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RESPONSE OF *TYPHA LATIFOLIA* L. TO CUTTING, COMPETITION, WATER LEVEL AND GLYPHOSATE UNDER FIELD CONDITIONS

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ABSTRACT

Typha latifolia L. is a widespread nuisance aquatic weed species. It is a harmful weed in the Iranian freshwater systems, especially in the Anzali lagoon. The effects of frequent cutting at the different levels of water, competition and late application of glyphosate on dry weight, shoot length, number of shoots and number of leaves per plants of *T. latifolia* were studied in the Anzali lagoon. *T. latifolia* dry weight and shoot length decreased significantly after cutting, compared to the control plants. Dry weight was uniformly reduced in all treatments after 1, 2 and 3 cuttings. Three cuts during the growing season resulted in almost complete death of the plants. Water level and intraspecific competition did not have a significant influence on dry weight and shoot length. The best time for cutting was late June to early August, when carbohydrate reserves in the rhizomes were low, and just before the inflorescence appears. *T. latifolia* was susceptible to glyphosate at doses of 1.5 kg a.i. ha^{-1} and higher. Although, high rates (1.5, 2, 3, and 4 kg a.i. ha^{-1}) of glyphosate provided excellent initial control of *T. latifolia*, long-term control of regrowth was not achieved. Late season application caused poorer control due to a lack of the moyement of photosynthate to areas of high metabolic activity.

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Key words: Anzali lagoon, Cutting, Competition, Glyphosate, Iran, *Typha latifolia*, Water level.

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واکنش علف هرز لویی به قطع کردن، رقابت، سطوح مختلف آب و علفکش گلیفوسیت در شرایط مزرعه

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چکیده

لویی(*Typha laiifolia* L.) یک علف هرز خطرناک آبزی با دامنه وسیع انتشار می باشد که در بسیاری از آب های داخلی ایران و بویژه تالاب انزلی رشد و ایجاد مزاحمت می نماید. در این مطالعه، اثرقطع کردن در سطوح مختلف آب، رقابت و کار برد علف کش گلیفوسیت بر وزن خشک، طول، تعداد ساقه های هوایی وتعداد برگ درگیاه در تالاب انزلی بررسی شد. وزن خشک و طول لویی پس از قطع کردن، در مقایسه با شاهد به طور معنی داری کاهش یافت. در تمام تیمارها وزن خشک به طور یکنواخت پس از ۱، ۲و۳ بار قطع کردن، کاهش یافت. تعداد ۳ بار قطع کردن علف هرز لویی در طول فصل رشد باعث مرگ و کنترل کامل آن شد. سطوح مختلف آب و رقابت تاثیر معنی داری بر وزن خشک و طول گیاه نداشت. بهترین زمان برای قطع کردن علف هرز لویی اواخر خرداد تا اواسط شهریور بود. در این زمان میزان ذخیره کربوهیدرات در اندام های زیر زمینی این علف هرز، در حداقل بود و این زمان تقریبا بلافاصله پیش از گلدهی است که علف هرز لویی به غلظت های بالاتر از ۱/۵ کیلو گرم ماده موثر علفکش گلیفوسیت حساس می باشد. گر چه غلظت های بالاتر از ۱/۵ کیلو گرم ماده مؤثره گلیفوسیت درمراحل اولیه کاربرد باعث کنترل مناسب لویی گردید، اما در دوره های طولانی باعث جلوگیری از رشد مجدد این علف هرز نشد. این نتایج نشان

داد که کاربرد گلیفوسیت در انتهای فصل رشد به دلیل حرکت نکردن مواد فتوسنتزی به مناطقی با فعالیت متابولیکی بالا، قادر به کنترل مؤثر علف هرز لویی نیست.

INTRODUCTION

In many parts of the world, *Typha latifolia* is a major component of wetland ecosystems. This species grows most vigorously in shallow waters and competes very successfully with other emergent macrophytes (6, 8, 9). *T. latifolia* is a rhizomatous perennial that usually grows in dense, monospecific stands (6, 8). Rapid and excessive growth of *Typha* has adverse effects on water quality, blocking water courses, and hindering fishing and creates problems for rice growers (7, 17).

The most common method of controlling *T. latifolia* is cutting, but this is no more than a short term solution. *T. latifolia* is particularly difficult to control just by cutting because networks of underground rhizomes give rise to new shoots. Several reports (12, 13, 14, 15, 18, 22, 23, 28, 29, 31) suggested that cutting the shoots below the water level and keeping the stubble submerged under water for a long time is effective for the control of *T. latifolia*. Past experience (2, 12, 16, 22, 28, 31) suggests that growth of the *Typha* was not limited by cutting-off the foliage, unless this was done over a long period.

The use of shade for reduction of macrophyte growth could be a useful alternative for cutting. Dawson (5) reported that direct removal of plants is only a short term control and is currently becoming more expensive. He proposed that the reduction of light by shading is an alternative technique for the limitation or reduction of excessive growth of aquatic macrophytes.

The objectives of these experiments were to investigate i) the possibility of controlling *T. latifolia* grown from rhizomes by frequently cutting the shoots close to the substrate at different levels of water with and without competitors, and ii) to assess the susceptibility of *T. latifolia* to glyphosate during the mid-autumn period. The reason for choosing this stage of the life cycle of *T. latifolia* was to identify potential vulnerable for improving control.

MATERIALS AND METHODS

Experiment 1

Three blocks of approximately equal area (500 m^2) were randomly selected in the Anzali lagoon in the north of Iran. In order to control *T. latifolia* in different levels of water, 24 plants were selected from 0-5, 20-30 and 60-80 cm water depths. On May 22, 1999, when shoots were about 80 cm, shoots of 6 plants were cut about 5 cm above the water level, 6 plants were cut about 20 cm below the water level, and 6 plants were cut about 60 cm below the water level. Six plants were left intact to serve as controls. For a half of each set of the *Typha* plants, competing plants were cleared to a radius of 0.5 m. The plots were naturally dominated by *Glyceria*, *Carex*, and *T. latifolia*. In the other half, the competitors were left untouched.

After 45 days (on July 7, 1999) any regrowth was removed at the same point as in the first cut. The third cut was carried out on August 15 like the previous cuts. Fifteen months after the first cutting (on 20 August 2000), all cut plants and controls were harvested. A 3 × 4 × 2 factorial design under complete randomized block in which three levels of water depth were cross-classified with four levels of cutting and two levels of competition was used with 3 replicates. Traits measured were shoot length and above ground dry weight at final harvest.

Experiment 2

Control of *T. latifolia* with glyphosate: late season application. On September 5, 1999, 4 blocks (1 × 7 m^2) were randomly selected in the Anzali lagoon, Iran. As far as possible, uniform stands of *T. latifolia* were selected. Each block was divided into 7 plots. On September 6, 1999 seven glyphosate rates (0, 0.5, 1, 1.5, 2, 3, and 4 kg a.i. ha^{-1}) were applied into plots. The depth of water in the plots were higher than 40 to 60 cm. The experimental design was a randomized complete block with four replications. The effects of the treatments were assessed by counting the numbers of shoots in each plot, shoot length, leaf number, and above ground dry weight one year after glyphosate application.

Data were subjected to analysis of variance followed by separation of means by the least significant differences (LSD) tests, at the P=0.05 level, using the Genstat and Minitab Softwares.

RESULTS

Experiment 1

T. latifolia dry weight decreased significantly ($P<0.001$) after cutting, compared with the control plants. Dry weights were uniformly reduced by all treatments after 1 and 2 cuttings (Fig. 1). The highest plant dry weight was obtained for the control, compared to reduction of 53, 84, and 100% after 1, 2, and 3 cuttings (Fig. 1). A single cut at the early or middle stage of the growth season did not produce satisfactory control. Except for a few plants, there was no regrowth after second cut. In both 2 and 3 times cuttings, regrowth of *T. latifolia* was not significant at the time of final cut on early autumn (Fig. 1). A significant decrease ($P<0.01$) in shoot length was observed after 1, 2, and 3 cuts. The reductions were 22, 58, and 100%, respectively. The highest shoot length was recorded for the treatment combination of uncut *T. latifolia* at 60 cm depth without competitors (Fig. 1).

Water depth did not have a significant influence on dry weight and shoot length, although *T. latifolia* dry weight at a 60-cm depth was 12 and 30% growth than at 5 and 20 cm depth, respectively. There were also 8 and 44% increases in shoot length at 60 cm water depth, compared to 5 and 20 cm depth, respectively. However, variability in shoot length led to a lack of statistical significance between treatments (Fig. 1)

The analysis of variance showed that intraspecific competitors had little influence on shoot length, and plant dry weight at all water depths. However, there were approximately 3 and 10% reductions in dry weight and shoot length, respectively, in the presence of competitors. The highest dry weight for *T. latifolia* was observed at 60 cm depth without competitors.

After 3 cuts, 90% of *T. latifolia* for those cuts 60 to 80 cm below water level had died. Frequeat observations showed a discoloring of leaves for more than 70% of uncut plants at different water depths, but new shoots were beginning to emerge from the sediment at the last stage of experiment. Extensive tissue breakdown was observed in the stubble of *T. latifolia* which was cut and submerged for more than 3 wk.

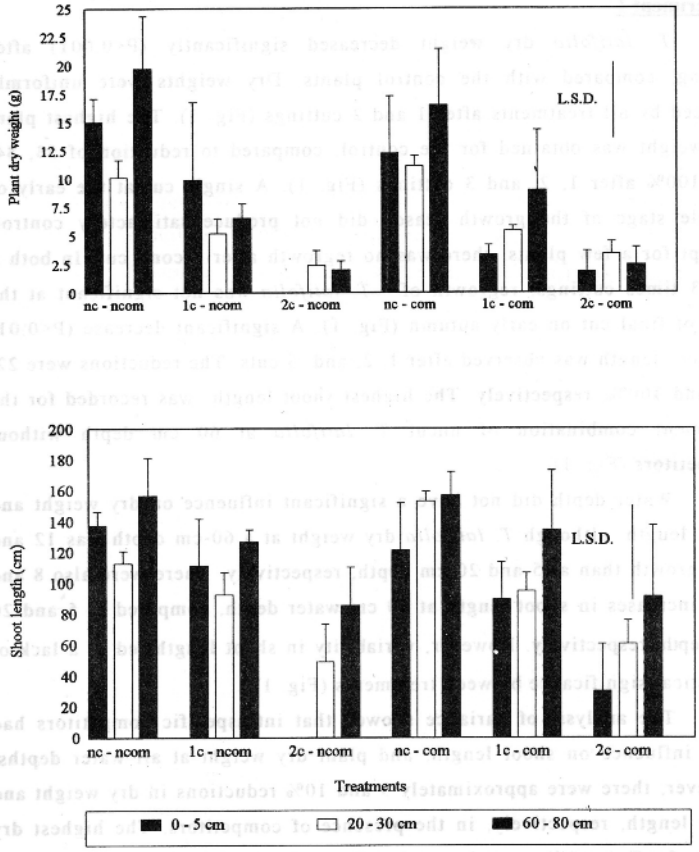

Fig. 1. Plant dry weight (g), and shoot length (cm) of *Typha latifolia* along a gradient of water depth with and without competitors, and different levels of cutting. Bars on histograms represent ±1 SE.; separate bars represent least significant difference ($P<0.05$). Key to treatments: c = cutting, nc =no cutting, 1c = one cut, 2c = two cuts, com = competition, ncom = no competition.

Experiment 2

A significant ($P<0.001$) increase in *Typha* mortality at 1.5, 2, 3, and 4 kg a.i. ha^{-1} glyphosate was observed 2 mo after application. Glyphosate treatments at 2, 3, and 4 kg a.i. ha^{-1} caused a severe injury and an increased mortality at the end of growing season. Visible effects were gradual wilting and yellowing of the treated plants at lower doses after 1 wk to complete browning, deterioration of plant tissue and ultimate decomposition of the underground roots and rhizomes at upper doses 3 wk after application.

'A 43, 59, 68 and 78% reduction in *Typha* dry weight was found at 1.5, 2, 3, and 4 kg a.i. ha^{-1} glyphosate, respectively, compared to control, but no significant differences (P=0.05) were observed at lower doses (Table 1). Plant dry weight in all treated areas never exceeded that observed in the controls (Table 1). Reduction of growth rate was directly proportional to the rate of glyphosate.

Table 1. Mean comparisons of biomass dry weight (g), shoot length (cm), number of leaves per plant and shoots per m^2 with controls in the late season application of glyphosate.

Treatments	Dry weight (g)	Shoot length (cm)	Number of leaves	Number of shoots
Control	194.0a†	128.75a	7.00a	98.0a
0.5 kg a.i. ha^{-1}	170.5a	109.50a	6.25a	88.0a
1 kg a.i. ha^{-1}	149.0a	99.25a	5.50a	82.5a
1.5 kg a.i. ha^{-1}	110.5b	90.00b	5.75a	65.0b
2 kg a.i. ha^{-1}	79.5b	77.00b	5.25a	46.0b
3 kg a.i. ha^{-1}	62.0b	73.00b	4.75b	40.0b
4 kg a.i. ha^{-1}	42.7b	64.00b	4.00b	29.5b

† Means followed by similar letters in each column are not significantly different at the 5% level.

The number of shoots and leaves were also strongly reduced by increasing glyphosate rate, and the strongest effects were observed at the

highest glyphosate concentration (Table 1). Compared with the untreated control, glyphosate at 1.5, 2, 3, and 4 kg a.i. ha^{-1} significantly (30, 40, 43, and 50%, respectively) reduced the shoot length. The reduction, however was not significantly greater at 4 kg a.i. ha^{-1} than at 2 kg a.i. ha^{-1}. Significant reductions of number of leaves per plant at 1.5, 2, 3, and 4 kg a.i. ha^{-1} glyphosate were 21, 25, 32, and 43%, respectively (Table 1).

Glyphosate at 0.5 and 1 kg a.i. ha^{-1} had no effect on the number of shoots in each plot, and though a reduction (10 and 16%) was indicated for number of plants in each plot, these values were not significantly different (P=0.05). Higher concentrations of glyphosate reduced significantly (34, 53, 59, and 70%) the number of plants in each plot (Table 1). None of *Typha* treated with more than 1 kg a.i. ha^{-1} went on to flowered by the end of the experiment.

DISCUSSION

Aquatic plant management by cutting mainly depends on water depth, frequency of cutting, and time of cutting. Ideally, *T. latifolia* shoots should be cut below the water surface and just before flowering when most of nutrient reserves are located in the foliage. Shoot growing points were deeper than the cutting level and some were embedded in soil, at mid-May before flowering. Therefore, cutting was not effective at this time. Similar results were obtained by Van der Toorn and Mook (27) on *Phragmites australis* and Ham *et al.* (11) on *Ranunculus penicillatus*.

At most of the experimental sites, uncut *T. latifolia* flowered from mid-July to early September. Plants cut in mid-May regrew but did not flower. Other studies (13, 20) agreed with these research findings. The present study shows that late June to early August is the best time for cutting (in Northern Hemisphere conditions), when carbohydrate reserves in the rhizomes are low, and just before the inflorescence appears. Westlake (30), Dawson (4), Singh and Moolani (22) and Filizadeh (8) suggested that cutting *T. latifolia* before flowering in spring may stimulate further growth. Similar rapid regrowth of *T. latifolia* after cutting was observed. Despite a change in canopy formation, there were no significant differences in biomass between the control and cut, in the early growing season, in all experimental sites.

Experimental results showed that three cuts during the growth season resulted in almost complete death of the plants. These results are in agreement with those of Shekhov (21), Riemer (18), Sale and Wetzel (19), Husak (12), and Wade (28) who found that cutting-off shoots below the water surface two or three times during the growing season had a strong control effect on *Typha* stands.

Experimental results showed that *T. latifolia* was susceptible to glyphosate at a dose of 1.5 kg a.i. ha^{-1} and above. These findings were similar to those of a study on *Glyceria maxima* by Barrett (2) who concluded that survival rate for a short time after a treatment with 2 kg a.i. ha^{-1} glyphosate was very low. Despite a large decrease in plant dry weight at 2, 3, and 4 kg a.i. ha^{-1} glyphosate compared with untreated plants, there was a substantial recovery of *T. latifolia* one year after treatment. This finding agrees with that of Smith *et al.* (24) who concluded that a single application rarely suffices for complete control of a rhizomatous species for a relatively long period. Glyphosate must be absorbed and translocated to the rhizomes in quantities that are phytotoxic. Although high rates (1.5, 2, 3 and 4 kg a.i. ha^{-1}) of glyphosate provided excellent initial control of *T. latifolia*, long-term control of regrowth was not achieved. Experimental results suggested that a late season application resulted in poorer control due to a lack of the movement of photosynthate to areas of high metabolic activity. Agreeing with Murphy and Barrett (16) these results suggested that late-season treatments of glyphosate produce a poor result due to senescence of plants before the glyphosate has been fully translocated into the rhizome system (10, 25). It must be pointed out that satisfactory control of *Typha* by using low doses of glyphosate could be achieved if applied during intensive growth, i.e., before and during flowering (1, 3, 20).

The low degree of control at 1.5, 2 and 2.5 kg a.i. ha^{-1} glyphosate suggests that for obtaining a low regrowth in the following season the rate of herbicide must be increased. At 0.5, 1 and 1.5 kg a.i. ha^{-1} glyphosate no symptoms of having been sprayed were observed, and treated plants were indistinguishable from untreated plants.

Like other rhizomatous species, *Typha* is a resistant species. Its growth is suppressed in the season of application but regrowth occurs the following spring. In order to obtain long term control (>24 mo) of *Typha*, rhizomes must be controlled (2). *Typha* rhizomes, were not as sensitive as

shoots to glyphosate except at the highest concentration. Complete inhibition of rhizome regrowth, therefore, requires higher doses of herbicide.

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LITERATURE CITED

1. Arsenovic, M. and B. Konstantinovic. 1990. Aquatic weed control with herbicides in drainage systems in Yugoslavia. Proceedings of EWRS 8th Symposium on Aquatic Weeds. Wageningen, The Netherlands. 17-18.
2. Barrett, P.R.F. 1976. The effect of dalapon and glyphosate on *Glyceria maxima*. Proceedings of 17th British Crop Protection Conference. London, England. 79-82.
3. Barrett, P.R.F. and M.T. Gibson. 1990. The control of some emergent weeds with glyphosate. Proceedings of EWRS 8th Symposium on Aquatic Weeds. Wageningen, The Netherlands. 21-25.
4. Dawson, F.H. 1976. The annual production of the aquatic macrophyte *Ranunculus penicillatus* var. *calcareus* (R.W. Butcher) C.D.K. Cook. Aquat. Bot. 2:51-73.
5. Dawson, F.H. 1989. Ecology and management of water plants in lowland streams. Freshw. Biol. 57:43-60.
6. Dickerman, J.A. and R.G. Wetzel. 1985. Clonal growth in *Typha latifolia*: Population dynamics and demography of the ramets. J. Ecol. 73:535-552.
7. Djebrouni, M. and A. Huon. 1988. Structure and biomass of a *Typha* stand revealed by multidimensional analysis. Aquat. Bot. 30:331-342.
8. Filizadeh, Y. 1996. The management ecology of aquatic weeds which cause problems in Iranian freshwater systems. Ph.D. Thesis, University of Glasgow. Glasgow, U.K. 159 p.

9 Grace, J.B. and R.G. Wetzel. 1982. Niche differentiation between rhizomatous plant species: *Typha latifolia* and *Typha angustifolia*. Can. J. Bot. 60:46-57

10. Grossbard, E. and D. Atkinson. 1985. The Herbicide Glyphosate. Butterworths, London, England. 490 p.

11. Ham, S.F., J.F. Wright and A.D. Berrie. 1982. The effect of cutting on the growth and recession of the freshwater macrophyte *Ranunculus penicillatus* (Dumort). Bab. var. *calcareus* (R.W. Butcher) C.D.K. Cook. J. Environ. Manage. 15:263-271.

12. Husak, S. 1978. Control of reed and reedmace stands by cutting. In: D. Dykyjova and J. Kevt (eds.), Pond littoral ecosystems. Structure and Functioning. Ecol. Studies 28:404-408.

13. Husak, S. and J. Kvet. 1986. Experiments with mechanical control of *Typha* spp. stands. Proceedings of EWRS 7th Symposium on Aquatic Weeds. Loughborough, England. 175-181.

14. Jordan, T.E. and D.F. Whigham. 1988. The importance of standing dead shoots of the narrow leaved cattail, *Typha angustifolia* L. Aquat. Bot. 29: 319-328.

15. McKee, K.L., I.A. Mendelssohn, and D.M. Burdick. 1989. Effect of long-term flooding on root metabolic response in five freshwater marsh plant species. Can. J. Bot. 67:3446-3452.

16. Murphy, K.J. and P.R.F. Barrett. 1990. Chemical control of aquatic weeds. In: A.H. Pieterse, and K.J. Murphy (eds.), Aquatic Weeds. Oxford Univ. Press, Oxford, U.K. 136-173.

17. Penko, J.M. and D.C. Pratt. 1986. Growth and mortality of shoots in three populations of *Typha glauca* Godr. J. Minnesota Acad. Sci. 52:25-28.

18. Riemer, D.N. 1984. Introduction to Freshwater Vegetation. AVI Pub.g, Connecticut, U.S.A. 386 p.

19. Sale, P.J.M. and R.G. Wetzel. 1983. Growth and metabolism of *Typha* species in relation to cutting treatments. Aquat. Bot. 15:321-334.

20. Sculthorpe, C.D. 1967. The Biology of Aquatic Vascular Plant. Edward Arnold, London, England. 595 p.

21. Shekhov, A.G. 1974. Effect of cutting time on renewal of stands of reed and cattail. Hydrobiologa 10:45-48.

22. Singh, S.P. and M.K. Moolani. 1973. Control of cattail (*Typha angustata*) in relation to period of stubble submergence. Proceedings of the Fourth Asian-Pacific Weed Science Society Conference, Rotorua, New Zealand. 2:329-338.

23. Singh, S.P., S.S. Pahuja and M.K. Moolani. 1976. Cultural control of *Typha angustata* at different stages of growth. In: C.K. Varshney and J. Rzoska (eds.), Aquatic Weeds in South East Asia. W. Junk, The Hague, The Netherlands. 245-247.

24. Smith, B.E., D.G. Shilling; W.T. Haller and G.E. MacDonald. 1980. Factors influencing the efficacy of glyphosate on torpedograss (*Panicum repens* L.). J. Aquat. Plant Manag. 31:199-202.

25. Spencer, W. and G. Bowes. 1990. Ecophysiology of the world's most troublesome aquatic weeds. In: A.H. Pieterse and K.J. Murphy (eds.), Aquatic Weeds. Oxford Univ. Press, Oxford, U.K. 39-73.

26. Sundblad, K. 1990. The effects of cutting frequency on natural *Glyceria maxima* stands. Aquat. Bot. 37:27-38.

27. Van der Toorn, J. and J.H.Mook. 1982. The influence of environmental factors and management on stands of *Phragmites Australis*. J. Appl. Ecol. 19:477-499.

28. Wade, P.M. 1990. Physical control of aquatic weeds. In: Pieterse, A.H. and K.J. Murphy (eds.) Aquatic Weeds. Oxford Univ. Press, Oxford, U.K. 94-135.

29. Waters, I. and J.M. Shay. 1990. A field study of the morphometric response of *Typha glauca* shoots to a water depth gradient. Can. J. Bot. 68:2339-2343.

30. Westlake, D.F. 1968. The biology of aquatic weeds in relation to their management. Proceedings of the 9th British Weed Control Conference. Cardif, England. 371-379.

31. Wright, D.M. 1983. Shading the Streams. Country Life 21:1067.