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Management of cattail in standing water of Swabi district, Khyber Pakhtunkhwa (KPK) province, Pakistan

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ABSTRACT

Management of cattail (*Typha latifolia*) was carried out in stagnant water ponds to assess the effect of various weed control methods in the Swabi district of KPK Pakistan in the March of 2015. The experiment was laid out in a randomized complete block design, replicated thrice with 8 treatments: glyphosate (1.0, 1.5, and 2.0 kg a.i. ha^{-1}), isoproturon (0.741 kg a.i. ha^{-1}), clodinafop-propargyl (0.3 kg a.i. ha^{-1}), and halosulfuron methyl (0.0375 kg a.i. ha^{-1}), along with a hand-weeding treatment and an untreated control. The highest number of sprouts were recorded (51.67 m^{-2}) in control followed by hand-weeding (51.0 m^{-2}) treatments, compared to the three rates of glyphosate (0.05 m^{-2}, 3.33 m^{-2}, and 6.0 m^{-2}, respectively), 40 days after treatment application. Similarly glyphosate resulted in the lowest biomass (0.03 kg m^{-2}) compared to the control (0.92 kg m^{-2}). Canopy coverage was 98% in the control, while only 0.02% was observed in glyphosate-treated plots. Rhizome biomass was also greater in control and hand-weeding plots compared to glyphosate. It is concluded that glyphosate did well at all three doses but 2 kg a.i ha^{-1} proved best regarding cattail control. Perhaps hand weeding was difficult but if supplemented with herbicides application may provide better results for cattail control.

Key words: aquatic weed control, herbicides, hand weeding, aquatic weeds, *Typha latifolia*.

INTRODUCTION

Pakistan has extensive irrigation canal systems along with many fresh water bodies such as lakes, rivers, reservoirs, streams, and ponds; many of these water bodies are infested with aquatic weeds, and the rest are prone to weed infestation if no monitoring and proper management plans are adopted. As fresh water is one of the most valuable commodities in the world, factors that deteriorate water quantity or quality are pressing issues of the current century.

Aquatic flora are an essential part of maintaining and balancing ecosystems, decreasing soil erosion on river banks, and mitigating water pollution through phytoremediation of excess nutrients and other chemicals through bioaccumulation (Harvey and Fox 1973, Martin and Fernandez 1992, Wilson et al. 2000, Klink et al. 2013). However, invasive plants create severe weed problems and must be managed, otherwise they will overgrow and dominate the natural ecosystems. Invasive weeds grow, propagate, and spread very fast, covering entire water bodies, and in their presence desirable aquatic plants are often unable to reproduce and persist. By displacing native flora, invasive plants reduce aesthetic and monitory value of property, block waterways and drainage systems, and result in significant economic losses through losses to livelihoods and ecosystem services (Williams et al. 2010). Moreover, they also interfere with intended uses of water by hindering water flow in irrigation canals and altering recreational activities and water sports in inland waters (Ramlan 1991, Julien et al. 1999, Charudattan 2001, Rezene 2005).

Invasive aquatic weeds like water hycianth (*Eichhornia crassipes* L.) water lettuce (*Pistia stratiotes* L.), hydrilla (*Hydrilla verticillata* (L.f.) Royle), giant salvinia (*Salvinia molesta* Mitchell), duckweed (*Lemna minor* L.), and common cattail (*Typha latifolia* L.) are widespread in Pakistan and must be actively managed. Cattail is the fourth most problematic aquatic weed in the Swabi district of the Khyber Pakhtunkhwa province, after water hyacinth, water lettuce, and common reed (*Phragmites australis* (Cav.) Trin. ex Steud.). Cattail covers almost all water bodies in this district, especially drainage ditches and stagnant water ponds (Fawad et al. 2013).

Cattail is an emergent plant that has an extensive rhizome system, making it capable of perennating in the hydrosoil. The flowers are in a compact spike, with the male flowers on the upper and female flowers on the lower portion of the spike (Stevens and Hoag 2000). Cattail is distributed worldwide, from tropical to subtropical as well as temperate areas of the world. It has a wide range of tolerance to different climates, allowing it to occupy various aquatic conditions and dominate a variety of other plants (Murkin and Ward 1980, Mitch 2000).

For proper management, weeds must be correctly identified, and the intended use of a water body must be taken in to account. In Pakistan, relevant research into weed management solutions for the increasing fresh water body cattail infestation is limited and few management options are available. Therefore, the objective of the study was to evaluate various herbicides for control of cattail in marshy conditions and stagnant water ponds.

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Table 1. Cattail number of sprouts (m^{-2}), fresh aboveground biomass (kg m^{-2}), canopy coverage (%), rhizome biomass (kg m^{-2}), and rhizome bud number (m^{-2}) as affected by different treatments.[1]

Treatments	Number of Sprouts	Aboveground Biomass	Canopy Coverage	Rhizome Biomass	Rhizome Bud Number
Glyphosate (2 kg a.i ha^{-1})	0.05 d[2]	0.03 c	0.02 e	0.11 c	13.00 d
Glyphosate (1.5 kg a.i ha^{-1})	3.33 cd	0.25 c	10.00 d	0.13 c	15.33 d
Glyphosate (1.0 kg a.i ha^{-1})	6.00 c	0.32 c	23.33 c	0.18 b	19.00 c
Isoproturon (0.74 kg a.i ha^{-1})	39.67 b	0.80 b	88.33 b	0.35 a	22.33 ab
Clodinafop-propargyl (300 g a.i ha^{-1})	37.33 b	0.79 b	87.00 b	0.35 a	20.00 bc
Halosufluron methyl (37.5 g a. i. ha^{-1})	36.67 b	0.79 b	90.00 b	0.35 a	19.00 c
Hand weeding	51.00 a	0.89 b	97.00 a	0.37 a	24.67 a
Control	51.67 a	0.92 a	98.00 a	0.37 a	24.00 a
LSD at α (0.05)	3.55	0.051	6.7784	0.0273	2.75

[1]The trials were carried out in Swabi district of Khyber Pakhtunkhwa province, Pakistan, during the spring of 2015.
[2]The basic set of treatments were replicated three times; there were three blocks or replications.

MATERIALS AND METHODS

Experimental site

A field experiment was carried out to evaluate management of cattail during the spring of 2015. The experimental site is situated at 72°16′00.30″E longitude and 34°13′00.32″N latitude, with an elevation of 321.564 m above sea level. The experiment was conducted in a stagnant water pond with an average depth of 0.5 m and minute slope toward the edges. The pond was naturally and heavily infested with cattail.

Experiment design and layout

The experiment was laid out in randomized complete block design with three replications and six herbicidal treatments, a hand-weeding treatment, and a control. The herbicide treatments consisted of glyphosate (2, 1.5, and 1 kg a.i. ha^{-1}), isoproturon (0.74 kg a.i. ha^{-1}), clodinafop-propargyl (0.300 kg a.i. ha^{-1}), and halosulfuron methyl (0.0375 kg a.i. ha^{-1}). Each experimental unit was a 4 m^2 plot. The recommended amount of herbicides was applied on March 2015 to a fix amount of water (6.0 L) sufficient for all the three plots (one in each replication) with a single-nozzle sprayer until full coverage of the treatment area was achieved. Control plots were kept weedy for the whole duration of the trial, while the hand weeding was done once simultaneously at the time of herbicide application. In case of hand-weeding treatments, regrowth from the stubbles was observed until 40 d after weeding. Hand weeding was carried out with a sickle at the water level. The cut biomass of cattail was deposited away from the water body to avoid nutrient enrichment.

Data were recorded on the number of cattail sprouts (m^{-2}) at the sixth week after herbicide application. Aboveground fresh biomass (kg m^{-2}) of cattail was recorded in a randomly selected 1 m^2 area in each plot. Similarly, rhizome fresh biomass and number of buds on rhizome were recorded in each 1 m^2 area, which was randomly selected; the rhizomes were excavated and weighed, and the developed buds were counted to achieve the final data. Likewise, for canopy coverage (%), a 1-m^2 area in each treatment was randomly selected, and canopy coverage was measured visually by calculating the surface of the soil covered by the plant canopy as compared to the surface of the ground seen from above.

The data were recorded individually for each parameter, and analysis of variance was conducted using GenStat release 8.1 (GenStat 2005). Means were compared by using a least significant difference (LSD) test at 0.05 level of probability (Steel and Torrie 1980).

RESULTS AND DISCUSSION

Number of sprouts (m^{-2})

For the number of sprouts, analysis of variance indicated a significant treatment effect ($P = 0.0001$). The highest number of sprouts was recorded for the control treatment (51.67 m^2) and was similar to the hand-weeding control (51.0 m^2) (Table 1). The results showed that the highest number of sprouts was recorded for the control treatment (51.67 m^{-2}), but this was statistically similar to the hand-weeding treatment (51.0 m^{-2}). The minimum number of sprouts were recorded in the glyphosate treatment at 2 kg ha^{-1} (0.05 m^{-2}), followed by glyphosate at 1.5 kg ha^{-1} (3.33 m^{-2}) and glyphosate at 1.0 kg ha^{-1} (6.0 m^{-2}), respectively. However, isoproturon, clodinafop-propargyl, and halosulfuron methyl all performed poorly and were statistically similar to each other (between 36 and 39 sprouts m^{-2}). The high number of resprouting in the hand-weeded treatment is due to the high determinative ability of cattail after cutting. As a strategy to survive in stressful conditions, cattail mobilizes stored resources from the rhizomes for use in vegetative growth.

All rates of glyphosate were effective regarding weed management, but the higher application rate should be used if complete eradication is desirable. These results are similar with the findings of Pahuja et al. (1980), who reported that herbicide application on mature cattail achieved better weed control than mechanical weeding, since rapid resprouting after cutting reinfested and recovered the open spaces cleared from weeds through mechanical control. Conversely, the authors observed that herbicide use maintained the openings for at least 3 yr after application. The results of Arsenovic and Konstantinovic (1990) strongly support our results as well; the authors found that aquatic weed control with glyphosate at various rates resulted in up to 98% cattail control. However, to avoid herbicide resistance, herbicide tank mixing or herbicide rotation is recommended and reliance on just one herbicide (glyphosate).

In contrast, Nelson and Dietz (1966) reported that hand weeding or mechanical cutting of cattail, when integrated with flooding to submerge the cut stubbles after cutting, resulted in higher weed control. They achieved up to 100% control for 2 yr after using this method. There was no visible resprouting in 1 yr, because of decomposition of rhizomes from submerged conditions after cutting. Rhizome death likely occurred because of induced hypoxic to anoxic conditions by the flooding treatment. As glyphosate is a nonselective translocated herbicide having an amino acid biosynthesis inhibitor mode of action, therefore, the highest cattail control of any method tested was achieved by two clippings followed by stem submergence to at least 7.5 cm. The clipping probably increased the rate of photpsynthate mobilization and subsequently herbicide translocation to the rhizomes. The submergence of plants after clippings probably synergized the herbicide activity. Control was best if plants were cut in late summer or early fall (Nelson and Dietz 1966) when the translocation of surplus food is more toward the storage organs (rhizomes). Since the cattail stubbles were not submerged after cutting in our study, we were unable to achieve the same level of weed control. In another study, certain herbicides were ineffective to control the growth and development of cattail (Moore et al. 1999).

Above ground biomass (kg m^{-2})

Analysis of variance indicated a significant treatment effect on cattail biomass production ($P = 0.0000$). The maximum biomass was found in the control plot (0.92 kg m^{-2}) followed by the hand weeding (0.89 kg m^{-2}) (Table 1). Regrowth biomass was almost identical between isoproturon, clodinafop-propargyl, and halosulfuron, ranging between 0.79 and 0.8 kg m^{-2}, while the lowest biomass of cattail was noted in glyphosate-treated plots (0.03 to 0.32 kg m^{-2}) at all three rates.

The highest biomass was obtained in control and hand-weeded plots because no herbicide was applied in these two treatments, which resulted in high emergence of cattail sprouts. The minimum biomass was noted in the glyphosate treatments, likely because of its systemic nature, translocating to control the underground parts of the plant. In the case of selective herbicides used in this study (isoproturon, clodinafop-propargyl, and halosulfuron), they were comparatively less effective on cattail alone, but these herbicides if used in combinations may work well. This will not only provide a better option for weed management but also will minimize the chance of herbicide resistance. These results are in line with the work of Lopez (1993), who reported that glyphosate is the best control method for the reduction of cattail biomass to zero as compared to other herbicides and nonherbicidal control strategies. He stated that glyphosate at 5 L ha^{-1} can reduce cattail biomass by 95%. In contrary to chemical weed control, deep submergence of cattail plants decreases photosynthate allocation to roots, flowering, and reproduction; thus, an increase in leaf and stem biomass is noted (Grace 1982). Similarly, the increase in biomass in the nonherbicidal treatments might be attributed to nutrient enrichment, most likely phosphorus, as reported by Craft and Richardson (1997). They suggested that cattail populations in wetlands reached peak biomass due to P enrichment.

Canopy coverage (%)

For the canopy coverage (%), analysis of variance indicated that there was a significant treatment effect ($P = 0.0001$). The highest canopy coverage was recorded for the control treatment (98%); however, it was similar to the hand weeding (97%) and followed by halosulfuron (90%), isoproturon (88%), and clodinafop-propargyl (87%) as shown in Table 1. The lowest canopy coverage of cattail was noted in plots treated with glyphosate at 2 kg ha^{-1} (0.02%), followed by glyphosate at 1.5 kg ha^{-1} (10%) and glyphosate at 1 kg ha^{-1} (23%). These results are in line with the findings of Miao et al. (2000), who reported that the growth and expansion of *Typha* sp. after a period of 7 mo produced greater leaf biomass, with each plant producing 6.7 new ramets on average and canopy coverage reaching about 1.2 m^2 per original plant. Lopez (1993) also reported that glyphosate reduced plant biomass, whereas in the control plots leaf biomass and hence canopy cover were the highest. Similarly, the increase in leaf biomass in the control plots might be attributed to the phosphorus enrichment as reported by Craft and Richardson (1997), who suggested that in these conditions the highest population peaks in biomass were obtained and the canopy was expanded to the fullest limit. In deep water the capacity for rhizome extension results in extensive growth and population expansion as compared to medium or low water levels where the plants face periods of drought (White and Ganf 1998).

Rhizome biomass (kg m^{-2})

Analysis of variance indicated a significant treatment effect on cattail rhizome biomass ($P = 0.0000$). Maximum rhizome biomass of cattail (kg m^{-2}) was found in the control and hand-weeded plots (0.37 kg m^{-2} each), which were statistically similar to isoproturon- and clodinafop-propargyl-treated plots (0.35 kg m^{-2} each). The minimum rhizome biomass was noted in plots treated with glyphosate applied at 2 kg ha^{-1} (0.11 kg m^{-2}). However, it was statistically similar to the rhizome biomass obtained from glyphosate-treated plots at 1.5 and 1.0 kg ha^{-1} (0.13 kg m^{-2} and 0.18 kg m^{-2}, respectively) as shown in Table 1. Thus, glyphosate proved to be the best control option in not only reducing cattail aboveground biomass, but also in reducing belowground biomass as compared to other herbicidal or nonherbicidal treatments. These results agree with those of Richard and Kent (1993), who advocated glyphosate use because of its ability to successfully translocate to the rhizomes and destroy cattail's underground system. The authors suggested mid- to late summer applications when photosynthate translocation is maximum; at this time the storage and effective translocation of herbicide is ensured due to the flow of photosynthate and also due to the active growth stage of the plants. This idea is strengthened by the work of Grace and Wetzel (1982), who measured biomass allocation in cattail and reported greater allocation to vegetative reproduction and rhizome formation than to sexual reproduction and flowering formation. Sojda and Solberg (1993) also reported that the rhizomes elongate in early summer, and annual growth in plant height can be more than 61 cm in the absence of control measures (particularly herbicides).

Rhizome bud number m^{-2}

Analysis of variance indicated that various herbicidal and manual control treatments had significant effect on cattail rhizome buds number m^{-2} excavated from a 1 m^2 area from each treatment ($P = 0.0000$). Maximum rhizome bud development was observed in the hand-weeded treatment (24.67 m^{-2}), which was statistically similar to the control treatment (24.00 m^{-2}). The minimum number of rhizome buds (13.00 m^{-2}) were observed for glyphosate applied at 2 kg ha^{-1}. However, this was statistically similar (15.33 m^{-2}) to the glyphosate applied at 1.5 kg ha^{-1}. The rest of the herbicides (isoproturon, clodinafop-propargyl, halosulfuron methyl, and lower dose of glyphosate, 1 kg ha^{-1}) had comparatively poor performance as shown in Table 1. Our results are supported by Richard and Kent (1993), who used glyphosate and reported maximum underground biomass destruction. The regeneration of cattail from its rhizomes is a tool that ensures its survival, but the use of glyphosate causes injury to the developing rhizome and causes bud death. Similar results have been reported by Sojda and Solberg (1993), who stated that herbicides that are translocated to the rhizomes were most effective in controlling cattail populations. Omezine (1991) also reported that systemic herbicides disturb regenerative capacity of rhizome fragments and hence ensure successful weed control.

CONCLUSIONS

Cattail is a noxious aquatic weed that forms dense populations once established, potentially blocking waterways. Chemical control methods represent a potential tool for controlling infestations in stagnant waters. Glyphosate at 2 kg ha^{-1} was the most effective herbicide tested in reducing the number of cattail sprouts, biomass, canopy coverage, rhizome biomass, and number of rhizome buds compared to controls. Glyphosate represents an effective and economic tool for controlling cattail populations in standing water in Pakistan. Hand weeding needed repeated application and was labor intensive, and therefore proved costly, but if supplemented with a suitable herbicide such as glyphosate, it might prove more effective. Further research on cattail management is recommended, particularly by integrating mechanical and chemical weed control methods.

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