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Evaluation of herbicide efficacy and combinations for weed management in non-crop situations

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Abstract

A field experiment was conducted during rainy season of the year 2019-20 at Navsari Agricultural University, Navsari to identify efficient herbicides and their combinations to manage weeds in non-crop situation. The experiment was laid out in a randomized block design replicated thrice with seven weed management treatments involving herbicides *i.e.* glyphosate, paraquat, oxyfluorfen, 2,4-D amine salt along with mowing and weedy check. All treatments significantly reduced the weed density and biomass compared to weedy check. Midst different treatments, Glyphosate 41% SL 3.0 kg/ha (W₂) found effective and completely destroyed the growth of weeds, however, negligible dry weight was observed at 60 DAA. Further, it was observed statistically at par with Glyphosate 41% SL 2.0 kg/ha alone (W₁) or in combination with 2,4-D salt 58% SL 2.0 kg/ha (Tank mix) (W₆) upto 60 DAA and Glyphosate 41% + Oxyfluorfen 2.5% SC 2.0 kg/ha (Ready mix) (W₅) upto 30 DAA. It means, spraying of Glyphosate 41% SL alone/combination was found appropriate for checkout the dry weight of weeds significantly upto 60 DAA. Amongst the different herbicides combination, Glyphosate 41% + Oxyfluorfen 2.5% SC was found more effective compared to Glyphosate 41% + 2,4-D salt 58% SL for monocot weeds. While, combine application of Glyphosate 41% + 2,4-D salt 58% SL most effectively destroyed the dicot weeds at 60 DAA.

Keywords: Glyphosate, 2,4-D amine salt, non-cropped areas, paraquat, weed management

Introduction

Weeds are undesirable plants for human activity at any time, any place and will always be associated with human endeavors. The unchecked growth of vegetation on non-crop areas such as rights-of way, road sides, storage areas, public works yards, parking lots, grazing land and transmission lines can create problems ranging from creating fire hazards, reducing drainage, reducing accessibility and visibility to snow blockage, shrinkage of the area for animal grazing, fodder production and thus threat to ecology and human health, besides deterioration in the aesthetic values of the area and finally the problem of environmental degradation. Their presence in these vacant and uncultivated areas is highly undesirable as they provide food, shelter and reproductive sites for various pest organisms (Plant pathogens, insects, mites, nematodes etc.) and serve as alternate hosts for these harmful organisms which may spread to neighbouring fields during cropping season and adversely infest crop plants (Bhowmick, 2002; Bhowmick *et al.*, 2012) ^[1, 2]. Poor weed management practices may increase weed seed reservoirs and the potential for weed problems if the land is ever brought into crop production, provide for a source of new weed problems in adjoining fields through seed dispersed by wind, animals or perennials creeping in from field edges and lower economic land values. Overall, weed flora in non-cropped situations is much more complex as compared to cropped area. So far, very little attention has been paid for weed control in non-cropped areas/situation. Weeds can be controlled by cultural methods like mowing or cultivation in combination with herbicide use. Further, non-availability of timely labour and wages has forced farmers to go for herbicides. Thus, use of herbicide is becoming inevitable in modern agriculture, especially under large holdings, lack of climatic condition congenial for hand weeding and being tedious. For total vegetation control, non-selective post emergent herbicides can be used after weed emergence. Non-selective herbicides will control all plants including grasses and broadleaf weeds when

applied according to the label directions. Presently, Paraquat and Glyphosate are being used as total weed killer in non cropped areas. Therefore, it is imperative to find out the right dose of application with appropriate combination of post emergence herbicides, particularly Glyphosate and Paraquat combine with Oxyfluorfen or 2,4-D (ready or tank mixture) and alone for maximizing herbicidal activity.

Materials and Methods

This experiment was conducted at College Farm, NMCA, Navsari Agricultural University, Navsari during Kharif 2019-20 under non cropped situation in field that was not used for cultivation and undisturbed. The selected site has uniform level and infested with location specific weeds, a true representative of non-cropped area. The soil of experimental site belongs to Vertisol, clayey in texture with pH of 7.6 and EC of 0.70 dS/m. The experiment was laid out in a randomized block design (RDB) with three replications that comprised nine weed management treatments, viz. glyphosate 2.0 kg/ha glyphosate 3.0 kg/ha, paraquat 3.0 kg/ha, paraquat 4.0 kg/ha, glyphosate + oxyfluorfen 2.0 kg/ha (ready-mix), glyphosate 2.0 kg/ha + 2,4-D amine salt 2.0 kg/ha (tank-mix), paraquat 2.0 kg/ha + 2,4 D amine salt 2.0 kg/ha (tank-mix), mowing (one weed flush) and weedy check. Before the onset of monsoon, selected site was prepared manually, demarcated with the help of wire to each of experimental unit. The required quantity of herbicides was applied using a knapsack spray fitted with a flat fan nozzle. Fresh solution for individual plot was prepared separately for each plot and spray volume i.e. 460 litres/ha was determined after calibration. Mowing was done manually with the help of iron sword. All the weed management treatments were imposed after 25 days of normal session of monsoon. The observation on category wise pre-existing weeds of monocots, dicots and sedges were recorded at 7, 15, 21, 30 and 60 days after herbicidal application by using a quadrat. The quadrat of 1 m² was randomly placed in each plot and then the total and species wise weed count (density) was recorded. Weeds were clipped from ground surface, and dried in an oven at 65 °C ±2 for 48 h for

determining dry weed biomass. The data collected were subjected to Fisher's analysis of variance technique using "MSTATC" statistical software at $\alpha = 0.05$ probabilities was applied to compare the differences among treatments means.

Results and Discussion

Weed flora in non-cropped land

The data presented in table1 revealed that the experimental field was infested by number of weed species. Among monocot weeds, viz., *Sorghum halepense* L., *Cynodon dactylon* L., *Digitaria sanguinalis* L., *Echinochloa crusgalli* L., *Commelina benghalensis* L., *Dactyloctenium aegyptium* L. and *Eleusine indica* L. While, dicot weeds, viz., *Parthenium hysterophorus* L., *Solanum xanthocarpum* L., *Digera arvensis* L., *Alternanthera sessilis* L., *Amaranthus viridis* L., *Trianthema portulacastrum* L. and *Abelmoschus ficulneus* L.; *Cyperus rotundus* L. only the sedge were predominantly observed during the course of experimentation.

Relative density of weeds in non-cropped area

Relative density of dominant weed flora observed in weedy check is presented in the table 1. It is obvious from the data that monocot weeds (*Sorghum halepense*, *Cynodon dactylon*, *Digitaria sanguinalis*, *Echinochloa crusgalli*, *Commelina benghalensis* and other monocot) were rampant in non cropped land, as they constituted 52.62 per cent relative density during 7 DAA, which increased to 53.16 per cent at 60 days of experiment. Whereas, the dicot weeds (*Parthenium hysterophorus*, *Solanum xanthocarpum*, *Digera arvensis*, *Alternanthera sessilis* and other dicots) contributed 36.90 per cent to the total density during initial stage (7 DAA), which increased to 37.16 per cent at 60 days of experiment. The *Cyperus rotundus* contributed only 10.49 per cent to the total relative density at 7 DAA, which decreased to 9.68 per cent in relative density during 60 day of experiment. On an average, monocot, dicot and sedge weeds composition was 52.98, 37.20 and 9.82 per cent, respectively.

Table 4.2: Densities of weeds observed periodically in weedy plots in non-cropped area

No.	Botanical name	Weed density (no./m ²)					Relative density (%)					
		7 DAA	15 DAA	21 DAA	30 DAA	60 DAA	7 DAA	15 DAA	21 DAA	30 DAA	60 DAA	Average
[A]	Monocot weeds											
1.	<i>Sorghum halepense</i> L.	17.67	19.67	21.33	23.67	24.00	9.93	9.88	9.86	9.97	9.29	9.79
2.	<i>Cynodon dactylon</i> L.	20.33	22.67	23.33	26.67	28.67	11.42	11.39	10.78	11.24	11.10	11.19
3.	<i>Digitaria sanguinalis</i> L.	17.67	20.67	23.33	24.33	25.33	9.93	10.39	10.78	10.25	9.81	10.23
4.	<i>Echinochloa crusgalli</i> L.	13.67	14.33	17.00	18.33	21.67	7.68	7.20	7.86	7.72	8.39	7.77
5.	<i>Commelina benghalensis</i> L.	13.00	13.67	14.33	15.67	18.67	7.30	6.87	6.62	6.60	7.23	6.92
6.	Other monocot weeds	11.33	14.00	15.00	18.33	19.00	6.37	7.04	6.93	7.72	7.35	7.08
	Total monocot weeds (A)	93.67	105.00	114.33	127.00	137.33	52.62	52.76	52.85	53.51	53.16	52.98
[B]	Dicot weeds											
1.	<i>Parthenium hysterophorus</i> L.	14.67	16.67	19.00	20.67	23.67	8.24	8.38	8.78	8.71	9.16	8.65
2.	<i>Solanum xanthocarpum</i> L.	7.67	8.67	9.00	10.00	11	4.31	4.36	4.16	4.21	4.26	4.26
3.	<i>Digera arvensis</i> L.	17.67	19.33	20.00	21.00	22.67	9.93	9.71	9.25	8.85	8.78	9.30
4.	<i>Alternanthera sessilis</i> L.	14.67	17.67	18.33	21.00	21.33	8.24	8.88	8.47	8.85	8.26	8.54
6.	Other dicot weeds	11.00	12.67	14.33	15.00	17.33	6.18	6.37	6.62	6.32	6.71	6.44
	Total dicot weeds (B)	65.67	75.00	80.67	87.67	96.00	36.90	37.69	37.29	36.94	37.16	37.20
[C]	Sedge											
1.	<i>Cyperus rotundus</i> L.	18.67	19.00	21.00	22.67	25.00	10.49	9.55	9.86	9.55	9.68	9.82
	Total sedges weeds (C)	18.67	19.00	21.33	22.67	25.00	10.49	9.55	9.86	9.55	9.68	9.82
Total (monocot, dicot and sedge) weed (A + B + C)		178.00	199.00	216.33	237.33	258.33	100.00	100.00	100.00	100.00	100.00	100.00

Dry biomass of weed (g/m²)

Dry matter accumulation by weeds is an indication of weed growth under particular treatments. There was conspicuous

difference in dry weight of weeds among different weed management treatments at 15, 30 and 60 DAA, especially in comparison with weedy check (W₉) control. The comparison

among treatment means have been made only on transformed values.

Dry biomass of monocot weeds (g/m²)

All the herbicidal weed control treatments had curbed the dry weight of monocot weeds identically over weedy check (W₉). However, Post emergence application of the Glyphosate 41% SL was found to be effective in curtailing the dry matter of the monocot. Application of Glyphosate 41% SL higher dose *i.e.* 3.0 kg/ha (W₂) was gave cent per cent reduction in monocots dry weight up to 30 DAA with minimum dry weight was observed at 60 DAA, being statistically at par with Glyphosate 41% SL 2.0 kg/ha (W₁), Glyphosate 41% 2.0 kg/ha + Oxyfluorfen 2.5% SC 2.0 kg/ha (Ready mix) (W₅) and Glyphosate 41% SL 2.0 kg/ha + 2,4-D salt 58% SL 2.0 kg/ha (Tank mix) (W₆). Similar trends were also witnessed at 60 DAA, whereas, total monocot weeds

was controlled significantly and minimum population was documented under application Glyphosate 41% SL 3.0 kg/ha (W₂) and eventually recorded significantly lower dry weight of weeds (1.33 g/m²), which was statistically at par with Glyphosate 41% SL 2.0 kg/ha alone (W₁:1.75 g/m²) or in combination with either Oxyfluorfen 2.5% SC 2.0 kg/ha (Ready mix) (W₅:2.07 g/m²) or 2,4-D salt 58% SL 2.0 kg/ha (Tank mix) (W₆:2.28 g/m²). It means, spraying of Glyphosate 41% SL alone/combination was found appropriate for checkout the dry weight of weeds significantly upto 60 DAA. Paraquat dichloride 24% SL alone or with 2,4-D salt 58% SL (tank mixed) check the dry weight of weeds considerably, however, not upto the acceptance level as higher population and dry weight of weeds was observed compared to superior treatments. While, weedy check (W₉) recorded significantly highest dry weight of monocot weeds (54.85 g/m²).

Table 2: Dry biomass of total monocot weeds at 15, 30 and 60 DAA as influenced by weed management treatments

Treatment		Dry biomass of total monocot weeds (g/m ²)					
		15 DAA		30 DAA		60 DAA	
W ₁ :	Glyphosate 41% SL 2.0 kg/ha	0.73	(0.04)	0.85	(0.27)	1.49	(1.75)
W ₂ :	Glyphosate 41% SL 3.0 kg/ha	0.71	(0.00)	0.71	(0.00)	1.35	(1.33)
W ₃ :	Paraquat dichloride 24% SL 3.0 kg/ha	0.95	(0.41)	2.62	(6.40)	3.86	(14.41)
W ₄ :	Paraquat dichloride 24% SL 4.0 kg/ha	0.85	(0.23)	2.45	(5.49)	3.71	(13.26)
W ₅ :	Glyphosate 41% + Oxyfluorfen 2.5% SC 2.0 kg/ha (Ready mix)	0.78	(0.11)	0.76	(0.09)	1.60	(2.07)
W ₆ :	Glyphosate 41% SL 2.0 kg/ha + 2,4-D salt 58% SL 2.0 kg/ha (Tank mix)	0.87	(0.25)	0.84	(0.22)	1.66	(2.28)
W ₇ :	Paraquat dichloride 24% SL 2.0 kg/ha + 2,4-D salt 58% SL 2.0 kg/ha (Tank mix)	0.91	(0.33)	2.49	(5.75)	3.56	(12.20)
W ₈ :	Mowing (one weed flush)	1.02	(0.54)	3.73	(13.39)	5.02	(24.75)
W ₉ :	Weedy check (control)	4.07	(16.18)	5.98	(32.25)	7.43	(54.85)
	S.Em. ±	0.07		0.09		0.13	
	CD (p=0.05)	0.22		0.27		0.39	
	CV%	10.74		6.95		6.84	

*Data in parenthesis indicate actual value and $\sqrt{X + 0.5}$ transformed value of weeds those outside.

Dry biomass of dicot weeds (g/m²)

Dry biomass of dicot weeds was differed significantly due to different weed management treatments. All herbicidal treatments completely devastated the population, ultimately completely checked the dry weight of dicot weeds at 15 DAA. However, limited resurgence was observed under mowing (W₈) that show 0.64 g/m² dry weight of weeds, but found significantly superior then weedy check (W₉), that reported maximum dry weight of dicot weeds (12.69 g/m²). Further, Glyphosate 41% SL 2.0 or 3.0 kg/ha (W₁ and W₂) were show their superiority by paralyzed the dry weight of dicot weeds cent per cent up to 30 DAA. Moreover, spraying of Glyphosate 41% SL 2.0 kg/ha was excellent when it was applied with 2,4-D salt 58% SL 2.0 kg/ha (Tank mix) (W₆) as there was observed hundred per cent

reduction in dry weight of dicot weed at 60 DAA, remained at par with Glyphosate 41% SL 2.0 or 3.0 kg/ha (W₁ and W₂). Furthermore, treatment Glyphosate 41% + Oxyfluorfen 2.5% SC 2.0 kg/ha (Ready mix) (W₅) was at par with Glyphosate 41% SL 2.0 or 3.0 kg/ha (W₁ and W₂) and glyphosate 2.0 kg/ha + 2,4-D amine salt 2.0 kg/ha (tank-mix) (W₆) at 30 DAA. With passage of time, the efficiency of Paraquat dichloride 24% SL at 3.0 or 4.0 kg/ha (W₃ and W₄) or combined with 2,4-D salt 58% SL 2.0 kg/ha (tank mixed) (W₇) were reduced and reported considerable amount of dicot weeds dry weight, but found significantly lower than weedy check (W₉). Contrary to this, significantly higher dry weight of dicot weeds (37.95 g/m²) was recorded under weedy check (W₉), followed by mowing (W₈:13.79 g/m²) as it was observed resurgence of weeds within the 15 DAA.

Table 3: Dry biomass of total dicot weeds at 15, 30 and 60 DAA as influenced by weed management treatments

Treatment		Dry biomass of total dicot weeds (g/m ²)					
		15 DAA		30 DAA		60 DAA	
W ₁ :	Glyphosate 41% SL 2.0 kg/ha	0.71	(0.00)	0.71	(0.00)	0.95	(0.43)
W ₂ :	Glyphosate 41% SL 3.0 kg/ha	0.71	(0.00)	0.71	(0.00)	0.84	(0.23)
W ₃ :	Paraquat dichloride 24% SL 3.0 kg/ha	0.71	(0.00)	1.94	(3.26)	3.14	(9.38)
W ₄ :	Paraquat dichloride 24% SL 4.0 kg/ha	0.71	(0.00)	1.76	(2.63)	3.09	(9.05)
W ₅ :	Glyphosate 41% + Oxyfluorfen 2.5% SC 2.0 kg/ha (Ready mix)	0.71	(0.00)	0.75	(0.06)	1.19	(0.97)
W ₆ :	Glyphosate 41% SL 2.0 kg/ha + 2,4-D salt 58% SL 2.0 kg/ha (Tank mix)	0.71	(0.00)	0.71	(0.00)	0.71	(0.00)
W ₇ :	Paraquat dichloride 24% SL 2.0 kg/ha + 2,4-D salt 58% SL 2.0 kg/ha (Tank mix)	0.71	(0.00)	1.14	(0.82)	2.39	(5.24)
W ₈ :	Mowing (one weed flush)	1.06	(0.64)	3.31	(10.50)	3.78	(13.79)
W ₉ :	Weedy check (control)	3.63	(12.69)	5.98	(35.25)	6.20	(37.95)
	S.Em. ±	0.05		0.08		0.11	
	CD (p=0.05)	0.16		0.23		0.34	
	CV%	8.54		7.02		7.99	

*Data in parenthesis indicate actual value and $\sqrt{X + 0.5}$ transformed value of weeds those outside

All the weed control treatments restricted the dry weight of monocot weeds significantly over weedy check (W_9) that offered significantly the maximum dry mass of monocot weeds. Post emergence application of the Glyphosate 41% SL was found to be equally effective in curtailing the dry matter of the major monocot weeds which could be due to rapid absorption and translocation of Glyphosate at lethal concentration to monocot weeds which caused inhibition of protein synthesis due to restricted activity of EPSP enzyme.

The activity of Glyphosate 41% SL herbicide against monocot weeds was improved and paralysed the dry weight applied with either Oxyfluorfen 2.5% SC 2.0 kg/ha (Ready mix) (W_5) or 2,4-D salt 58% SL 2.0 kg/ha (Tank mix) (W_6) compared to lower dose of Glyphosate 41% SL 2.0 kg/ha (W_1). Same line of results was also viewed at 60 DAA and the lower dry weight of total monocot was registered with Glyphosate 41% SL 3.0 kg/ha (W_2). This may be due to inhibition of translocation of photosynthate to the growing point coupled with 100% inhibition of aromatic acids synthesis, could be assigned the reasons for restricted growth of total monocot. However, Glyphosate 41% SL 3.0 kg/ha (W_2) closely followed by Glyphosate 41% SL 2.0 kg/ha (W_1), Glyphosate 41% + Oxyfluorfen 2.5% SC 2.0 kg/ha (Ready mix) (W_5) and Glyphosate 41% SL 2.0 kg/ha + 2,4-D salt 58% SL 2.0 kg/ha (Tank mix) (W_6). Different weed control methods reduce the weed population and growth considerably which might have reflected in reduced dry weight of weed under these treatments. Such positive and significant effect of the herbicides on decline of dry matter yield is in accordance with those testified earlier by Yadav *et al.* (2000) [6], Sukhadia *et al.* (2000) [5], Sharma *et al.* (2007) [4]. Uninterrupted growth of weeds under weedy check produced significantly maximum dry weight of monocot weeds. The dry weight of dicot weeds was significantly maximum under weedy check among all the treatments and it was reduced remarkably under herbicidal treatments. Application of Glyphosate 41% SL + 2,4-D salt 58% was found to be the most effective by curtailing the dry matter of the dicot weeds. The reduction in dry weight of these weeds after application of herbicidal treatment, was due to rapid absorption and translocation of the herbicide molecules at lethal concentrations in dicot weeds at the site of action which enhanced inhibition of protein synthesis leading to its mortality. These results are corroborated the findings of Ghosh *et al.* (2002) [3]. The activity of Glyphosate 41% SL 2.0 kg/ha was found significantly good, but enhanced further when applied at higher rate *i.e.* 3.0 kg/ha. Moreover, spraying of Glyphosate 41% SL 2.0 kg/ha was excellent when it was applied with 2,4-D salt 58% SL 2.0 kg/ha (Tank mix) (W_6) as there was observed hundred per cent reduction in dry weight of dicot weed at 60 DAA. The reason responsible for reduction in dry weight of total dicot under the treatment Glyphosate 41% SL 2.0 kg/ha + 2,4-D salt 58% SL 2.0 kg/ha (Tank mix) (W_6) because it caused simultaneously dislocation of photosynthate and inhibition of protein synthesis due to restricted activity of EPSP enzyme. These results also corroborated the findings of Ghosh *et al.* (2002) [3], Anugya Sharma (2007) [4]. Further, significantly the highest dry weight of total dicot weeds was recorded with the treatment weedy check (W_9) at 15, 30 and 60 DAA.

Conclusion

The efficacy of mowing and Paraquat dichloride alone or in combination with 2,4-D excellently controlled the monocot and dicot weeds up to 10-15 days of application, onwards considerable resurgence of weeds would be observed.

Application of Glyphosate 41% SL 2.0 kg/ha completely destroyed the weeds upto 21 days, however effect was more acute with the higher rate of Glyphosate 41% SL *i.e.* 3.0 kg/ha which demolished the weeds upto 30 DAA. Under the dominance of dicot weeds, application of Glyphosate 41% SL 2.0 kg/ha + 2,4-D salt 58% SL 2.0 kg/ha (Tank mix) found most suitable, whereas, Glyphosate 41% + Oxyfluorfen 2.5% SC 2.0 kg/ha (Ready mix) found appropriate where monocot weeds become dominant.

Overall, Glyphosate 41% SL found much better as compared to other herbicides which crumbed the monocot, dicot and sedge weeds hundred percent within fortnight and checked the resurgence for a month with negligible resurgence at 60 days of application. Thus, it is advised to apply Glyphosate 41% SL 2.0 kg/ha for effective and economic control of weeds in non-cropped land.

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