NEW ASPECTS IN THE CONTROL OF RHIZOMATOUS GRASSES WITH SPECIAL REFERENCE TO *CYNODON DACTYLON* (L.) PERS.

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(Submitted by the author)

The control of weeds in sugar cane plantations is an important agricultural problem, for weeds compete with the crop for water, light, and mineral nutrients. The only methods for their eradication had been, until the discovery of the synthetic plant-growth regulators in 1940, hand weeding and mechanical cultivation. A new era began for the sugar cane growers as the selective herbicides MCPA and 2,4-D found application in the eradication campaign against weeds in the sugar cane crop. Although outstanding results had been obtained in the control of annual weeds, yet the sugar industry, the world over, has still to face the problem of rhizomatous grasses on which large sums of money are being spent annually. In the forefront of these 'hard-to-kill' perennials is *Cynodon dactylon* which, owing to its wide distribution in mostly all sugar cane areas of the world, sets up an important agricultural problem.

Rhizomatous grasses, of which every sugar-producing country has its own array, are difficult to eradicate owing to their efficient method of reproduction by means of spreading rhizomes and stolons. With the discovery that trichloroacetic acid (TCA) and 2,2-dichloropropionic acid (Dalapon) could be used for controlling graminaceous weeds, a new method became available for their eradication. As a result, a large number of experiments were laid down with these chemicals on a wide range of perennial grasses in different parts of the world and in diverse plantation crops. From this extensive experimental work, conflicting results were reported by different workers on the rates of application that should be used to obtain satisfactory results. Discrepancies in the data obtained have been attributed to various factors, notably soil-moisture relationship, rainfall, and time of application. The fact that varying results could also be due to the existence of different clones of the same grass species, which differ in their tolerance to the acids, has, until recently, been overlooked.

In the present paper some new aspects in the control of *Cynodon dactylon*, a widely distributed weed in many sugar-producing countries, are emphasized following experimental results obtained on its control by TCA and Dalapon.

VARIATIONS IN CLONAL TOLERANCE TO TCA AND DALAPON

The existence of biotypes within a plant species is fairly well known. However, the significance of biotypes in weed control research has been only recently appreciated following conflicting results upon the chemical control of rhizomatous grasses.

In Hawaii, it has been reported that there exist more than a dozen clones of *Cynodon dactylon* (Bermuda grass) differing in their growth characteristics, and also showing different tolerances to TCA and Dalapon. In Wisconsin, BUCHHOLTZ reported the existence of different clones of *Agropyron repens* (Quack grass), varying significantly in their sensitivity to Dalapon, while in California, McHENRY suggested
that the variable results obtained in the control of *Sorghum halepense* (Johnson grass) may be attributed to resistant strains of that grass.

Varying results in Mauritius upon the control of *C. dactylon* by TCA and Dalapon led to detailed studies on the botany of that grass. Four biotypes were distinguished, two of which are tetraploids named Constance and Réduit, and two triploids named Beau Champ and Bel Ombre. The Réduit clone is usually found growing along roadsides while the three others are important weeds of agricultural lands. Botanical differences existing between the biotypes have been described elsewhere.

The growth responses of the four biotypes to TCA and Dalapon were investigated using the water-culture technique. These studies showed that the biotype differed in their resistance to the acids, the order of resistance, from high to low, being Réduit, Constance, Beau Champ and, Bel Ombre. Field trials were subsequently laid down on pure swards, of the biotypes, but the Réduit biotype could not be included owing to the difficulty of establishing it as a pure sward under field conditions. In these trials, TCA and Dalapon were applied at various dosage rates and at different seasons of the year. The efficacy of the different treatments was assessed in terms of duration of control after spraying. It was found that the three clones differ in their tolerance to both TCA and Dalapon confirming the results obtained with the water-culture technique. The variation in clonal tolerance to the two acids applied in September at two dosage rates, are illustrated in Fig. 1.

![Figure 1](image)

**Fig. 1.** Effect of Dalapon and TCA on biotypes of *C. dactylon*, expressed in terms of duration of control after spraying. Herbicide application made in September. (A = Bel Ombre – B = Beau Champ – C = Constance)

**KNOWLEDGE OF THE BIOLOGY OF THE PLANT IN RELATION TO ITS CONTROL BY CHEMICALS**

The usual procedure to evaluate the efficacy of an herbicide on a rhizomatous grass consists of applying various doses of the chemical on pure swards of the plant to determine which are most effective under different conditions of soil and climate. The correct interpretation of the data obtained is possible only if some knowledge of the life history of the plant is available. Plant growth occurs in phases, and the particular growth phase at the time of herbicide application has an important bearing upon the interpretation of results. The importance of such information on the control of a rhizomatous grass is considered here with reference to *C. dactylon*. 
Growth studies made on the four clones of *C. dactylon* established that the most important phases in their development are seasonal. The development of rhizomes, for example, is as follows:

(i) Formation of new rhizomes takes place at two seasons of the year, in May at the beginning of the cool dry season and in September, at the beginning of the warm dry season. However, while only a few rhizomes are formed in May, a large number are produced in September.

(ii) The position of new rhizomes in the soil also varies with the season. In May, they usually occur in the first 3 in. of soil, while from July to August, during the cool dry months, they are found at a depth of about 6 in. In September they penetrate more deeply, and until November they occur at depths varying from 6 to 12 in. and even deeper.

(iii) Horizontal growth of rhizomes ceases at the end of the warm dry season, November to December; in these months the apices of the rhizomes turn in a vertical position and begin an ascending growth. However, their emergence from the soil apparently depends on soil-moisture conditions, since it occurs in January after the onset of the heavy summer rains.

Studies on the total available carbohydrates in the rhizomes have shown that the quantity varies with the season. The amount of these reserve substances increases slowly from May, the beginning of the cool dry season, to mid-August, then rises rapidly until September, the beginning of the warm dry season, after which it decreases until December. During the warm wet season, January to March, the carbohydrate content fluctuates without following any distinct trend. This seasonal variation in total available carbohydrate in rhizomes is shown in Fig. 2.

Some of the results obtained in the control of *C. dactylon* may now be considered. In a series of trials, TCA at 100, 200, 300 and 400 lb./acre and Dalapon at 10, 20, 40 and 80 lb./acre were applied at different times of the year on pure swards of the three biotypes Constance, Beau Champ, and Bel Ombre, growing under the same environ-
mental conditions. The sprayings were made on the 12th of each of the following months: May – beginning of the cool dry season; July – during the cool dry season; September – beginning of the warm dry season; and February – during the warm wet season.

From the results obtained it was established that:
(i) the three biotypes were best controlled by the September spraying; and of the other three sprayings, that made in May gave the most satisfactory results;
(ii) to spray in September is more economic since rates of application necessary to obtain satisfactory results are lower.

To illustrate these results the effect of Dalapon at 20 lb./acre and TCA at 100 lb./acre applied in February, May, July, and September on the three clones Constance, Beau Champ, and Bel Ombre, are illustrated in Fig. 3, while the growth response of the Bel Ombre biotype to the different rates and times of application of these chemicals are shown in Fig. 4.

When field data are considered in conjunction with knowledge of rhizome growth and carbohydrate content it is observed that the more pronounced effects obtained in
September and in May are connected with the formation of new rhizomes and the downward translocation of metabolites to the rhizomes. Such findings therefore suggest that when there is a downward movement of metabolites to the storage organs, the acids are also carried down, resulting in a concentration which proves lethal to the already established rhizomes and to the formation of new rhizomes. This may then explain the better control which is obtained during these months.

On the other hand, in February the apical buds of the rhizomes and the tillers produced from their dormant buds emerge into new shoots. There is a time interval between the emergence of individual shoots, and it is reasonable to believe that an upward movement of metabolites occurs from the storage organs to the developing shoots as well as a downward movement to the storage organs from the shoots themselves. This movement of metabolites may explain the fluctuation observed in the carbohydrate content of the rhizomes during the warm wet season. If, as already
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suggested, the acids move in the stream of metabolites to the storage organs. Fluctuations in that movement might prevent accumulation of a lethal dose in the rhizomes, hence the poor results obtained. Turning now to the experimental data obtained in July, which is the cool season, environmental factors in particular temperature and light intensity are not then conducive to optimum photosynthesis. A slow downward movement of metabolites, therefore, presumably takes place, and this is supported by the fall in carbohydrate content in the rhizome. If the acids move in the translocation stream, it might be inferred that the building up of a lethal dose in the rhizomes is slowly reached, thus explaining the relatively unsatisfactory control registered in that month.

THE DORMANCY ASPECT IN RELATION TO HERBICIDE APPLICATION

When the rhizome system of a rhizomatous grass is broken up by cultivation, some of the buds on the rhizome fragments grow out vigorously to form tillers, while others remain dormant for varying periods of time. Application of chemicals is made at an appropriate time after cultivation when a sufficient number of rhizome buds have developed into green shoots. The correct timing of the two operations to obtain maximum weed control, depends on many factors, the most important being: (i) the time of the year at which cultivation is performed in relation to rhizome formation and placement; (ii) the extent to which cultivation breaks down the natural dormancy of rhizome buds; (iii) the degree to which the chemicals induce bud dormancy; (iv) the way the chemicals are absorbed, which relates to the development of the rhizome fragments. It is not proposed in this paper to examine in detail the significance of these factors but only to draw attention to some of the experimental results obtained on *C. dactylon* in these respects.

Studies on the germination of isolated single-bud rhizome fragments under greenhouse conditions showed that the cumulative percentage of buds that germinate at fortnightly intervals bears a linear relationship with time for the first 10 weeks after planting, thereafter this relationship is lost (Fig. 5). Further, this relationship was found to be the same for all the biotypes, and independent of the season at which the buds were planted. It would appear therefore that in *C. dactylon*, cultivation will stimulate the germination of rhizome buds only slightly. It is interesting to observe that in England isolated rhizome buds of *Agropyron repens* germinated readily under favourable growth conditions, indicating that cultivation breaks down bud dormancy and stimulates germination of this grass.

Experimental results have also established that the uptake of Dalapon and TCA via the roots is directly associated with the transpiration stream, since in the absence of a green shoot on a rhizome fragment, bud germination was not found to be affected by different concentrations of the acids. Such an observation is important because it indicates that in rhizome fragments where there is no green shoot present, uptake of these chemicals via the roots does not take place and the herbicides are then ineffective.

DISCUSSION

Studies on the biology of *Cynodon dactylon* revealed the existence of different clones of this grass, and showed that these clones differ in their tolerance to TCA and Dalap-
They also stressed the importance of investigations on the botanical character of a sward of rhizomatous grass before laying down field trials, and drew attention to the fact that an herbicide applied to control a sward of a perennial grass made up of different biotypes may encourage the growth and spread of the more resistant strains. Such a situation has arisen in certain areas of Mauritius where the repeated use of TCA on *C. dactylon* swards has led to the establishment of the Constance biotype to the exclusion of the two others, Beau Champ and Bel Ombre.

One other point that has been brought forward in these studies is that the most important phases in rhizome development coincide with the time of the year at which TCA and Dalapon are more effective. This observation is of importance, for it may explain why varying results may be obtained in the control of rhizomatous grasses if the herbicide is applied at different times of the year.

It is interesting to note that in Mauritius a better control of two other rhizomatous grasses, *Phalaris arundinacea* and *Paspalidium geminatum*, are also obtained in September. Since the response of three rhizomatous grasses in Mauritius to TCA and Dalapon is more pronounced at the beginning of the warm dry season in September, it would appear therefore that a particular phase growth in their development is then reached which makes them more responsive to herbicide activity.

With reference to breaking up the rhizome system by cultivation prior to herbicide application to improve results, it has been shown that the problem is inherently
complex. In fact many factors are involved, the most important being the cultivation procedure, the plant response to the environment, and the mode of action of the herbicide. Obviously therefore, the success of such an operation will depend on how much is known about these factors and the way they interact.

SUMMARY

Studies on *Cynodon dactylon* showed that four clones of this grass species exist in Mauritius, two of which are tetraploids and two triploids. Investigations on their phasic growth, established that the most important phases in their development are seasonal. The clones were also found to show different tolerances to TCA and Dalapon. Results obtained from field trials on the control of the grass indicated that the more pronounced effects are obtained at the beginning of the warm dry season and this coincides with the formation of new rhizomes and the downward translocation of metabolites to the storage organs. Cultivation, prior to herbicide application, to break up the dormancy of rhizome buds and stimulate their germination in order to obtain better control of the grass, has been shown to depend on many factors, and the importance of these factors in relation to the success of such an operation has been considered.

It is emphasized that a study of the life history of a rhizomatous grass is necessary to improve the efficacy of herbicides used for its control.

REFERENCES


DISCUSSIONS

H. Evans (B. Guiana): I notice in figure 4 that there is no difference between 10 lb and 80 lb Dalapon. We have very good results with 2-3 lb. Dalapon, particularly when some 2,4-D is added to it. Have you tried lower rates?

E. Rochecoste (Mauritius): We have tried Dalapon at 2 lb and 3 lb per acre but with poor results.

A SUMMARY OF INVESTIGATIONS ON THE POSSIBILITY OF ARTIFICIALLY RIPENING SUGAR CANE WITH VARIOUS CHEMICALS

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(Presented by Dr. H. Evans)

INTRODUCTION

Preliminary results of experiments carried out by Bookers Sugar Estates Ltd. with the view of improving quality of cane at harvest were reported upon by Yates and Bates\(^8\). These experiments included the following treatments: