crop lends itself very well to chemical weed control.

The extent to which herbicides are used in the sugarcane areas of South Africa, has and will depend on a number of factors:

(*a*) the availability of labour;

(*b*) the cost of the herbicides in relation to cultural methods of control;

(*c*) the efficiency of the particular herbicides against the prevailing weed population; and

(*d*) the degree in which it aids cultural methods of control.

Thus it depends on the interrelation of all these factors whether or not chemical weed control can be justified in any particular case.

Nevertheless there is a definite advantage in applying a pre-emergent spray of 2.4–D, provided the area is not dominated by a resistant type of weed. Under favourable conditions excellent weed control can be obtained when the young plant cane is establishing a root system. At this critical stage moisture and nutrients should be readily available and this condition is only obtained when weed competition is eliminated. Mechanical and manual methods do not achieve the same results, because the young shoots are easily damaged and root development distrubed. In addition, pre-emergent spraying of hill-sides eliminates unnecessary cultivation and therefore reduces the chance of soil erosion.

Pre-emergent Spraying

Sodium M.C.P.A. has been in use for many years, but not so extensively as the ester and amine formulations of 2.4-D.

Both 2.4-D. formulations have their merits, although under general field conditions they have the same herbicical value.

Lee Ling[6] describes and compares the more common herbicide preparations on the market today, and referring to 2.4–D formulations he rates the ester as having the most potent herbicidal action, the amine salt as intermediate and sodium salt the least potent.

Lee Ling adds that sodium M.C.P.A. produces the same herbicidal responses as sodium 2.4–D, but they appear to differ in their persistence in the soil,

M.C.P.A. having a longer herbicidal effect. Also M.C.P.A. is more effective against certain weeds and *vice versa*.

Time of Pre-emergent Spray

The most dramatic results from 2.4–D are obtained from pre-emergent sprays. However, the pre-requisites for a good control of broad leaf weeds and annual grasses necessitates:

1. early pre-emergent application before any vegetation has appeared above the soil surface; and
2. a moist soil with a fine tilth.

Under these conditions weed seeds germinate quickly and are killed by the freshly applied herbicide.

2.4–D has very little effect on grasses once they have developed beyond the seedling stage. On the other hand most broad-leaf weeds are easily destroyed in the seedling stage and they can also be suppressed in the adult stage, but in this case greater quantities of herbicide may be required.

Method of Application

In applying pre-emergent herbicides normally, both the cane row and interline are covered with the herbicidal spray. This method is termed a complete cover spray and recommendations for rates of application are usually made on this basis.

The above method can be modified by only spraying the cane line itself and leaving the weeds in the inter-row to be controlled by cultivators, and this method has a number of advantages:

1. weeds are controlled in the cane line with the least possible disturbance to the young cane;
2. labour normally used to weed in the cane row can be employed elsewhere;
3. cultivation of the inter-row not only destroys weeds but also helps to aerate the soil;
4. only half the quantity of herbicides per acre is required.

The disadvantage of treating the cane line only, is that weeds in the inter-row are not affected, and it may be necessary to cultivate at an early stage. This can cause untreated soils to fall into the cane line and nullify the effect of the pre-emergent spray.

Rates of Application

1. *Complete Cover.*—For complete cover sprays 1½–2 lb. 2.4–D (ester or amine) per acre should destroy susceptable weeds and remain effective for a period of three to six weeks, depending on the soil and weather conditions, but in some cases control has been obtained for a period of ten weeks. However, the chemical is broken down quicker in heavy moist soils than sandy soils, and also heavy rains reduce the herbicides' effective life.

2. *Cane Line.*—When only the cane line itself is to be treated, then half the above dose should suffice, as only 50 per cent. of the land is sprayed.

The presence of perennial weeds presents a different problem, and in the Natal sugar belt nut grass is generally considered to be one of the most troublesome weeds. It is a native of the tropics and warmer areas of the temperate zones. Botanically it falls into the family Cyperaceæ of the order Cyperales, and there are two main types of economic importance to be found in Natal cane fields.

I. *Cyperus rotundus* (Fig. 1) is often associated with having a purple flower, but *Cyperus rotundus L. forma* has a yellow flower with long spikelets. Both these varieties possess a deep ramified system of strong wiry rhyzomes, which join a series of hard brown scaly tubers. The tubers nearer the soil surface produce aerial shoots and additional rhyzomes, hence the name "uintjies kweek," because of its creeping habit.

II. *Cyperus esculentus* (Fig. 2) is also characterised by a yellow flower, but in this case the spikelets tend to be much shorter. The underground portion consists of a shallow, less ramified system of more succulent rhyzomes which sometimes terminate in a round succulent tuber, however surface rhyzomes are capable of producing aerial shoots, but the creeping habit is less apparent than in the case of *Cyperus rotundus*. In addition *esculentus* is easier to control than *rotundus*.

Further research into the growth habits, morphology and physiology of the different types of cyperus is still required in order to find a weak link, whereby it might be successfully controlled with herbicides.

In general pre-emergent applications of 2.4–D formulations at economic rates (2 lb./acre) have given little or no positive control of nut grass. Under particular conditions 2.4–D may retard the development of shoots and delay flowering to a certain extent, but this condition is only temporary and the weed soon recovers.

Post-emergent Spraying

Certain weeds, especially grasses, are resistant to post-emergent applications of 2.4–D. Consequently once these resistant weeds have fully germinated contact herbicides, or mechanical methods have to be used.

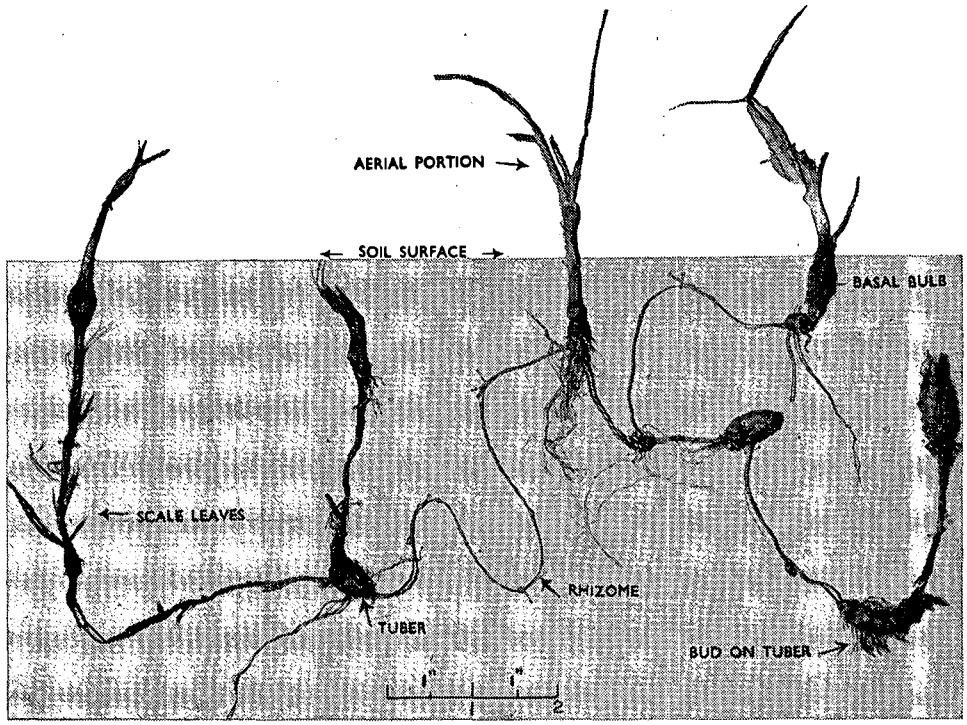

Fig. 1 *CYPERUS ROTUNDUS*

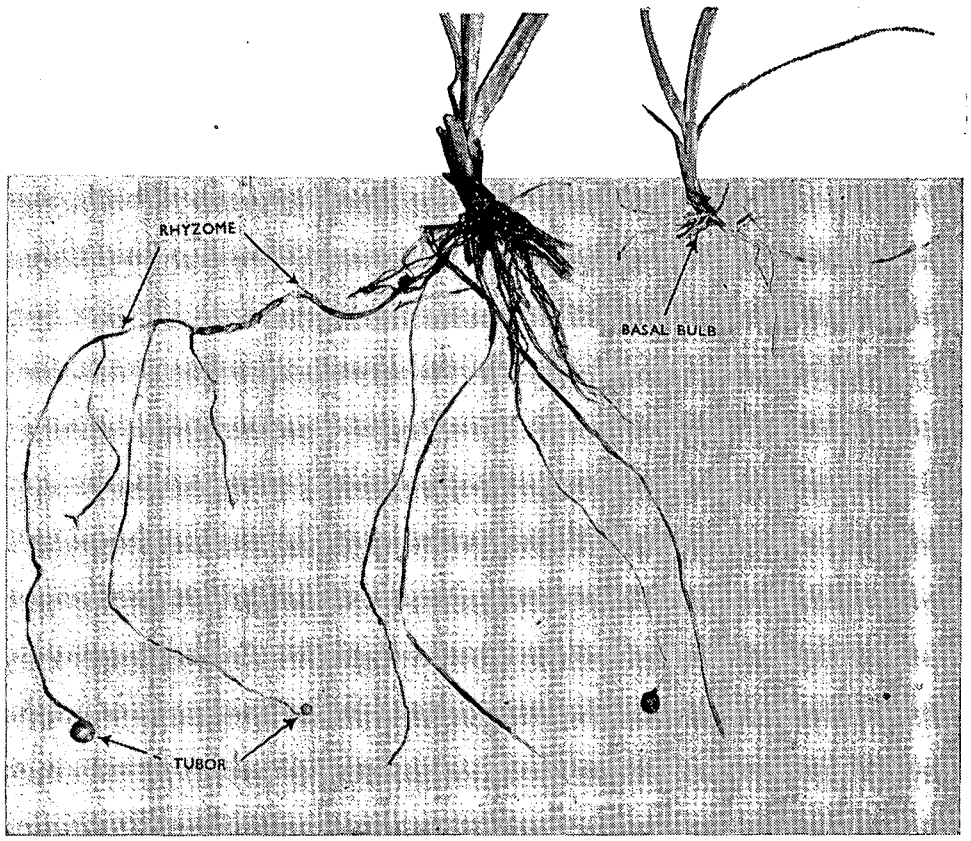

Fig. 2 *CYPERUS ESCULENTUS*

1. Mechanical methods not only eliminate weed competition, but also perform the important function of aerating the soil and breaking any hard surface crust. The disadvantages, however, is that fresh weed seeds are brought to the surface, however, the control of weeds can be extended by applying a pre-emergent application of 2.4-D. directly after cultivation to control the germination of fresh seeds.

2. Under certain conditions it is profitable to control resistant weeds by post-emergent contact herbicides, especially where heavy clay fields may be too wet to cultivate, or where there is an acute labour shortage.

Post-emergent Chemicats

Under Natal conditions the most satisfactory results with post-emergent chemicals in the suppression of grasses and nut grass have been obtained with contact herbicides. The best formulation consists of an aromatic oil fortified with P.C.P. and containing an emulsifying agent. 2.4-D can be added to the contact herbicide to make what is known as a total herbicide.

This will increase the efficiency of the contact herbicide and inhibit the germination of susceptable weed seeds.

Time of Post-emergent Spraying

In order to derive the greatest benefit from one application a full flush of aerial grass shoots should have developed.

If the cane has germinated at the time of application and only the spikes appear above the soil surface, no precaution need be taken to protect the cane. Exposed cane leaves can be severely burnt if the herbicide is applied after the spike stage, and although the young shoots are not killed, cane growth is retarded and the object of weed control is defeated. It is possible to adopt a technique whereby the cane leaves are protected, and therefore the use of contact herbicides can be extended to any stage in the canes' growth.

Rates of Application

Contact herbicides on the market today contain about ½ lb. pentachloro-phenol per gallon of oil, and for this specification the following quantities are normally applied.

1. *Complete Cover*

   (*a*) 1½ lb. 2.4-D ester } per
   (*b*) 2–4 gallons contact herbicide } acre

2. *Cane Line*

   Only half the above quantities are required.

Although only low volumes are required for pre-emergent spraying, relatively high volumes are necessary for contact herbicide application.

The volume to which the above materials should be diluted is dependent on a complete coverage of the weed vegetation. Invariably nut grass control is the main object of post-emergent treatments and the volume rate should be consistent with thorough crown penetration. When sufficient liquid runs into the central axis (crown), the herbicide penetrates and kills the growing point. In the case of *Cyperus escluentus* the succulent basal bulb is killed completely and regrowth will be dependent on healthy rhyzomes and tubers. The basal bulb of *cyperus rotundus* is not killed unless it is very small and succulent, however the bud which formed the aerial portion is usually destroyed, but regrowth can easily take place from a healthy bud on the same tuber.

A dilution of at least 50—60 gallons per acre is necessary to suppress a full flush of nut grass successfully with a complete cover spray. When only the cane line itself is being sprayed, this quantity is halved.

Equipment

Owing to the difficult terrain and relatively small acreages to be sprayed at any one time, the knap-sack sprayer has proved very satisfactory and even on large estates it has been both economical and efficient. Furthermore the selective placement of contact herbicides is accomplished well by the knap-sack sprayer and it is difficult to visualize a better method for hill-side cane fields of Natal.

Where tractor-mounted spray equipment can be used economically the operation is carried out quickly and more efficiently than with a knap-sack sprayer.

Aeroplane spraying is used extensively overseas, where large areas can be sprayed at any one time (50 acres/hour), but on account of the high operating costs (for spraying small areas) the use of aeroplane spraying is limited in South Africa and in the sugar belt, only one company (Natal Estates) possesses an aircraft for this purpose.

In considering the type of jets used in herbicide spraying, the ceramic T-jet is the most satisfactory type for present methods and techniques. This type offers better penetration of the weed foliage, more selective placement of the herbicide and better control of spray drift than in the case of cone jets.

However, in the case of a jet becoming blocked, cone-type jets are easily cleaned and replaced, and this is an important practical consideration.

OVERSEAS WEED CONTROL

No direct comparison can be drawn between overseas practices and those commonly used in South Africa. Climatic conditions, weed populations, cultural methods and labour economics vary in overseas cane-growing areas and, consequently, the problem of weed control presents itself in a different light. Although their findings offer very useful fundamental information, the value of particular field practices and methods must first be assessed in the light of our own local conditions.

In reviewing overseas literature, Hawaii, Queensland and Mauritius have been chosen to represent the development of chemical weed control in other sugarcane growing areas of the world.

HAWAII

Du Toit[7] in his report wrote "In Hawaii weed control is particularly highly-developed as a result of the natural luxuriant weed growth, high labour costs and excellent work conducted by the chemical department of the H.S.P.A. Experimental Station, under Dr. Hance." The report adds that owing to the prohibitive expense of importing herbicide preparations, it was found essential for them to prepare their own herbicide mixtures from the raw materials.

Soon after the discovery of 2.4–D this material came into general use as a pre-emergent herbicide, and then in order to combat more resistant weeds which escaped 2.4–D, a C.A.D.E. (concentrated, activated diesel-oil emulsion) was introduced by Dr. Hance[8] consisting of the following ingredients:

67 gallons diesel oil
7 lb. penta chloro-phenol
14 lb. wetting agent
33 gallons of water.

Later it was found that by increasing the aromatic content of the oil constituent, the herbicidal properties were improved. Thus a modified and more effective herbicide emerged known as A.R.C.A.D.E. The addition of 2.4–D to the above contact herbicides extended their value by inhibiting the germination of weed seeds in the soil.

T.C.A. has also been found useful for the control of grassy weeds and the H.S.P.A.[8] reports that a mixture of 2.4–D and T.C.A. is of value in a mixed weed population as the two herbicides supplement each other in controlling broad-leaf weeds and grasses respectively. Another mixture is based on a combination of T.C.A. and C.A.D.E. and in this case the oil content of the C.A.D.E. is said to facilitate the entry of T.C.A. into the plant tissue. Still another mixture consists of T.C.A., C.A.D.E. and 2.4–D and here again the three components are said to have a complementary effect.

The new herbicide C.M.U. was subjected to pot tests in 1951 and the preliminary results presented by Dr. Hance[9] shows that 1—2 lb. C.M.U. controls weeds well and has little effect on the cane itself, but as the rates of application are increased, the cane becomes progressively stunted, until at 30 lb./acre growth is completely inhibited.

During the year 1953 C.M.U. continued to be the principle herbicide under investigation[10] and a large number of co-operative field tests were carried out. Results indicate that pre-emergent applications of 4—5 lb./acre appear to be optimum and no harmful effects are observed at this rate, but at 10 lb./acre harmful effects become evident. Although C.M.U. has been used on a field scale over the past two years the problem of this chemical building up a residual toxic effect in the soil is being examined. Recently Dr. H. M. Baker of the Du Pont Company[11] has been investigating this possibility, however results are not yet available, but preliminary investigations have shown that the greatest concentrations are in the top three inches of soil, while concentrations at the 3—6 inch level are markedly lower.

C.M.U., being insoluble in both water and oil, must be kept in suspension by continual agitation, and the Hawaiian[12] Experimental Station has found C.A.D.E. and A.R.C.A.D.E. to be an ideal dispersing agent for C.M.U., while water, dilute molasses and aromatic oils are found to be less effective.

Du Toit[13] quoted the cost of weed control in relation to other items and on one plantation the cost of fertilizers amounted to 0.9 dollars and that of weed control to 1.3 dollars per ton of cane. On an irrigated plantation a break-down of the costs of growing the crop to maturity showed:

Item	Percentage of Total Cost
Irrigation flumes and pumping ...	37.0
Fertilizers	15.7
Weed control...	18.5
Cultivation	4.8
Cleaning, hand ploughing and planting	9.2
Preparation of ratoons	10.3
Agricultural research	2.3

He also found that the normal rates of herbicide application in Hawaii were as follows:

2.4–D at	2– 4 lb.	diluted in 20–30	U.S. gals./acre
T.C.A.	,, 20–40 lb.	,, ,, 20–30	,, ,,
C.M.U.	,, 4– 6 lb.	,, ,, 20–25	,, ,,
C.A.D.E.	... ...	20–30	,, ,,

QUEENSLAND

(Australia)

A preliminary investigation into the chemical control of weeds with the hormone herbicide 2.4–D commenced in 1946,[14] but it was not until 1949-50 that field trials were conducted.

The success of these trials and the high cost of labour in Australia added impetus to the use of 2.4–D in cane fields, and the two techniques of chemical control were evolved:

1. a pre-emergent treatment with 2.4–D to inhibit weed seed germination;
2. post-emergent spraying with a contact herbicide to control the more resistant weeds which were unaffected by the pre-emergent treatment.

Pre-emergent Treatment

Pre-emergent applications of 2.4–D were carried out over a wide range of soils and climatic conditions. Results showed that freedom from weeds and grasses could be obtained for periods ranging between eight to twenty weeks.[15]

Before applying a pre-emergent spray it is considered desirable to carry out a single cultivation in order to remove the sharp shoulders of the furrow sides. Planting furrows generally have an almost vertical side and as the soil dries out if falls back into the furrow, and this reduces the efficiency of the herbicide by exposing untreated soil. However, planting furrows vary considerably from one district to another, deep wide furrows are favoured in the north, while shallow, almost imperceptable drills are preferred in the Mackay district. Furthermore, where planting is spread over a week this method of cultivation destroys the grassy weeds which have already germinated. An immediate application of 2.4–D prevents the germination of remaining weed seeds. King[15] states "the open furrow favours tillering and there is no necessity for soil to be worked into the cane row in the early stages. Under some conditions the initial spraying with weedicide is sufficiently long-lasting in its effects to prevent any weed growth before the cane has 'covered'."

Some growers believe in the need to stir up the soil regularly, in which case the herbicide can be applied directly to the cane row in a strip two feet wide, leaving the untreated inter-row to be cultivated at regular intervals.

Post-emergent Treatment

In dryer areas the pre-emergent effect may wear off before the cane has covered in and two courses can be followed:

1. to destroy the weeds by cultivation and follow with another pre-emergent spray;
2. or apply a contact[16] (diesel oil or creosote) containing 2.4–D.

In nut grass areas 2.4–D has no pre-emergent effect on this weed, but post-emergent applications of 2.4–D and methoxone have been found useful in killing the aerial portion and suppressing its growth for three to six weeks, however, only the surface tubers are killed and new growth is produced by healthy tubers.

Under certain conditions post-emergent contact herbicides can be useful in the control of resistant weeds in the cane line itself before the cane has made leaf, or as a cover spray in the interline before the cane has "covered in."

The concentrated contact herbicide contains the following ingredients:[16]

70—80 per cent. diesel oil or creosote

3 per cent. P.C.P.

3—5 per cent. 2.4–D

and an emulsifier.

Vallance[17] recommends the use of 4 lb. sodium 2.4-D. (80 per cent.) in twenty gallons of water per acre, for both pre- and post-emergent applications. For post-emergent contact spraying, four gallons of the above-mentioned concentrated contact herbicide and 3 lb. 2.4-D. (80 per cent.) in thirty gallons of water are recommended. When only the cane row itself is to be sprayed, then the above quantities can be halved.

Tooley and Mathews[18] observed that in addition to the above chemicals, T.C.A. has shown promise as a root poisoning herbicide for special grasses in the Mackay district, and while contact herbicides have not proved entirely satisfactory for the control of couch and guinea grasses, T.C.A. has been found promising.

MAURITIUS

Chemical weed control has been an important item of research during the past ten years, and the results of more recent advances have been published by Rouchecouste.[25]

For pre-emergent treatments it is found that:

1. sodium M.C.P.A. at the rate of 3—4 lb./acre gave the best results and treated plots remained weed-free for a period of six weeks to three months;
2. the sodium and amine salts of 2.4–D are found to be the second best treatments;
3. The ester formulations of 2.4–D, however, are found to be less effective than the others, and produce a marked retardation in cane growth when used at rates over:

   1 lb. 2.4–D ethyl ester/acre

   1½ lb. 2.4–D isopropyl ester/acre

   1½ lb. 2.4–D butoxy-ethanol/acre

This stunting effect became evident two weeks after application, when scorching of leaves and the occasional death of young shoots was observed.

In post-emergent treatments the esters are found to be more efficient than sodium M.C.P.A., sodium 2.4–D, and amine 2.4–D. Here again the danger of retarding the cane still exists and care must be taken not to exceed the rates of application as recommended in the previous paragraph.

Where an area, to be planted with cane, is heavily infested with perennial grasses, it may be necessary to eradicate them before planting operations begin. Rochecouste[19] recommended the following chemicals for perennial weed control: 100 lb. sodium chlorate or 100 lb. T.A.C. in 100 gallons of water per acre, this should be applied one to three months before planting to avoid any toxic effects on the plant cane.

Immediately after planting, the interlines can be harrowed to destroy any weed growth and a pre-emergent application of 3-4 lb. sodium M.C.P.A. in thirty gallons of water per acre should be applied.

When the effects of the initial spray have been exhausted the field can be cultivated and given another pre-emergent spray. The other alternative is to omit the cultivation and apply a contact herbicide.

Recently a semi pre-emergent herbicide has been developed in Mauritius for use in fields where weeds may have already germinated, and especially in ratooning cane. The formulation consists of: P.C.P. (¼-½ gallon Monsanto 15 per cent. emulsion concentrated) which acts as a contact herbicide for growing weeds; T.C.A. (5 lb.) for grass control; and M.C.P.A. (1½-2 lb.), kills broad-leaf weeds and prevents the germination of seeds. The above quantities are diluted to 45 gallons of water and applied to 1½ acres.

Experiment Station,
South African Sugar Association,
Mount Edgecombe.
March, 1955.

Dr. McMartin, in the Chair, stated that weed control was a matter which had been of vital importance to agriculturists throughout the ages, but only in the last few years had chemical science come to their assistance. These new herbicides had different effects on different plants and when studying the literature it was necessary to know exactly which plants were being referred to as the same weed might have different names in different countries. The meeting was very grateful to Mr. Stewart for introducing all the different facets of the subject.

Mr. King asked if one of the delegates from Mauritius would tell us what happened in Mauritius.

Mr. Bax said that Mr. Park was more qualified than he to reply to that question, but he would like to mention that what struck him from the results of applications of weed-killers was that in fields heavily infested by grasses, T.C.A. was applied after the young canes had grown, and that under such conditions the weed-killer could only be applied at low concentrations.

In Mauritius, for fields that were to be replanted and that were heavily infested with grasses, the recommended practice was to apply, per arpent, 100 lb. of a mixture of 60 per cent. T.C.A. and 40 per cent. sodium chlorate in 150 gallons of water, at least two months before planting the cane. This was in order that the weed-killers might have time to translocate to the roots and kill the whole grass plant before it was removed and planting started. Where necessary, localised applications were made when the canes had grown, but this was done carefully with the aid of inverted funnels on the sprayers, in order not to damage the cane plants. He added, however, that recently sodium chlorate had been abandoned, not only because it was difficult to obtain, but because of its explosive properties and the danger during storage.

Dr. McMartin asked if the hazard of storing sodium chlorate was not reduced by adding calcium chloride. He said that it had been abandoned in Natal, not because of the difficulties of storage, but it could not do the work effectively.

Mr. Park referred to so-called "cocktail mixtures" of various herbicides in Mauritius. He gave details of various mixtures used and the strength applied. Such mixtures had helped tremendously owing to labour difficulties and would most unlikely be abandoned now.

Mr. Dymond inquired what harmful residual effects these herbicides had when they eventually found their way into the soil.

Mr. Stewart said that if recommended quantities of these herbicides were used they would have little effect on insects, however their possible effect on the soil micro-organisms was being investigated at the Experiment Station.

Mr. Main wished to know if Mr. Stewart could detail anything new about the use of hydrazine. His interest was more directed towards the suppression of weeds in irrigation furrows. He said that this was used extensively in America, for the purpose of merely stunting plants and not to eliminate them altogether.

Mr. King said that Mr. Main was probably thinking of maleic hydrazide, when he referred to hydrazine. He had conducted small experiments on teff, using maleic hydrazide and had found that it definitely retarded the growth. As regards T.C.A. and sodium chlorate, the application was costly and in Mauritius the cost of an application was sometimes as high as £10 per acre, but he was led to understand that this was only the case in small areas. The cost at the higher rates of application would be prohibitive in Natal. When speaking of costs it appeared that in those countries where labour was short and the cost was high, that they used herbicides more extensively. In South Africa we are now being confronted with a shortage, and not particularly in the high cost, of labour. It was the shortage of labour which would induce the planters to make use of herbicides.

Mr. Bax said that heavy applications of T.C.A. in Mauritius were rather limited to those fields which were heavily infested by grasses, and that the high initial cost was offset in the long run by easier and cheaper weedings.

Mr. Boyes said that prior to entering the sugar industry he was employed by the Shell Refining and Marketing Co. Ltd., in Essex. The two principal weed-killers manufactured there were di-nitro ortho cresol and penta chlor phenol. He was surprised that the former was not mentioned in the papers. It was a weed-killer extensively used by the Royal Dutch Shell Group in Venezuela, but it was very toxic and had been responsible for a number of deaths among labourers. In a series of tests which he had supervised, using D.N.O.C. weed-killer, the labourers were made to wear white overalls and caps, goggles, rubber-boots and gloves. They were not allowed to carry canisters of weed-killer on their backs and the liquid at 0.5 to 5.0 per cent. strength was pumped from a bowser. If any liquid fell on an article of clothing, the article had to be removed and be replaced by a clean one.

He mentioned these facts to draw attention to the hazardous nature of some weed-killers. Manufacturers would be in a position to inform buyers of the necessary safety precautions and these should be adhered to.

Mr. Brassey said that difficulty as far as danger to labour was concerned had been experienced with 2.4.D. oil emulsions.

Mr. Palairet suggested that there was a need for a total weed-killer that could be used on roadways, tramlines and the like. He asked if Mr. Stewart could indicate any herbicide which would be effective against perennial grasses without any danger of eventual translocation into the cane.

Mr. Stewart replied that sodium chlorate and T.C.A. were soluble in water and could be carried into the cane-fields by run-off water. Heavy doses of thse herbicides could eliminate grasses by sterilising the soil.

C.M.U. was a very stable and insoluble compound which would not readily be washed into the cane-field. Experiments with this herbicide have shewn that heavy applications of 40—80 lb. per acre could cause complete elimination of all vegetation for many months, however, the high cost of this material restricted its use as an economic proposition.

Mr. Bax said he thought that sodium arsenite had been used successfully in destroying grasses, but it was highly dangerous to allow labourers to collect the grasses for feeding their animals, which would thus be killed.

Mr. Stewart said that he had concentrated on the less toxic types.

Mr. Coignet asked if it were possible to concentrate on some herbicide which might leave a residual fertilising effect in the soil, such as cynanide.

Mr. Twinch said that during the war weed-killers were mixed with fertiliser. This was discontinued, as it was desired to get the fertiliser into the soil and a herbicide on top of the soil. As far as hydrazide was concerned, this appeared to be used in America and only for domestic purposes, and not a field scale.

Mr. Pearson referred to the differences between herbicide treatment and cultivation and it would

appear that the heavier yields seemed to be reached when pre-emergent spray, cultivation and weeding were applied. He pointed to the treatments No. 8 and 9 in Messrs. King and Almond's paper, where cultivation had not been performed for some eleven weeks and the yields were particularly low. He found that in carrying out trash blanketing and other protective coverings, yields were not as good when the ridge and furrow formation of planting was not levelled out.

Mr. Rault stated that it was interesting to split the sucrose per acre yield into its component parts, i.e. tons cane and sucrose per cent. cane.

It was sometimes stated that a well-cultivated high-yielding field was at a disadvantage for sucrose content of cane, compared with the short and thin material from poor soils and dry areas. The results quoted in Messrs. King and Almond's paper do not support this statement, which should be qualified by saying that rank growth of 60 to 80 tons per acre promoted by excess of moisture and heat, may result in low density juices and corresponding sucrose.

Within the average of 30 to 50 tons, good cultivation should not be blamed for lowered sucrose content of cane.

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