Management of Parthenium hysterophorus L. in wastelands of Himachal Pradesh

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***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 wasteland ecosystem of Himachal Pradesh. At the time of application, plants of Parthenium were 22.3-55.1 cm in height in the first year and 22.8-47.8 cm in the second year. Glyphosate 0.5 and 0.75%, metribuzin 0.25 and 0.50%, metsulfuron methyl 0.005 and 0.01%, 2, 4 - D 0.2 and 0.3% and atrazine 0.2 and 0.3% applied before flowering were effective to control the previous flush of Parthenium as compared to other treatments. All herbicides were effective to control Parthenium upto four months after application with 100% kill. The herbicidal treatments were also superior to manual treatments in reducing the count and dry weight and height of Parthenium subsequently upto 7 months after treatment. Though all the herbicidal treatments resulted in significantly lower density and dry weight of Parthenium as compared to other weed control treatments up to four months after treatment but metribuzin, 2, 4-D, metsulfuron methyl and atrazine were effective without any phytotoxic effects on grasses. In hot summer months, the heat stress killed the populations but, with the onset of monsoon the weed again emerged. The manual weeding treatment resulted in lower weed density and dry weight at initial stages only but, uprooting was superior to the cutting treatment. With the effective management of Parthenium the population of other vegetation (Ageratum conyzoides, Bidens pilosa and local grasses) increased significantly especially in the glyphosate treated plots.**

Index Terms- Parthenium hysterophorus, wastelands, management, herbicides.

INTRODUCTION

Parthenium hysterophorus L., commonly called as carrot weed, white top or congress grass in India is an annual herbaceous erect plant belonging to the family Asteraceae (Compositae). The origin of Parthenium is considered to be Mexico, America, Trinidad and Argentina. Within last 100 years, it has found its way to Africa, Australia and Asia. According to Holm et al. [1997] this noxious invasive species is considered to be one of the worst weeds currently known. In India, the weed was first noticed in Pune (Maharashtra) by Professor Paranjape, 1951, as stray plants on rubbish heaps and was reported by Rao [1956] as a new species in India, but the earliest record of this species in India goes back to 1814 by Roxburgh, the father of Indian Botany, in his book Hortus Bengalensis [Rao 1956; Roxburgh 1814]. Now it has spread alarmingly like a wild blaze to almost all the states in India including Himachal Pradesh and were established as a naturalized weed. The first introduction of this weed was along road sides or in locations of hydro-electric projects and other civil engineering works through vehicular transport and construction material. From such areas it has spread to undisturbed ecosystems of the hills like pasture and grasslands, forests and orchards through water, wind and migratory sheep and goat (Angiras and Kumar, 2010; Angiras and Saini, 1997). Its entry along roads on upstream side has helped in its introduction to the catchments in downstream sides through rain water. The spread of this weed has threatened the biodiversity of hills, reduced productivity of pasture and grasslands, orchards and forests apart from its pollution to the environment affecting health of animals and human beings. In Himachal Pradesh more than 45% of the total geographical area is under pastures, grasslands, fallow lands and other non cultivated lands which provide favorable conditions for invasion by this alien weed. A loss in yield of agricultural crops upto 40% (Mundra et al. 2015) and forage production upto

90% has been reported (Angiras and Rana, 2005). Since these lands provide support to the agriculture by providing fodder to the livestock of the state, it is imperative to control this weed effectively. Mannual uprooting of Parthenium before flowering and seed setting is the most effective but it is not cost effective due to its continuous germination. Recent researchers have identified several potential herbicides for the control of Parthenium in cropped and non-cropped situations (Mundra et al. 2015; Singh et al. 2004; Reddy et al. 2007; Susheelkumar 2015). The present study was undertaken to evolve herbicidal management strategy for the control of Parthenium under wasteland ecosystem of Himachal Pradesh.

MATERIALS AND METHODS

An investigation was carried out for two years in wasteland ecosystem with heavy infestation of Parthenium in Bairghatta Panchayat (31053′17″ to 31053′49″ N latitude and 76029′05″ to 76029′47″ E longitude) of Jaisinghpur Tehsil in Kangra District of Himachal Pradesh to standardize the dose and time of application of different herbicides to control Parthenium in waste land ecosystem. During first year seven treatments (Table 1) consisting of glyphosate (0.50 and 0.75%) and metribuzin (0.25 and 0.50%) each at two doses, plus manual cutting twice, uprooting and untreated check were evaluated in randomized block design with three replications. The plot size was 5m x 5m. During the second year thirteen treatments were laid out in randomized block design with three replications. In addition to the first year treatments, metsulfuron methyl (0.005 and 0.01%), 2, 4-DEE (0.20 and 0.30%) and atrazine (0.20 and 0.30%) each at two doses were also evaluated. The plot size was 5.5m x 4m. The herbicides were applied when plants of Parthenium were 22.3-55.1 cm in height in the first year (in November) and 22.8-47.8 cm in the second year (June). The herbicides were sprayed with knapsack power sprayer using 600 L water per hectare. Observations on population were recorded at monthly interval. Parthenium infestations were assessed in terms of its density by sampling in one sq. m area using quadrates in wasteland ecosystems. The weed density, weed dry weight and plant height were recorded at one month interval.

RESULTS AND DISCUSSION

Effect on Parthenium density

The data on count of Parthenium before and after spray of herbicides are summarized in Table 1. In the first year, application of glyphosate and metribuzin applied in November effectively reduced the population of Parthenium upto three months after application. However, the herbicidal effect was quite slow during winter. During the fourth month another flush of Parthenium was emerged and lately the population of the weed built up to the level as under manual uprooting or manual cutting or unsprayed control. Manual uprooting or cutting were comparable to herbicidal treatments until three months of treatments. In the month of June , the hear stress desiccated and killed the population but with the onset of monaoon Parthenium again emerged. The newly emerged flush was sprayed with other additional treatments besides those applied in winter. Glyphosate 0.5 & 0.75%, metribuzin 0.25 and 0.50,mmetsulfuron methyl 0.005 & 0.010%, 2,4-DEE 0.2 & 0.3% and atrazine 0.2 & 0.3% applied before flowering were effective to control the existing flush of Parthenium as compared to manual treatments. All herbicidal treatments were effective to control Parthenium upto four months after treatment with 100% kill. The effectiveness of glyphosate, metribuzin, metsulfuron methyl, 2,4-DEE and atrazine in controlling Parthenium in cropped and non-crlopped lands has been documented (Singh et al. 2004; Mundra et al. 2015; Reddy et al. 2007; Goodall et al. 2010). However, none of the treatments offered lasting control because Parthenium regeneration density later on was no different to densities at the start of the trial. Thus successful management of Parthenium rests on a strong commitment to follow up spraying until alternative vegetation has covered and stabilized areas under treatment.

Effect on Parthenium dry weight

Application of glyphosate and metrubuzin during winter effectively reduced the dry weight of Parthenium upto fourth month of application (Table 2). Similarly the summer application of glyphosate, metribuzin, metsulfuron methyl, 2,4-DEE and atrazine gave effective reduction in dry weight of Parthenium upto fourth month of application. Like

count none of the treatments gave lasting satisfactory reduction in weed weight, though there was significant reduction in Parthenium weight under herbicidal treatments as compared to untreated control. Manual cutting and manual uprooting initially were superior to untreated check but at later stages dry weight of Parthenium was no more different among them during the first year.

Effect on height of Parthenium

All herbicidal treatments were significantly superior to untreated check in reducing the height of Parthenium upto seven months after treatment (Table 3). Manual uprooting also gave significant reduction in height of Parthenium upto seven months after treatment. But manual cutting had higher height of Parthenium at the later stages of observation. The reduction in height of Parthenium under herbicidal and manual treatments may probably be owing to late emergence and late bolting of the new flush.

Effect on count of other vegetation

The effective suppression of Parthenium due to different herbicidal treatments led to occupy the land by other vegetation during both the years. The population of other vegetation in most of the treatments was higher than the untreated check. This was obvious owing to reduction in competition in these treatments whereas Parthenium might have eliminated the other vegetation in the untreated check due to its vigorous competition and allelopathy. There was significant variation in the population of other vegetation due to herbicidal treatments depending upon efficacy, residual activity, persistence and phytotoxicity of the herbicides.

In summary the wasteland was dominated by Parthenium as well as other broad leaved weeds. Herbicides were applied when Parthenium was 22.3-55.1 cm in height in the first year and 22.8-47.8 cm in the second year. In wasteland ecosystem glyphosate 0.5 and 0.75 per cent, metribuzin 0.25 and 0.50 per cent, metsulfuron methyl 0.005 and 0.01 per cent, 2, 4 -D 0.2 and 0.3 per cent and atrazine 0.2 and 0.3 per cent were effective to control the existing flush of Parthenium. All herbicides were effective to control Parthenium upto four months after application with 100% kill. The herbicidal treatments were also superior to manual treatments in reducing the count and dry weight and height of Parthenium Subsequently upto 7 months after treatment. Though all the herbicides treatments resulted in significantly lower density and dry weight of Parthenium as compared to other weed control treatments up to four months after treatment but metribuzin, 2, 4-D, metsulfuron methyl and atrazine were effective without any phytotoxic effects on grasses. The manual weeding treatment resulted in lower weed density and dry weight at initial stages only but, uprooting was found superior than the cutting treatment. With the effective management of Parthenium the population of other vegetation (Ageratum conyzoides, Bidens pilosa and local grasses) increased significantly especially in the glyphosate treated plots. The conclusive inference in that repeated sprays of herbicides are required to check Parthenium unless the area is occupied by useful grasses. Alternatively suitable forage sp needs to be planted once the area made free from Parthenium. The subsequent flushes of Parthenium may be checked with selective herbicides or when plants of the weed must be sprayed or uprooted immediately as and when noticed.

Table1Effects of treatments on parthenium population (No./m^2) in Wasteland ecosystem.

Treatment	Before spray		1 MAT		2 MAT		3 MAT		4 MAT		5 MAT		6 MAT		7 MAT	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Glyphosate 0.5%	15.2 (233.3)	8.4 (70.0)	2.19 (6.7)	1.4 (1.0)	1.0 (0.0)	1.0 (0.0)	2.5 (6.7)	1.0 (0.0)	10.9 (118.7)	1.0 (0.0)	12.4 (155)	4.5 (20.0)	15.1 (230.0)	5.3 (28.0)	9.8 (96.0)	5.9 (34.0)
Glyphosate 0.75%	9.3 (86.7)	8.4 (70.2)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	11.4 (128.7)	1.0 (0.0)	12.4 (154.0)	3.5 (12.0)	10.2 (103.7)	4.5 (20.0)	9.3 (85.3)	4.5 (20.0)
Metribuzin 0.25%	6.6 (44.0)	8.3 (68.8)	7.1 (50.0)	1.0 (0.0)	3.5 (16.0)	1.0 (0.0)	1.9 (3.0)	1.0 (0.0)	8.3 (69.0)	1.0 (0.0)	10.8 (117.7)	4.9 (24.0)	9.3 (85.0)	5.1 (26.0)	8.5 (68.5)	4.3 (18.0)
Metribuzin 0.50%	11.9 (144.0)	8.1 (64.6)	8.1 (66.7)	1.0 (0.0)	2.5 (5.3)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	2.2 (6.7)	1.0 (0.0)	9.3 (85.3)	3.8 (14.0)	6.9 (46.7)	3.8 (14.0)	5.2 (26.0)	4.5 (20.0)
MSM 0.005 %	-	8.5 (72.2)	-	1.7 (2.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	4.4 (18.7)	4.5 (20.0)	-	5.1 (26.0)	-	5.5 (28.0)
MSM 0.01%	-	8.4 (70.4)	-	1.7 (2.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	3.5 (12.0)	-	4.5 (20.0)	-	5.1 (26.0)
2,4-DEE 0.2%	-	8.3 (68.8)	-	1.9 (3.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	4.3 (18.0)	-	5.3 (28.0)	-	5.5 (30.0)
2,4-DEE 0.3%	-	8.2 (66.4)	-	1.7 (2.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	3.8 (14.0)	-	5.1 (26.0)	-	5.3 (28.0)
Atrazine 0.2%	-	8.4 (70.1)	-	1.7 (2.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	4.1 (16.0)	-	5.3 (28.0)	-	5.5 (30.0)
Atrazine 0.3%	-	8.3 (68.8)	-	1.7 (2.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	3.5 (12.0)	-	4.9 (24.0)	-	5.5 (30.0)
Manual uprooting	10.3 (108.0)	8.7 (76.2)	5.1 (33.3)	4.8 (23.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	2.3 (4.5)	10.8 (116.0)	2.5 (5.3)	14.4 (211.0)	6.3 (40.0)	12.7 (167.3)	6.5 (42.0)	9.3 (86.3)	6.8 (46.0)
Manual cutting	7.0 (49.3)	8.5 (72.2)	8.5 (73.3)	5.0 (25.0)	1.0 (0.0)	1.8 (2.4)	1.0 (0.0)	2.6 (6.2)	9.3 (85.7)	3.0 (8.6)	11.5 (134.0)	6.8 (46.0)	10.1 (102.7)	7.6 (58.0)	7.7 (58.3)	8.1 (66.0)
Unsprayed control	9.4 (88.0)	8.5 (72.3)	10.2 (154.0)	8.2 (67.0)	13.9 (152.0)	7.1 (50.8)	7.8 (59.3)	7.1 (50.8)	15.3 (239.3)	6.3 (40.0)	14.7 (220.0)	10.9 (120.0)	12.0 (145.0)	11.7 (138.0)	11.4 (130.7)	12.2 (150.0)
LSD (P=0.05)	2.75	NS	3.14	0.29	1.9	0.14	1.5	0.12	1.98	0.17	2.82	0.58	2.57	0.47	1.54	0.41

I, year I; II, year II; MAT, month after spray; values given in parentheses are the means of original values

Table 2. Effect of treatments on dry weight of Parthenium (g/m2) in wasteland ecosystem

Treatment	Before spray		1 MAT		2 MAT		3 MAT		4 MAT		5 MAT		6 MAT		7 MAT	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Glyphosate 0.5%	6.5 (41.9)	6.9 (48.0)	1.0 (0.0)	1.0 (0.1)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.1 (0.2)	1.0 (0.0)	2.8 (7.3)	2.7 (6.4)	10.4 (107.2)	2.9 (7.4)	9.8 (97.1)	2.7 (6.2)
Glyphosate 0.75%	9.8 (99.7)	6.4 (40.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.1)	1.0 (0.0)	1.9 (4.3)	2.8 (6.8)	10.5 (109.9)	2.8 (6.8)	16.5 (274.9)	2.5 (5.4)
Metribuzin 0.25 %	9.8 (99.7)	6.8 (46.0)	4.0 (15.3)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.1 (0.3)	1.0 (0.0)	1.0 (0.1)	1.0 (0.0)	2.8 (6.8)	3.0 (7.8)	6.4 (40.7)	3.0 (8.2)	13.7 (188.5)	2.8 (6.7)
Metribuzin 0.50 %	9.2 (86.3)	6.5 (42.0)	3.8 (13.7)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.4 (1.1)	2.3 (4.2)	3.8 (13.7)	2.5 (5.2)	4.2 (16.5)	2.3 (4.2)
MSM 0.005 %	-	6.7 (44.0)	-	1.4 (1.1)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	2.9 (7.4)	-	3.1 (8.6)	-	2.7 (6.2)
MSM 0.01%	-	6.8 (46.0)	-	1.4 (1.2)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	2.8 (6.8)	-	2.9 (7.2)	-	2.5 (5.1)
2,4-DEE 0.2%	-	6.9 (48.0)	-	1.8 (2.4)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	3.1 (8.8)	-	3.0 (8.2)	-	2.7 (6.1)
2,4-DEE 0.3%	-	7.1 (50.0)	-	1.4 (1.2)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	2.9 (7.2)	-	3.0 (8.0)	-	2.6 (5.6)
Atrazine 0.2%	-	6.8 (46.0)	-	1.5 (1.4)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	2.7 (6.2)	-	2.8 (7.0)	-	2.5 (5.2)
Atrazine 0.3%	-	6.7 (44.0)	-	1.5 (1.4)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	2.7 (6.1)	-	2.8 (7.0)	-	2.6 (5.7)
Manual uprooting	9.5 (89.9)	6.5 (42.0)	1.0 (0.0)	3.6 (12.4)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.8 (2.3)	1.0 (0.0)	2.0 (3.2)	2.3 (4.3)	3.7 (12.8)	4.1 (16.3)	4.4 (18.8)	14.8 (218.1)	3.9 (14.4)
Manual cutting	7.1 (50.4)	6.9 (47.0)	8.2 (66.4)	3.9 (14.8)	1.0 (0.0)	1.5 (1.3)	1.0 (0.0)	2.1 (3.4)	1.0 (0.0)	2.3 (4.2)	2.6 (6.0)	4.8 (22.4)	11.8 (137.9)	5.8 (32.4)	18.4 (340.3)	4.7 (20.8)
Unsprayed control	11.0 (122.1)	7.1 (50.8)	11.0 (120.7)	7.6 (58.2)	12.4 (155.1)	5.4 (28.8)	2.0 (3.1)	4.5 (20.2)	1.6 (1.6)	5.7 (31.2)	2.8 (7.1)	7.2 (50.8)	12.2 (149.3)	8.4 (70.2)	19.2 (368.9)	6.8 (45.2)
LSD (P=0.05)	2.6	0.4	0.97	0.28	1.07	0.14	0.15	0.15	0.15	0.12	NS	0.34	1.32	0.37	2.29	0.31

I, year I; II, year II; MAT, month after spray; Values given in parentheses are the means of original values

Table 3. Effect of treatments on height of Parthenium (cm) in wasteland ecosystem

Treatment	Before spray		1 MAT		2 MAT		3 MAT		4 MAT		5 MAT		6 MAT		7 MAT	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Glyphosate 0.5%	4.8 (22.3)	6.2 (38.3)	1.0 (0.0)	1.6 (1.8)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.7 (2.2)	1.0 (0.0)	3.3 (10.1)	2.8 (7.4)	5.0 (23.9)	4.9 (24.0)	5.4 (28.1)	5.4 (28.4)
Glyphosate 0.75%	5.8 (34.1)	6.8 (46.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.1)	1.0 (0.0)	2.1 (3.5)	2.7 (6.8)	7.5 (57.5)	5.1 (26.0)	7.8 (60.2)	5.3 (28.0)
Metribuzin 0.25 %	6.1 (36.3)	5.1 (25.8)	6.8 (45.2)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.1 (0.3)	1.0 (0.0)	1.9 (3.0)	1.0 (0.0)	3.4 (10.6)	2.6 (6.2)	3.8 (14.0)	4.5 (20.0)	6.6 (42.8)	5.4 (29.0)
Metribuzin 0.50 %	6.5 (41.8)	5.8 (33.0)	5.9 (34.4)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	3.7 (12.6)	2.7 (6.6)	4.1 (16.1)	4.1 (16.0)	4.7 (21.0)	4.6 (21.0)
MSM 0.005 %	-	5.4 (28.5)	-	2.3 (4.7)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	2.6 (6.2)	-	4.3 (18.0)	-	4.8 (23.0)
MSM 0.01%	-	5.7 (32.3)	-	2.2 (4.1)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	2.9 (8.0)	-	4.5 (20.0)	-	5.4 (28.2)
2,4-DEE 0.2%	-	6.3 (38.7)	-	2.4 (5.2)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	2.8 (7.0)	-	4.7 (22.0)	-	5.0 (24.4)
2,4-DEE 0.3%	-	6.5 (41.5)	-	2.4 (5.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	3.1 (8.8)	-	4.9 (24.0)	-	5.2 (26.8)
Atrazine 0.2%	-	5.4 (28.3)	-	2.6 (6.1)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	2.7 (6.8)	-	5.1 (26.0)	-	5.4 (28.8)
Atrazine 0.3%	-	5.8 (33.5)	-	2.7 (6.5)	-	1.0 (0.0)	-	1.0 (0.0)	-	1.0 (0.0)	-	3.0 (8.4)	-	4.3 (18.0)	-	4.6 (20.4)
Manual uprooting	3.6 (12.0)	4.9 (23.)	1.0 (0.0)	3.6 (12.4)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	3.0 (8.2)	1.0 (0.0)	3.0 (8.2)	1.8 (2.2)	3.0 (8.2)	1.2 (0.6)	4.5 (20.0)	1.6 (1.6)	5.4 (28.8)
Manual cutting	7.4 (55.1)	5.5 (29.8)	2.8 (6.8)	4.1 (16.0)	1.0 (0.0)	3.8 (14.0)	1.0 (0.0)	3.2 (9.3)	3.0 (8.0)	3.3 (10.0)	5.2 (26.7)	3.1 (8.9)	8.5 (72.2)	7.1 (50.2)	8.6 (73.8)	8.4 (70.3)
Unsprayed control	7.2 (50.9)	6.9 (47.8)	8.9 (78.8)	8.1 (66.0)	7.3 (52.7)	6.9 (48.0)	3.9 (14.5)	4.8 (23.0)	5.2 (26.3)	4.2 (17.3)	6.7 (44.1)	5.4 (28.4)	8.6 (73.9)	7.5 (55.8)	9.1 (82.7)	8.9 (78.4)
LSD (P=0.05)	1.47	0.32	0.78	0.21	0.78	0.16	0.55	0.21	0.70	0.27	0.48	0.43	1.38	0.49	0.75	0.45

I, year I; II, year II; MAT, month after spray; Values given in parentheses are the means of original value

Table 4. Effect of treatments on count of other vegetation (No. /m2) in wasteland ecosystem

Treatment	Before spray		1 MAT		2 MAT		3 MAT		4 MAT		5 MAT		6 MAT		7 MAT	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Glyphosate 0.50%	10.3 (106.3)	9.4 (88.0)	1.0 (0.0)	1.0 (0.0)	9.4 (87.7	6.9 (46.8)	13.3 (177.7)	7.4 (54.0)	7.7 (59.0)	5.9 (34.0)	9.0 (80.3)	9.4 (88.5)	2.6 (8.0)	5.9 (34.6)	2.7 (8.0)	4.8 (22.1)
Glyphosate 0.75%	8.0 (64.3)	9.6 (92.0)	1.0 (0.0)	1.0 (0.0)	6.9 (47.0)	6.4 (40.0)	9.2 (84.3)	7.0 (48.1)	9.1 (81.7)	6.2 (38.2)	10.0 (99.0)	9.5 (90.5)	4.1 (15.7)	6.1 (36.8)	1.7 (2.3)	5.0 (24.5)
Metribuzin 0.25 %	6.7 (44.7)	9.7 (94.0)	5.9 (34.3)	6.2 (38.4)	11.8 (140.0)	10.1 (101.2)	14.7 (217.7)	10.5 (110.2)	13.6 (184.3)	8.3 (68.7)	11.9 (142.7)	10.5 (110.4)	9.4 (89.3)	7.7 (58.4)	8.2 (68.0)	7.0 (48.7)
Metribuzin 0.50 %	11.6 (134.7)	9.5 (90.0)	8.5 (72.3)	6.4 (40.8)	7.1 (50.3)	9.6 (92.0)	19.1 (363.7)	9.9 (98.1)	8.4 (70.7)	8.4 (70.2)	11.2 (127.0)	10.6 (112.8)	9.2 (84.0)	7.2 (50.6)	6.5 (41.7)	6.9 (46.5)
MSM 0.005 %	-	9.8 (97.0)	-	7.1 (50.2)	-	9.7 (94.0)	-	10.6 (112.4)	-	8.5 (72.8)	-	11.0 (120.4)	-	7.3 (52.1)	-	6.8 (45.7)
MSM 0.01%	-	9.4 (88.0)	-	7.3 (52.4)	-	9.8 (95.2)	-	10.2 (104.5)	-	8.3 (68.0)	-	11.5 (131.5)	-	7.7 (58.6)	-	6.6 (42.7)
2,4-DEE 0.2%	-	8.8 (78.0)	-	7.0 (48.6)	-	9.9 (98.5)	-	10.5 (111.2)	-	8.2 (66.5)	-	10.6 (112.5)	-	7.6 (56.2)	-	6.7 (44.6)
2,4-DEE 0.3%	-	8.7 (76.0)	-	7.3 (52.6)	-	9.5 (90.1)	-	9.9 (98.3)	-	7.9 (62.0)	-	11.1 (123.6)	-	7.5 (56.4)	-	6.9 (44.7)
Atrazine 0.2%	-	9.5 (90.0)	-	7.0 (48.7)	-	9.5 (90.1)	-	10.4 (108.2)	-	8.4 (71.2)	-	11.2 (125.4)	-	7.8 (60.2)	-	7.1 (50.1)
Atrazine 0.3%	-	10.9 (120.0)	-	7.8 (60.4)	-	9.6 (92.1)	-	10.1 (102.1)	-	8.3 (68.4)	-	10.6 (112.5)	-	8.0 (62.4)	-	7.3 (52.4)
Manual uprooting	12.7 (162.0)	10.5 (110.0)	19.6 (385.3)	11.8 (140.2)	18.2 (344.0)	12.6 (160.0)	20.8 (433.3)	16.1 (260.0)	8.6 (73.7)	8.3 (68.0)	11.5 (131.7)	8.9 (80.0)	11.6 (133.3)	8.1 (64.7)	7.0 (48.3)	6.2 (38.1)
Manual cutting	8.4 (70.0)	9.5 (90.0)	12.1 (147.0)	11.4 (130.5)	16.5 (275.3)	13.4 (180.0)	19.1 (367.0)	14.5 (210.0)	10.2 (105.0)	8.5 (72.0)	7.1 (50.0)	7.1 (50.0)	7.2 (51.3)	6.8 (44.8)	4.7 (21.7)	4.7 (21.5)
Unsprayed control	4.6 (20.7)	9.4 (88.0)	6.1 (36.7)	11.0 (120.0)	6.8 (45.7)	11.0 (120.2)	7.2 (51.3)	11.3 (128.0)	6.7 (44.3)	7.8 (61.2)	6.1 (36.0)	7.5 (56.1)	5.4 (28.3)	6.2 (38.0)	4.8 (22.3)	4.8 (22.4)
LSD (P=0. 05)	1.82	0.27	1.22	0.27	1.77	0.26	2.77	0.32	1.76	0.30	1.93	0.28	1.96	0.38	1.64	0.44

I, year I; II, year II; MAT, month after spray; Values given in parentheses are the means of original values

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