CONTEMPORARY RESEARCH IN INDIA
ISSN 2231 - 2137

HERBICIDAL MANAGEMENT OF *PARTHENIUM HYSTEROPHORUS* L. IN GRASSLAND ECOSYSTEM OF HIMACHAL PRADESH

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Received: 27/01/2017 | **Edited: 02/02/2017** | **Accepted: 08/02/2017**

Abstract: *Thirteen treatments viz., metsulfuron methyl (0.005 and 0.01%), 2, 4-DEE (0.30 and 0.20%), atrazine (0.20 and 0.30%), metribuzin (0.25 and 0.50%) and glyphosate (0.50 and 0.75%) each at two doses and manual cutting, uprooting and untreated check were evaluated for the control of Parthenium hysterophorus in a grassland ecosystem of Himachal Pradesh. The herbicides were applied at the juvenile stage of Parthenium during November and June. Winter application of metsulfuron methyl 0.01% was most effective in controlling Parthenium upto seven months after spray. This was followed by metsulfuron methyl 0.005%. Winter application of atrazine at 0.2 & 0.3% gave complete control of Parthenium upto two months of spray. Rainy season application of all the herbicides gave complete control of Parthenium upto three months of spray. All treatments were significantly superior to untreated control in reducing the dry weight of Parthenium. Metsulfuron methyl, metribuzin, atrazine and 2,4-DEE gave significantly higher dry herbage yield over other treatments. Although glyphosate resulted in effective control of Parthenium, it had phytotoxic effect on other vegetation and gave lower herbage yield. The manual uprooting resulted in significantly lower Parthenium density and dry weight than the cutting treatment.*

Key words: *Herbicides, Parthenium hysterophorus, grassland ecosystem.*

Introduction

Himachal Pradesh (30° 22' to 33° 12' N latitudes, 74°45' to 79°04' longitude and 650 to more than 2000 m altitude) located in North Western Himalayan region of India is a hilly state. Agro climatically, it is divided into four zones *viz*., zone I, Sub mountain low hills; zone II, Mid hill sub humid; zone III, High hill temperate wet zone and zone IV, High hill temperate dry zone, which have wide range of biodiversity and land utilization pattern. Because of hilly physiographic conditions about 80.2% land is under pastures & grasslands, forests and wasteland ecosystems. Such lands because of their poor management and over exploitation have been invaded by a variety of alien invasive weeds. Among them *Parthenium hysterophorus* has spread like a wild fire in almost all the districts of Himachal Pradesh except Kinnaur and Lahaul & Spiti (Angiras and Kumar, 2010; Angiras and Saini, 1997). *Parthenium* being member of Asteraceae (tribe: Heliantheae), is a fast maturing, erect, and much branched annual or ephemeral herb. It has two distinct phases in life: juvenile, rosette, or the vegetative stage and adult, mature, or the reproductive stage. The juvenile stage exhibits a rosette with large, dark green, simple, radicle, and pinnatisect small leaves lacking flowering. The large lower leaves are spread on the ground like a carpet, without allowing any vegetation underneath it [Lakshmi and Srinivas 2007]. The adult stage is erect, much branched with deep tap root system that reaches up to 2m in height. It completes its life - cycle within 3 - 4 months and it shows three to four generations in a year which helps in quick spreading and generation of adverse impacts on the surrounding vegetation [Kohli et al. 2006; The Wealth of India 2003; Gupta et al. 1977]. Seeds do not have a dormancy period and germinate any time of the year under wide range of environmental condition. High humidity, high moisture content and temperature around 25°C are the standard factors for seed germination (Bhatt *et al.,* 2012). Seeds germinate within a week with the onset of monsoon and flowering starts after a month and continues up to another three months. In northwest India, *Parthenium* germinates mainly in the months of February-March, attaining peak growth after rains in June-July and produces seeds in September-October. It normally

completes its life cycle within 180–240 days. Its growth remains less and stunted from November to January due to severe cold [Aneja 1991; 1999]. Its high germination ability throughout the year, an enormous seed bank, rapid spread and colonization and extreme adaptability in a wide range of habitats make it capable of spread vigorously (Kushwaha and Maurya 2012; Thapar and Singh 2006; Evans 1997). It has invaded pastures and grasslands, forests, orchards, wastelands and cultivated lands (Angiras and Kumar, 2008) covering about 15 lakh hectare area in the state. It produces up to 25,000 seeds and dispersal of such a large seed accounts for its vigorous spreading (Javaid and Adrees 2009; Navie 1996; Kohli et al. 2006). This weed would be more invasive in the future and may result in an accelerated range expansion under a changing climate (Patterson, 1993) that may then result in a reduced grazing land productivity and stock rating capacity. Its deep penetrating roots, erect shoot system and suppression of growth of other native species with its allopathic effect are major supports that help in its rapid establishment in any type of environment (Kohli et al. 2006). About 90% reduction in productivity of grassland and suppressing effects on biodiversity of useful vegetation have been observed (Angiras and Rana, 2005). Therefore, management of grazing lands that comprises mainly of C_4 species may become increasingly more difficult in future. The spread of weed can be controlled by the use of an integrated range of methods- mechanical, cultural, chemical, and biological. The manual removal is usually neither very effective nor economical, because of the rapid regrowth requiring repeated removals for season-long control (Robert 2011; Tamado and Milberg 2004). The use of synthetic herbicides (Monika Kumari 2014) is effective. But the timing of chemical control is critical. The plants should be treated before flowering and seed setting and when other plants, especially grasses are actively growing and can recolonize the infested area.

Materials and Methods

A field investigation was carried out for two years (2007-08 and 2008) in Bairghatta Panchayat (31° 53' 17" to 31° 53' 49" N and 76° 29' 05" 76° 29' 47" E) of Jaisinghpur Tehsil in Kangra District of Himachal Pradesh to standardize the dose and time of application of different herbicides to control *Parthenium hysterophorus* in grassland ecosystem. In the first year, *Parthenium hysterophorus* started its emergence in November immediately after the harvest of grass. During first year seven treatments *viz.* metsulfuron methyl (0.005 and 0.01%), 2, 4-DEE (0.30 and 0.20%), atrazine (0.20 and 0.30%) plus untreated check were evaluated in randomized block design with three replications. The concentrations given are based on the formulated products. The gross plot size was 5m x 5m. The herbicides were applied during November at two-three leaf stage of *Parthenium* i.e. its juvenile stage. *Parthenium* infestations were assessed in terms of its density by sampling technique in one sq. m area. The growth of *Parthenium* remain stunted during the winter months, the observation on its height were recorded five months after treatment. The population of other vegetation was also assessed at monthly interval from the 1 square m area in each plot. In the month of May-June, the heat stress killed the populations but with the onset of monsoons *Parthenium* again emerged.

During the second year thirteen treatments were laid out in randomized block design with three replications. The treatments were consisted of five herbicide viz., metsulfuron methyl (0.005 and 0.01%), 2, 4-DEE (0.30 and 0.20%), atrazine (0.20 and 0.30%), metribuzin (0.25 and 0.50%) and glyphosate (0.50 and 0.75%) each at two doses and manual cutting twice, uprooting and untreated check. The herbicides were applied at 2-3 leaf stages of *Parthenium* during June. The herbicides were sprayed with knapsack power sprayer using 600 L water per hectare. *Parthenium* infestations were assessed in terms of its density by sampling technique in one sq. m area using quadrates. Observations on population count were made at monthly interval. The weed dry weight and plant height were recorded at one monthly interval.

Results and Discussion

Effect on *Parthenium* population

Emergence of *Parthenium* was started immediately after the harvest of grass in the month of November. The herbicides (metsulfuron methyl 0.005 & 0.01%; 2,4-DEE 0.2 & 0.3% and atrazine 0.2 & 0.3%) were sprayed at its juvenile stage. The data on count of *Parthenium* before and after the spray of herbicides have been summarized in Table 1. A perusal of data revealed significant variation in the count of *Parthenium* at all the stages of observation during the first year. All treatments brought about significant curtail in the population of *Parthenium* upto seven months after treatment during the first year. Metsulfuron methyl 0.01% was the most effective treatment in killing *Parthenium* giving 100% control upto seven months after spray during the first year and was followed by metsulfuron methyl 0.005%. In the later treatment there was no emergence of *Parthenium* upto three months only. Atrazine 0.2 & 0.3% also gave complete kill of *Parthenium* upto two months only. After that the *Parthenium* started its emergence in the atrazine treated plots 2,4-DEE at both rates was comparatively less effective than metsulfuron methyl and atrazine. Javed (2007), Mishra and Bhan (1994) and Khan et al. (2012) reported that application of 2,4-DEE 0.2% was more effective for controlling *Parthenium* at 15 days after spraying causing its complete kill and did not allow any emergence of the weed. Khan et al. (2012) reported that the stage/time of *Parthenium* weed for herbicidal control is important and the weed was effectively controlled at rosette stage in wasteland, non-cropped areas, along railway tracks, water channels and roadsides. It is pertinent to highlight that higher dose of each of metsulfuron methyl, 2,4-DEE and atrazine was in general superior to its lower dose. In the grassland ecosystem *Parthenium* found emerging throughout the winter consequent upon favourable and standard factors for seed germination (Bhatt et al. 2012). However, in the months of May-June, the heat stress killed *Parthenium*.

On the onset of monsoon, *Parthenium* again emerged. Along with the previously tested treatments, additional treatments *viz*. metribuzin at 0.25 & 0.5%, glyphosate 0.5 & 0.75%, plus manual uprooting and manual cutting were also applied on the newly emerged flush. The data are given in Table 1. The results showed significant variation in the count of *Parthenium* at all the times of observation. All the treatments were significantly superior to unsprayed control at all the times of observation. The herbicidal treatments resulted in complete kill of the *Parthenium* upto three months after spray and were superior to manual uprooting or cutting. Later on *Parthenium* again emerged indicating for a continue effort to eradicate the problem. Javed (2007), Mishra and Bhan (1994) and Khan et al. (2012) reported that the application of 2,4-DEE (0.2%) and metribuzin (0.25 and 0.5%) were more effective for controlling *Parthenium* at 15 days after spraying causing its complete kill. Khan et al. (2012) reported glyphosate and metribuzin, the most effective herbicides having higher mortality of *Parthenium* weed at four weeks after treatment at both rosette and bolted stages. The manual weeding treatment resulted in significantly lower *Parthenium* density than the cutting treatment at all the stages of observation.

Effect on *Parthenium* dry weight

Parthenium dry weights were recorded during the second year of experimentation. The data are summarized in Table 2. All treatments were significantly superior to unsprayed control in reducing the dry weight of *Parthenium*. Herbicidal treatments gave a complete kill of the *Parthenium* plant and were superior to manual uprooting or manual cutting upto three months after spray. Manual uprooting had an edge over manual cutting in curtailing the dry weight of *Parthenium*.

Effect on other vegetation

With the effective management of *Parthenium* the population of other vegetation significantly increased. Application of metsulfuron methyl 0.005 and 0.01%, 2,4-D 0.2 and 0.3%, atrazine 0.2 and 0.3% and metribuzin 0.25 and 0.50% applied at 2-3 leaf stage of *Parthenium* resulted in significantly higher dry herbage yield as compared to other treatments (Table 3). However, there are several disadvantages

of using the chemical herbicides, such as the environmental hazards and the development of resistance against many herbicides [Njoroge 1991; Singh et al. 2004; Vila-Aiub et al. 2008]. Atrazine has been found to be highly persistent in soil and has been classified as a restricted use pesticide (RUP) in the USA due to its potential for groundwater contamination [Ware 1986]. Glyphosate is one of the most toxic herbicides, with many species of wild plants being damaged or killed by applications of less than 10 micrograms per plant. Moreover, glyphosate can be more damaging to wild flora than many other herbicides. Although, glyphosate 0.50 and 0.75% resulted in effective control of *Parthenium* in the present investigation, yet it had phytotoxic effect on other vegetation (*Ageratum conyzoides, Bidens pilosa, Oxalis* and local grasses), hence resulted in lower dry herbage yield.

Cost of control

Weeds should be controlled by the least expensive

Table 1: Effect of treatments on *Parthenium* population (No/m^2) in grassland ecosystem (The data transformed to square root transformation)

I, year I; II, year II; MAT, months after treatment; MSM, metsulfuron-methyl; Values given in parentheses are the means of original values; $, The concentrations given are based on the formulated products (MSM, Algrip 20%; 2,4-DEE, Weedmar 38%; Atrazine, Atrataf 50%; Metribuzin, Sencor 70%; Glyphosate, Round-up 42%)

Table 2: Effect of treatments on dry weight of *Parthenium* (g/m^2) in grassland ecosystem (The data transformed to square root transformation)

Treatment	Before spray	1 MAT	2 MAT	3 MAT	4 MAT	5 MAT	6 MAT	7 MAT
	II	II	II	II	II	II	II	II
MSM 0.005%	5.4 (28.4)	1.1 (0.4)	1.0 (0.0)	1.0 (0.0)	2.8 (1.9)	2.4 (4.8)	2.0 (3.1)	2.1 (3.8)
MSM 0.01%	5.5 (29.4)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.5 (1.4)	2.0 (3.2)	2.0 (3.2)	1.9 (2.9)
2,4-DEE 0.2 %	5.1 (26.1)	1.6 (1.8)	1.0 (0.0)	1.0 (0.0)	1.9 (2.9)	2.2 (4.1)	2.0 (3.4)	2.0 (3.1)
2,4-DEE 0.3 %	5.4 (28.4)	1.6 (1.9)	1.0 (0.0)	1.0 (0.0)	1.5 (1.5)	1.9 (3.0)	2.1 (3.8)	1.8 (2.4)
Atrazine 0.2%	5.4 (29.1)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.6 (1.6)	1.9 (2.9)	2.1 (3.6)	1.7 (2.0)
Atrazine 0.3%	5.5 (30.1)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.5 (1.4)	1.9 (2.8)	2.2 (3.9)	1.7 (2.1)
Metribuzin 0.25%	5.0 (25.1)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.5 (1.5)	1.8 (2.4)	1.9 (3.0)	1.5 (1.4)
Metribuzin 0.50%	5.1 (26.1)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.6 (1.6)	1.9 (2.8)	2.0 (3.2)	1.5 (1.5)
Glyphosate 0.5%	5.3 (27.4)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.5 (1.3)	1.9 (2.9)	2.0 (3.1)	1.6 (1.6)
Glyphosate 0.75%	5.3 (28.1)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.5 (1.4)	1.9 (2.7)	2.0 (3.4)	1.6 (1.9)
Manual uprooting	5.6 (31.2)	2.5 (4.1)	1.8 (2.4)	2.0 (3.2)	1.9 (2.9)	2.4 (4.9)	2.6 (5.8)	2.1 (3.8)
Manual cutting	5.7 (32.5)	2.6 (6.2)	2.2 (4.2)	2.6 (6.2)	2.6 (5.8)	2.7 (6.4)	2.8 (6.9)	2.4 (4.9)
Unsprayed control	5.4 (29.4)	5.5 (30.4)	5.6 (31.2)	5.7 (32.1)	5.5 (30.4)	6.4 (40.2)	6.8 (45.4)	6.5 (42.2)
CD 5%	NS	0.26	0.86	0.25	0.30	0.36	0.31	0.27

II, year II; MAT, month after treatment; MSM, metsulfuron-methyl; Values given in parentheses are the means of original values

Table 3: Effect of treatments on plant population (No. /m²) of other vegetation in grassland ecosystem and dry herbage yield

Treatment	Before spray	1 MAT	2 MAT	3 MAT	4 MAT	5 MAT	6 MAT	7 MAT	Dry herbage yield (q/ha)	Cost of treatment (INR/ha)
	I	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**II**	
MSM 0.005%	19.6 (386.3)	17.5 (307.0)	7.0 (48.3)	12.2 147.7)	8.3 (68.3)	9.3 (85.7)	8.9 (79.0)	7.6 (56.7)	15.8	1351
MSM 0.01%	14.8 (222.0)	14.6 (215.0)	11.1 (123.3)	11.3 (127.0)	9.2 (83.7)	8.5 (71.7)	9.5 (90.0)	8.7 (75.7)	16.9	1903
2,4-DEE 0.2 %	19.9 (402.0)	19.2 (370.0)	19.9 (402.3)	22.3 (501.0)	14.7 (216.7)	16.1 (257.7)	16.4 (270.0)	12.8 (162.7)	14.5	1173
2,4-DEE 0.3 %	18.5 (344.0)	18.6 (349.0)	16.9 (290.3)	15.7 (248.0)	13.6 (190.0)	14.1 (199.0)	15.2 (233.3)	13.7 (186.0)	15.4	1360
Atrazine 0.2%	9.5 (90.0)	7.5 (55.3)	8.4 (70.0)	7.5 (55.7)	7.6 (56.7)	7.3 (53.0)	8.1 (64.3)	7.2 (51.7)	14.2	1234
Atrazine 0.3%	16.8 (283.3)	13.4 182.3)	12.2 (150.0)	7.9 (62.7)	7.9 (63.0)	8.9 (78.3)	8.4 (70.0)	8.1 (65.7)	16.1	1452
Metribuzin 0.25%	-		-		-		-	-	16.2	3350
Metribuzin 0.50%	-	-	-	-	-	-	-	-	16.8	5900
Glyphosate 0.5%	-	-	-	-	-	-	-	-	5.9	2000
Glyphosate 0.75%	-	-	-	-	-	-	-	-	4.0	2600
Manual uprooting	-	-	-	-	-	-	-	-	13.5	8400
Manual cutting	-	-	-	-	-	-	-	-	12.6	3600
Unsprayed control	15.9 (253.3)	15.5 (241.7)	17.4 (303.3)	18.4 (338.3)	15.3 (233.3)	13.8 (191.3)	12.0 (144.0)	9.7 (93.7)	6.8	-
LSD (P=0.05)	3.27	2.51	3.17	2.61	2.76	1.52	1.88	1.18	3.2	-

I, year I; II, year II; MAT, month after treatment; MSM, metsulfuron-methyl; Values given in parentheses are the means of original values

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