SESSION NO.9

CHEMICAL METHODS FOR CONTROLLING HYDROPHYTES

By W.P. Dunk

INTRODUCTION

Hydrophytes present an unusual control problem as the growth is either wholly or partly submersed in water and is consequently protected to some extent both from the action of herbicides and from mechanical implements. In Victoria there are four important weeds of this type namely,

1. *Typha angustifolia* ...... Bullrush or cumbungi
2. *Paspalum distichum* ...... Water couch grass or silt grass
3. Submersed weeds .... Mainly *Potamogeton ochreatus* and *P. tricarinatus* (pondweeds), *Myriophyllum elatinoides* (cattail), and *Vallisneria spiralis* (ribbonweed)

and 4. *Juncus articulatus* ...... Jointed rush or onion grass.

The problem of weed control in waterways in Victoria is fundamentally the problem of controlling these four types of weeds, other weeds are less important as they are generally slow growing or limited in occurrence. The position in other States is probably much the same although additional weed species may be involved. A number of other weeds also frequently cause local troubles in Victoria but in this paper only the four main ones will be discussed.

From an experimental point of view the emergent hydrophytes are relatively easy to work with. This is because firstly, the plants usually grow in pure closed communities which means that long lengths of uniform weed growth are available for testing; and secondly under the hot, wet and silty conditions which prevail regrowth develops on the unsuccessfully treated plots at a meteoric rate which means that the control method must be a good one and must kill something like 75% of the plants.

Consequently large clear cut controls are being sought and, provided the experimental site is carefully selected, it is possible to carry out a great deal of preliminary screening of herbicides in the field without statistical treatment of results.

Completely submersed hydrophytes, although they grow in pure stands in the same way as the emergent plants, are much more difficult to handle experimentally. This is because the water medium which surrounds the plants introduces a number of variables and also makes the results difficult to assess.

The purpose of this paper is to summarise the work which has been carried out on the main hydrophytes and to state the present position with regard to the chemical control of each. More detailed summaries of the work done by the Victorian State Rivers and Water Supply Commission are given in other publications (W. P. Dunk 1953, 1954).

TYPHA ANGUSTIFOLIA - CUMBUNGI, BULLRUSH

1. GENERAL DESCRIPTION:- *Typha angustifolia* is an emergent perennial of world wide occurrence which is common in the irrigation districts of northern Victoria. The extensive system of underground rhizomes forms one means of spread but the plant also seeds prolifically and R. W. Prunster (1941) reports that each flower spike produces from 300,000 to 700,000 seeds, 66 per cent. of which are fertile.

2. REVIEW OF EXPERIMENTS:- Work by R. W. Prunster (1940) showed that regular underwater cutting was the most economical method of eradicating *Typha* from irrigation channels where water can be maintained above the cut stalks. Death of the plant is attributed by Prunster to anaeobic respiration resulting in the accumulation of alcohol and organic acids which kill the submersed organs including the rhizomes. Prunster found that only plants in shallow water survived frequent cutting and that the frequency of cutting depended on the depth of water in the channel. Thus, in a channel of more than 15 inches depth, it was found that 96 per cent. of the original population was killed with six cuttings at six-weekly intervals.

Underwater cutting has not given effective control in drainage systems where the water level fluctuates also the method is too expensive for general use in infested rivers and swamps. Consequently the need remained for a chemical treatment which would eradicate Typha, economically, particualarly from drainage systems.

Overseas studies on the chemical control of Typha have been mainly carried out by the U.S. Bureau of Reclamation. This work has indicated that ester forms of 2,4-D and mixtures of sodium 2,4-D and T.C.A. were the most promising, the applications being made at rates varying from 3 lb. to 13 lb/acre 2,4-D acid equivalent but mostly at the lower rates. A recent report (U.S.B.R., 1954) has concluded that the results obtained with these chemicals were not consistent and that a more effective method of control was needed.

Mr. E. Levi, who has been working on various irrigation weeds at the C.S.I.R.O. Research Station at Griffith in the Murrumbidgee Irrigation Area, reports that ...."the results of field trials using 2,4-D and 2,4,5-T on Typha have shown the favourable possibilities of 2,4-D for the control of this weed species. Effects of formulations of 2,4-D carriers, emulsifiers, stages of plant growth and number of applications as well as depth of water before and after spraying were studied. Results show that plants not actively growing are less responsive to 2,4-D and that depth of water may be an important factor. However available results do not allow definite conclusions to be drawn at this stage."

Experimental work has also been carried out on this problem by the Victorian State Rivers and Water Supply Commission over the last 3 years. At the outset a wide range of contact herbicides, soil sterilants, systematic herbicides, and carriers for systemic herbicides were compared in non statistical field trials. These trials indicated, as was to be expected from the American work, that the only effective chemicals were ester forms of 2,4-D such as the ethyl and butoxyethanol esters, and also a mixture of sodium 2,4-D and sodium T.C.A. Particularly good results were obtained with a formulation called EF980M prepared by the Vacuum Oil Company and having the following analysis:-

Ethyl ester of 2,4-D	37 per cent
Diesel distillate	22 per cent
Emulsifying & wetting agents	41 per cent
Specific gravity	1.07

Subsequent experiments have been carried out principally with (i) EF980M and (ii) the butoxyethanol ester of 2,4-D (Weedone 57 L.V. manufactured by Agricultural Services Ltd.), for the purpose of determining the conditions required for the successful application of these chemicals.

Experiment (i): In one experiment using a split plot design a comparison was made between the rates of application of EF980M at 6, 12 and 24 lbs. 2,4-D acid equivalent per acre and also between different volumes of water carrier namely 37½, 75, 150 and 300 gallons per acre. These treatments were compared with the effect of cutting the plants. The treatment was made under ideal conditions and very good results were obtained even at the lowest application rate thus when final counts were made 3 months after treatment average kills at 6, 12 and 24 lbs. 2,4-D acid equivalent per acre were 98.5%, 99.6% and 99.8% respectively and cutting gave a 60% kill. The 12 lb. per acre rate was significantly better than the 6 lb. per acre rate but the difference between 24 lbs. per acre and 12 lbs. per acre was not significant. Under the ideal conditions of the experiment the optimum application rate was therefore 12 lbs. 2,4-D acid equivalent per acre. Varying the amount of water in which the chemical was applied did not make much difference to the kill and there was no significant difference between any of the 4 volumes compared.

Experiment (ii): In another experiment using the butoxyethanol ester of 2,4-D applications were made at 3, 6 and 12 lbs. 2,4-D acid equivalent per acre applied to a young stand of cumbungi at different times of the year namely early in the season (23/10/52, mid-season (5/12/52) and late season (15/1/53). The stand was kept in a young condition by continued cutting, each spraying then took place as soon as the regrowth had reached approximately 2 ft. 9 in. in height. A factorial design was used for this experiment. The percentage reductions in the number of shoots from the different treatments are shown in Table I and the statistical treatment of the results is given in Table II.

The tables show that at the "Early Season" treatment there was no difference between the 3 lb/acre and 6 lb/acre rates of application but the 12 lb./acre rate reduced the stand significantly.

When sprayed "Mid Season" all rates significantly reduced the stand below the corresponding rates at "Early Season" spraying, also the difference between the 3 lb/acre and 6 lb/acre rates approaches significance and the difference between the 6 lb/acre and 12 lb/acre rates is significant.

At the "Late Season" spraying the 6 lb/acre rate was the only one to significantly reduce the stand below the Mid season value. In addition the 6 lb/acre and 12 lb/acre rates both significantly reduced the stand below the 3 lb/acre rate, but there was no difference between the 6 lb/acre and 12 lb/acre rates.

TABLE I

Percent reduction in stand of Typha by treatment of young plants at different times of the year using the butoxyethanol ester of 2,4-D. Counts taken ~~90~~ 40 days after spraying.

Treatment	Time of Treatment			
	Early 23/10/52	Mid 5/12/52	Late 15/1/53	Mean Value
acid equivalent	per cent kill	per cent kill	per cent kill	per cent kill
3 lb/acre	64	78	85	77
6 lb/acre	76	89	94	88
12 lb/acre	91	96	95	94
Mean Value	80	90	93	-
Cutting underwater	37	24	71	49

The difference between the mean values for the various times of treatment and also for the various application rates were all significant.

Thus it seems that provided a young growth is being treated the effectiveness of the spray increases as the season advances (between 23/10/52 and 15/1/53). Also the effectiveness increases with increasing rates of application of the butoxyethanol ester of 2,4-D (between 3 lb/acre and 12 lb/acre acid equivalent).

Experiment (iii): Following on this work a number of treatments made late in the season, but to mature growth, were observed to be almost complete failures. It was considered that these poor results could be caused by either (i) a factor within the plant itself probably associated with maturity or (ii) an environmental factor occurring outside the plant such as water depth or a temperature effect.

TABLE II

Average number of Typha plants per 4 sq. yards after each treatment with the butoxyethanol ester of 2,4-D. Counts taken 40 days after spraying.

Treatment	Time of Treatment			
	Early 23/10/52	Mid 5/12/52	Late 15/1/53	Mean Value
acid equivalent	~~per cent kill~~	~~per cent kill~~	~~per cent kill~~	~~per cent kill~~
3 lb/acre	119 (2.07)	58 (1.76)	35 (1.55)	63 (1.80)
6 lb/acre	82 (1.91)	31 (1.49)	13 (1.12)	32 (1.51)
12 lb/acre	31 (1.50)	10 (1.02)	11 (1.03)	15 (1.18)
Mean Value	68 (1.83)	26 (1.42)	17 (1.23)	-
Cutting underwater	211 (2.32)	197 (2.29)	69 (1.84)	141 (2.15)

Differences required for significance

(a) Between Treatment Means	$P < .05$	(0.18)
	$P < .01$	(0.23)
(b) Between Season Means	$P < .05$	(0.16)
	$P < .01$	(0.21)
(c) Between Means in Body of table	$P < .05$	(0.30)
	$P < .01$	(0.41)

Figures in brackets refer to the transformed values on which the statistical analysis was based. The log x transformation was used.

To evaluate these factors a stand of young Typha was treated with EF980M (distillate based 2,4-D ethyl ester) at 12 lbs. acid equivalent per acre applied in 200 gallons of water per acre. The applications were repeated on different plots at various times throughout the season as the growth matured. The kill obtained with each application was later assessed. The results, which are tabulated in Table III indicate a rapid falling off in effectiveness of the spray as the plants mature following the emergence of the flower stalks.

TABLE III

Effect of Maturity on Kill - Uncut Plants Sprayed November to March

Maturity of cumbungi plants when sprayed.	Date Sprayed	Per cent. kill obtained.
Flower stalks just appearing. 6-8 leaves, 3-7 ft. high.	Nov.12th, 1953	98
Flower stalks completely emerged, pollen partly or completely shed. 6-10 ft. high.	Dec.15th, 1953	80
Seeds forming in flower heads.	Jan.13th, 1954	29
Seed heads about ripe.	Jan.27th, 1954	* (Low kill obtained)
Plants mature and yellowing.	Feb.18th, 1954	*
Plants mature and yellowing.	Mar.5th, 1954	*

* The % kill of plants cannot be estimated until regrowth develops next season.

To show that a factor within the plant itself, and not an environmental factor is mainly responsible a second stand of cumbungi comparable in maturity and environment to the first was cut on December 18th, 1953. This cutting stimulated a young, fresh, immature regrowth which was then sprayed at intervals throughout the remainder of the season. The dates of treatment coincided with those for the first (mature) stand and the environmental conditions were similar. The per cent.kills obtained by spraying these immature plants are given in Table IV.

Although complete counts cannot be taken until next season (November 1954) and although direct statistical comparisons between Table III and Table IV are not valid it seems (when these results are taken in conjunction with Experiment ii) that a factor within the plant which is probably related to maturity is a vital consideration in determining the effectiveness of hormone spray treatments on *Typha*.

TABLE IV

Effect of Maturity on Kill - Plants Cut in December, and Sprayed January to March.

Maturity of cumbungi plants when sprayed.	Date Sprayed	Per cent. kill obtained
Vigorous young growth 2-3 ft. high.	Jan. 27th, 1954	99
Young growth 3-4 ft. high.	Feb. 18th, 1954	* (high kill obtained)
Regrowth 4 ft. high.	March 5th 1954	*
Regrowth 5 ft. high.	March 24th, 1954	*

* The % kill of plants cannot be estimated until regrowth develops next season.

3. CONCLUSIONS:- As a result of the work reported above, and of a number of other experiments which have been carried out, and also of the experience gained from the large scale spraying of about 50 miles of drainage channel it is considered that there is now no doubt whatever that *Typha* can be cheaply eradicated from most irrigation and drainage channel systems by chemical means. As a guide for making the application it is suggested that the following points be borne in mind.

(1) Best results have been obtained using oil based esters of 2,4-D, and a heavy oil such as diesel distillate would appear to give better results than a light petroleum fraction. This point has not been proved but it looks to be fairly definite.

(2) Although under ideal conditions 85 per cent. kills have been obtained with applications of 2,4-D esters at 3 lbs. 2,4-D acid equivalent per acre and 98 per

cent. kills have been obtained at 6 lbs. per acre it is recommended that, under normal circumstances, the higher rate of 12 lbs. 2,4-D acid equivalent per acre be used. This rate gives a reasonable margin of error. When making the application 200 gallons of water per acre will ensure thorough coverage.

(3) The plants must be young and vigorously growing when treated. Maturity is a vital consideration and once the plants have matured to the extent that the flower spikes have fully emerged then poor results are obtained by spraying. However if the stand is cut to promote a vigorous young regrowth then this regrowth is readily killed by spraying. Factors such as a dry channel bed or salty water, which slow down the growth rate, diminish the effectiveness of the spray.

(4) Spraying should be commenced when the new season's growth is about 3-5 ft. in height. Spraying should not be carried out later than the end of January as poor results may be obtained.

(5) Although good kills have been obtained with water depths up to 2 ft. 6 inches there is considerably more regrowth with the deeper water and best kills have been obtained when the water is less than 12 inches deep at the time of spraying.

When the treatment has been carried out correctly the plants first turn yellow and this is followed by drying out of the foliage and by rotting of the shoots at soil level. Within six weeks the shoots are completely rotted through.

PASPALUM DISTICHUM - WATER COUCH GRASS, SILT GRASS.

Paspalum distichum is a vigorously growing, creeping perennial which is usually found in the beds of shallow drains and channels and near the margins of deep waterways. Propogation is by means of underground and surface runners, by seed and also by vegetative means. From early December until mid February the grass grows rapidly spreading in towards the centre of the drain and in this way a tangled mass of roots and runners is formed which may completely block a shallow waterway. Now that *Typha* can be controlled *Paspalum distichum* has become the most serious weed infesting drainage systems in Victoria.

A range of contact herbicides, soil sterilants and systemic herbicides have been tested against this weed. Most of these chemicals gave negative results but it has been shown that control for a whole season is possible by applications of soil sterilants during late winter when the water level in the drain is low and the root zone of the plant is exposed.

The best of the treatments tested were 80% C.M.U. at 50, 100 and 200 lbs. per acre, Sodium 2,4-D at 70 lbs. per acre acid equivalent and "Ammate" (80% ammonium sulphamate) at 600 lbs. per acre. A number of other soil sterilants were tried including sodium T.C.A. and "Atlacide" each applied at 100 and 600 lbs/acre. These chemicals gave temporary sterilization only and did not persist in the water-logged soil with the result that regrowth developed rapidly.

When the cost of these treatments is taken into account it seems that the use of hormones as soil sterilants provides the most promising avenue for further research into the control of Paspalum distichum.

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POTAMOGETON SPP., MYRIOPHYLLUM ELATINOIDES and VALLISNERIA SPIRALIS - SUBMERSED WEEDS.

Although there are a number of types of submersed weeds they may be conveniently grouped together as they all present much the same problem and moreover control methods are likely to be similar for the various species.

Very little work has been carried out on methods of controlling these plants in Australia but the chemicals reported to be used overseas for this purpose include copper sulphate, sodium arsenite, nigrosine, fertilizers, growth regulants and a group of emulsified aromatics.

The emulsified aromatics, including chlorinated benzenes petroleum naphthas and coal tar naphthas are the most widely used and, according to the literature, are applied by injecting the material into the flowing water at a concentration of 300-600 p.p.m. for a period of 30 minutes. However a number of tests carried out using aromatic material prepared in Victoria have indicated that concentration of 600 p.p.m. for 1 hour may be necessary to obtain consistent results.

The field investigation of aromatic substances is not a very satisfactory approach because each application must be made in a different channel. Under these conditions there are a great many variables to consider for example water flow, water temperature, sunlight, density of weeds, species of weeds, maturity of weeds, channel grade and cross section. Also there are more fundamental variable such as the formulation of the aromatic material used and the concentration and period of application.

Work in Victoria has shown that it is possible to control all the main submersed weeds with applications of aromatic solvent at 600 p.p.m. for a period of 1 hour. However, as these chemicals have only a contact effect, regrowth is rapid and two applications are required each year to maintain control. At present the aromatic chemicals are too costly for general use in Australia.

In an endeavour to develop a cheaper treatment investigations have also been carried out with various hormone preparations. It is known that the common submersed weeds are susceptible to hormones but the difficulty is to apply the chemical to leaves which are completely surrounded by a water medium. Trials carried out have indicated that quick-breaking emulsions of 2,4-D ester products have definite promise in this direction.

JUNCUS ARTICULATUS - JOINTED RUSH, ONION GRASS

Most species of rush grow just above the water line and consequently do not obstruct channel systems. Juncus articulatus, which is an exception, is commonly found growing in the moist beds of shallow drains.

Trials have shown the plant can be effectively controlled using the ethyl ester of 2,4-D at the rate of 6 lbs. 2,4-D acid equivalent per acre applied in 150 gallons of water per acre. The best of the commercial products tested was an emulsifiable concentrate of the ethyl ester of 2,4-D based on a light petroleum fraction. Applications made at half the above rate have also been fairly satisfactory however the saving in cost is negligible in relation to the cost of labour. This control method has now been widely used on a practical scale and consistently good results have been obtained.

CONCLUSION

There are four main weeds which infest irrigation and drainage systems in Victoria and effective chemical control techniques have now been developed for two of them namely Typha angustifolia and Juncus articulatus. The other two namely Paspalum distichum and submersed weeds can also be controlled but at the present time the methods evolved are too costly for general use.

It has been noted that the elimination of one weed by chemical treatment frequently opens the way to invasion by another which is resistant to the spray. Thus in many instances Paspalum distichum has taken over where Juncus articulatus and Typha have been controlled. This succession of weeds growing in the place of others is not likely to occur in every case but economical control methods must be developed for Paspalum distichum and submersed weeds before chemicals can be of much value in the overall maintenance programme.

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