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RESEARCH NOTE

Weed control in non-cropped situation using herbicides and their combinations

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ABSTRACT

A field experiment was conducted during rainy season in 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. Glyphosate 3.0 kg/ha effectively controlled weeds registering negligible weed biomass at 60 days after application (DAA). Glyphosate 2.0 kg/ha alone or in combination with 2,4-D amine salt 2.0 kg/ha (tank-mix) and glyphosate + oxyfluorfen 2.0 kg/ha (ready-mix) were at par in their efficacy to control weeds up to 60 DAA and up to 30 DAA, respectively. Paraquat 4.0 kg/ha and paraquat 2.0 kg/ha + 2,4-D salt 2.0 kg/ha (tank-mix) were found effective up to two weeks only. Thus, glyphosate 2.0 kg/ha alone or in combination with 2,4-D amine salt 2.0 kg/ha (tank-mix) may be used to effectively minimize the weeds biomass and resurgences significantly up to 60 DAA with highest weed control efficiency.

Keywords: 2,4-D amine salt, Glyphosate, Non-cropped areas, Oxyfluorfen, Paraquat, Weed management

Weeds can grow under adverse climatic conditions interfering with the utilization of natural resources and become prolific, persistent, competitive, harmful, and even poisonous in nature (Patel *et al.* 2018). They have wide ecological amplitude, so multiply and flourish well even in aberrant environments. Non-cropland area such as orchards, pastures, grasslands, forests and wasteland ecosystems do not receive frequent cultivation and intensive care of the owners, hence are invaded by obnoxious weeds like *Parthenium hysterophorus, Cynodon dactylon, Cyperus rotundus, Sorghum halepense, Solanum xanthocarpum, Alternanthera sessilis*. The low productivity of these non-cropped ecosystems leads to scarcity of food, fuel wood, fodder, fruits, monkey menace and migration of men to towns and cities in search of jobs after leaving the land fallow (Kandasamy *et al.* 1999, Bajwa *et al.* 2016 and Kaur *et al.* 2020). However, majority of people depend for their subsistence needs on such uncultivated yet degraded lands. Productivity of such lands can be restored by managing these obnoxious perennial weeds with the available technologies. Besides, weeds invasion has led to shrinkage of grazing area for animals, reduction in productivity of grasslands by 90%, threat to plant biodiversity, reduced growth of newly planted trees in manmade forests and interference in succession of natural forests, act as hiding place for wild animals and threat to ecology of the region (Kumar *et al.* 2021). These weeds also cause toxic effects on animals and are threat to human health and environment (Bhowmick *et al.* 2016).

Weed control either manually or mechanically is costlier and less effective (Patel *et al.* 2017) under such situations. Herbicides have been found very effective and economically viable too, for control of weeds in non-cropped lands (Kewat *et al.* 2008; Bhowmick *et al.* 2017 and Kaur *et al.* 2020). Hence, tank mixture of 2,4-D with glyphosate and paraquat and glyphosate + oxyfluorfen (ready-mix) were tested for control of the weeds with regenerate underground parts and check their re-infestation in the same lands within short periods.

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 (62.37%), 0.68% organic carbon, 195.3, 51.3 and 480 kg/ha available nitrogen, phosphorus and potassium 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,

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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 (control).

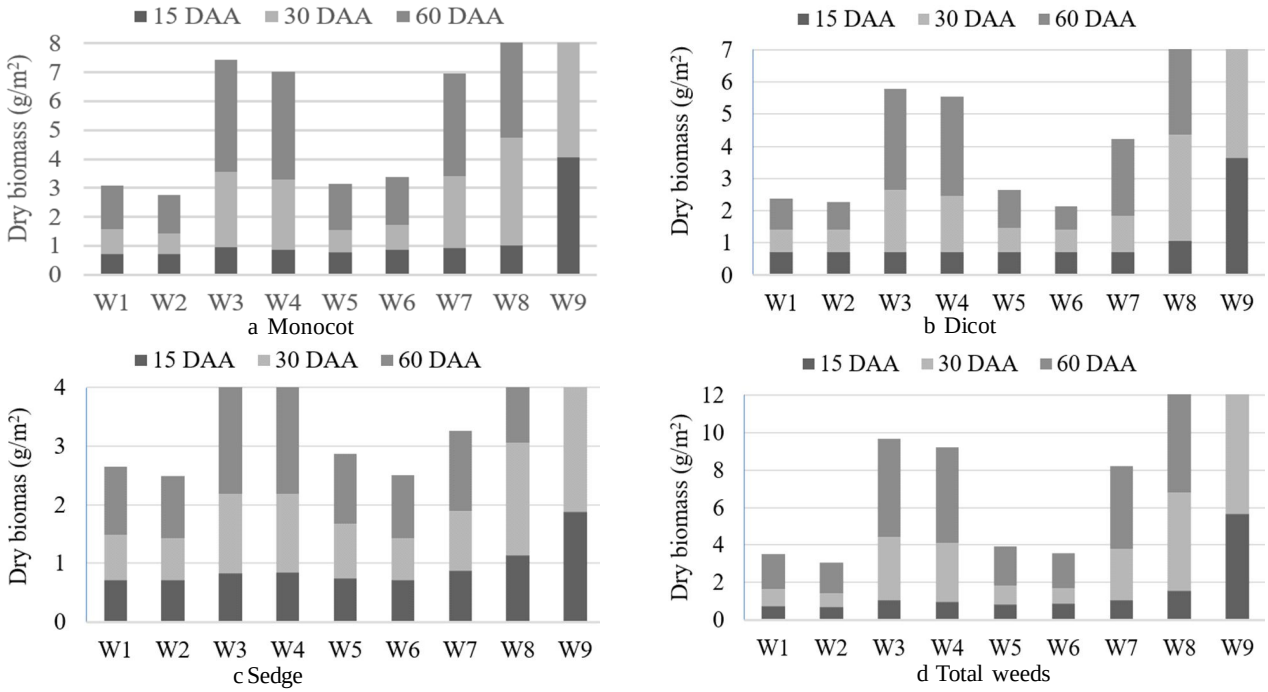
Before the onset of monsoon, selected site was prepared manually, demarcated with the help of wire to each of experimental unit. The net plot size was 5 m x 5 m. The required quantity of herbicides was applied using a knapsack spray fitted with a flat fan nozzle. Fresh solution for individual plot was 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 m^2 (1 x 1 m) 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 ºC ±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 $\sqrt{x+0.5}$ probabilities was applied to compare the differences among treatments means.

Weed flora and relative density

The predominant weeds in the experimental field include: *Sorghum halepense* (9.97%), *Cynodon dactylon* (11.10%), *Digitaria sanguinalis* (10.23%), *Echinochloa crus-galli* (7.77%), *Commelina benghalensis* (6.92%), others monocots (7.08%), *Parthenium hysterophorus* (8.65%), *Solanum xanthocarpum* (4.26%), *Digera arvensis* (9.30%), *Alternanthera sessilis* (8.54%), others dicots (6.44%) and *Cyperus rotundus* (9.82%). Further, non-dominant infestation was observed of *Dactyloctenium aegyptium* and *Eleusine indica* among monocot weeds and *Amaranthus viridis, Trianthema portulacastrum* and *Abelmoschus ficulneus* among dicot weeds.

Weed density and biomass

Monocot weeds: Mowing (one weed flush) was superior in completely reducing monocot weeds initially, and it was closely followed by paraquat (3.0 or 4.0 kg/ha). Further, glyphosate proved its efficacy by significantly reducing the monocot weeds density and biomass. Glyphosate at higher rate (3.0 kg/ha) controlled monocot weeds up to 30 days after herbicide application (DAA) with their minimal occurrence at 60 DAA (**Table 1** and **Figure 1**). Overall, post-emergence application (PoE) of glyphosate 2.0 kg/ha, glyphosate + oxyfluorfen 2.0 kg/ha (ready-mix) and glyphosate 2.0 kg/ha + 2,4-D



W_1: Glyphosate 2.0 kg/ha, W_2: Glyphosate 3.0 kg/ha, W_3: Paraquat 3.0 kg/ha, W_4: Paraquat 4.0 kg/ha, W_5: Glyphosate + Oxyfluorfen 2.0 kg/ha (ready mix), W_6: Glyphosate 2.0 kg/ha + 2,4 D salt 2.0 kg/ha (tank mix), W_7: Paraquat 2.0 kg/ha + 2,4 D salt 2.0 kg/ha (tank mix), W_8: Mowing (one weed flush), W_9: Weedy check (control)

Figure 1. Dry biomass (g/m²) of monocot, dicot, sedge and total weeds

salt 2.0 kg/ha (tank-mix) were found as effective as glyphosate 3.0 kg/ha in reducing the monocot weeds density and their dry biomass up to one 30 DAA with negligible incidence and biomass at 60 DAA. The density of perennial monocot weeds *viz.*, *Sorghum halepense* and *Cynodon dactylon* was reduced to nil at fifteen DAA by the aforesaid herbicides. Whereas the density of *Echinochloa crus-galli* and *Commelina benghalensis* was brought down to nil within a week of application of herbicides.

Dicot weeds: All the herbicidal treatments effectively minimised the weed density resulting in negligible dicot weeds biomass at 15 DAA. Glyphosate minimised the density of weeds *Parthenium hysterophorus* and *Solanum xanthocarpum* by 15 DAA and of *Digera arvensis* and *Alternanthera sessilis* by 7 DAA. Further, limited resurgence was observed under mowing with least weed biomass of 0.64 g/m^2. Further, glyphosate 2.0 or 3.0 kg/ha effectively minimised dicot weed density and biomass to nil up to 30 DAA. Moreover, spraying of glyphosate 2.0 kg/ha most effective when it was applied with 2,4-D salt 2.0 kg/ha (tank-mix) and recorded hundred per cent reduction in dicot weed density and biomass at 60 DAA and was at par with glyphosate 2.0 or 3.0 kg/ha in efficacy. Furthermore, glyphosate + oxyfluorfen 2.0 kg/ha (ready-mix) was at par with glyphosate 2.0 or 3.0 kg/ha and glyphosate 2.0 kg/ha + 2,4-D salt 2.0 kg/ha (tank mix) at 30 DAA.

Sedge: *Cyperus rotundus* was the only sedge observed, which was controlled by mowing (one weed flush) at 7 DAA (**Table 2** and **Figure 1**). Glyphosate 2.0 or 3.0 kg/ha caused complete control with zero density and dry weight at 15 DAA and negligible biomass at 60 DAA. However, effect was more acute with higher dose *i.e.* 3.0 kg/ha and combination of 2.0 kg/ha with 2,4-D amine salt. Moreover, glyphosate + oxyfluorfen 2.0 kg/ha (ready-mix) also significantly minimized the density and biomass of the sedge weed throughout the experiment. Likewise, paraquat 3.0 or 4.0 kg/ha or with 2,4-D salt 2.0 kg/ha significantly reduced the biomass of the sedge at 15 DAA.

Thus, spraying of glyphosate alone/ combinations was found appropriate for minimizing the weeds density and biomass significantly after 15, 30 and 60 days of application of herbicides as glyphosate is non selective translocated herbicide that effectively managed the weeds for longer duration as it affects underground part of weeds. Whereas, paraquat application caused the weeds mortality quickly, but reestablishment of weeds is very common as it is non-selective contact herbicide.

Weed regeneration

Glyphosate 2.0 kg/ha + 2,4-D salt 2.0 kg/ha (tank-mix) has persistent effect and zero resurgence was observed for dicot weeds. Moreover, no resurgence of weeds was observed at 30 DAA with

Table 1. Influence of different weed management treatments on monocot and dicot weed density

Treatment	Monocot weed density (no./m^2)						Dicot weed density (no./m^2)					
	Initial	7 DAA	15 DAA	21 DAA	30 DAA	60 DAA	Initial	7 DAA	15 DAA	21 DAA	30 DAA	60 DAA
Glyphosate 2.0 kg/ha	9.39 (87.3)	3.41 (10.7)	1.14 (0.3)	1.14 (0.3)	1.14 (0.3)	3.35 (10.3)	7.96 (63.0)	2.49 (5.3)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	1.87 (2.7)
Glyphosate 3.0 kg/ha	8.97 (80.0)	3.05 (8.3)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	2.85 (7.3)	7.45 (55.0)	2.08 (3.3)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	1.33 (1.0)
Paraquat 3.0 kg/ha	9.65 (92.3)	1.38 (1.0)	1.91 (2.7)	4.19 (16.7)	6.29 (38.7)	8.36 (69.0)	8.01 (63.3)	1.00 (0.0)	1.00 (0.0)	2.08 (3.3)	3.95 (14.7)	6.80 (45.3)
Paraquat 4.0 kg/ha	9.37 (87.0)	1.38 (1.0)	1.73 (2.0)	3.83 (13.7)	5.91 (34.0)	8.04 (63.7)	7.78 (59.7)	1.00 (0.0)	1.00 (0.0)	1.79 (2.7)	3.59 (12.0)	6.60 (42.7)
Glyphosate + oxyfluorfen 2.0 kg/ha (ready-mix)	8.98 (79.7)	2.87 (7.3)	1.28 (0.7)	1.00 (0.0)	1.14 (0.3)	3.49 (11.3)	7.34 (53.0)	1.91 (2.7)	1.00 (0.0)	1.00 (0.0)	1.14 (0.3)	2.57 (5.7)
Glyphosate 2.0 kg/ha + 2,4-D salt 2.0 kg/ha (tank-mix)	9.60 (91.3)	3.16 (9.0)	1.61 (1.7)	1.14 (0.3)	1.24 (0.7)	3.19 (9.7)	7.76 (59.3)	1.52 (1.3)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)
Paraquat 2.0 kg/ha + 2,4-D salt 2.0 kg/ha (tank-mix)	9.36 (86.7)	1.91 (2.7)	1.47 (1.3)	3.87 (14.0)	5.95 (34.7)	8.43 (70.3)	7.83 (61.0)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	2.30 (4.3)	5.79 (32.7)
Mowing (one weed flush)	9.71 (93.3)	1.00 (0.0)	3.16 (9.0)	6.16 (37.0)	7.77 (59.3)	9.96 (98.3)	7.85 (61.3)	1.00 (0.0)	2.14 (3.7)	4.79 (22.0)	5.82 (33.0)	7.50 (55.3)
Weedy check (control)	9.15 (83.0)	9.72 (93.7)	10.29 (105.0)	10.74 (114.3)	11.31 (127.0)	11.75 (137.3)	7.79 (59.7)	8.16 (65.7)	8.72 (75.0)	9.03 (80.7)	9.41 (87.7)	9.85 (96.0)
LSD (p=0.05)	NS	0.45	0.44	0.38	0.52	0.98	NS	0.27	0.22	0.53	0.36	0.59

*Data in parentheses indicate actual value and $(\sqrt{x+1})$ transformed value of weeds those outside.; DAA = days after herbicide application

Table 2. Influence of different weed management treatments on monocot and dicot weed density

Treatment	*Cyperus* density (no./m^2)						Total weed density (no./m^2)					
	Initial	7 DAA	15 DAA	21 DAA	30 DAA	60 DAA	Initial	7 DAA	15 DAA	21 DAA	30 DAA	60 DAA
Glyphosate 2.0 kg/ha	4.11 (16.0)	3.15 (9.0)	1.00 (0.0)	1.00 (0.0)	1.28 (0.7)	2.44 (5.0)	12.91 (166.3)	5.10 (25.0)	1.14 (0.3)	1.14 (0.3)	1.38 (1.0)	4.33 (18.0)
Glyphosate 3.0 kg/ha	4.24 (17.0)	2.87 (7.3)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	2.23 (4.0)	12.33 (152.0)	4.47 (19.0)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	3.64 (12.3)
Paraquat 3.0 kg/ha	4.00 (15.0)	1.72 (2.0)	1.49 (1.3)	1.99 (3.0)	2.76 (6.7)	4.04 (15.3)	13.10 (170.7)	2.00 (3.0)	2.21 (4.0)	4.88 (23.0)	7.80 (60.0)	11.43 (129.7)
Paraquat 4.0 kg/ha	4.08 (15.7)	1.63 (1.7)	1.52 (1.3)	1.73 (2.0)	2.51 (5.3)	3.96 (14.7)	12.77 (162.3)	1.91 (2.7)	2.08 (3.3)	4.39 (18.3)	7.23 (51.3)	11.04 (121.0)
Glyphosate + oxyfluorfen 2.0 kg/ha (ready-mix)	4.16 (16.3)	2.63 (6.0)	1.14 (0.3)	1.14 (0.3)	1.82 (2.3)	2.64 (6.0)	12.25 (149.0)	4.10 (16.0)	1.41 (1.0)	1.14 (0.3)	2.00 (3.0)	4.88 (23.0)
Glyphosate 2.0 kg/ha + 2,4-D salt 2.0 kg/ha (tank-mix)	4.46 (19.0)	1.79 (2.3)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	2.15 (3.7)	13.06 (169.7)	3.69 (12.7)	1.61 (1.7)	1.14 (0.3)	1.24 (0.7)	3.75 (13.3)
Paraquat 2.0 kg/ha + 2,4-D salt 2.0 kg/ha (tank-mix)	4.43 (18.7)	1.52 (1.3)	1.52 (1.3)	1.91 (2.7)	2.08 (3.3)	2.93 (7.7)	12.93 (166.3)	2.23 (4.0)	1.90 (2.7)	4.20 (16.7)	6.57 (42.3)	10.55 (110.7)
Mowing (one weed flush)	4.16 (16.3)	1.00 (0.0)	2.44 (5.0)	3.04 (8.3)	3.37 (10.3)	4.12 (16.0)	13.10 (171.0)	1.00 (0.0)	4.31 (17.7)	8.26 (67.3)	10.18 (102.7)	13.06 (169.7)
Weedy check (control)	4.24 (17.0)	4.43 (18.7)	4.47 (19.0)	4.71 (21.3)	4.86 (22.7)	5.10 (25.0)	12.67 (159.7)	13.37 (178.0)	14.14 (199.0)	14.74 (216.3)	15.44 (237.3)	16.10 (258.3)
LSD (p=0.05)	NS	0.51	0.38	0.37	0.26	0.36	NS	0.44	0.46	0.42	0.52	0.85

*Data in parentheses indicate actual value and $(\sqrt{x+1})$ transformed value of weeds those outside.; DAA = days after herbicide application

glyphosate 3.0 kg/ha. However, lower dose of glyphosate *i.e.* 2.0 kg/ha and glyphosate 2.0 kg/ha coupled with either oxyfluorfen 2.0 kg/ha (ready-mix) or 2,4-D amine salt 2.0 kg/ha (tank-mix) showed the re-establishment of weeds after 21 DAA. The paraquat and mowing caused the weeds resurgence within 10-15 DAA. Further, mowing treatment gave complete control of total weeds initially but significant resurgence of weeds was observed after 15 days of treatment. Similarly, paraquat was found effective up to 15 DAA and later weeds resurgence was witnessed. Further, application of higher rate of glyphosate *i.e.* 3.0 kg/ha has completely managed the weeds upto 30 DAA with minimum weed density at 60 DAA and it was closely followed by glyphosate 2.0 kg/ha alone or in combination with 2,4-D amine salt 2.0 kg/ha (tank-mix).

Weed control efficiency

Glyphosate 3.0 kg/ha recorded highest weed control efficiency at 15, 30 and 60 DAA, and it was closely followed by glyphosate 2.0 kg/ha + 2,4-D amine salt 2.0 kg/ha (tank-mix), glyphosate 2.0 kg/ha and glyphosate + oxyfluorfen 2.0 kg/ha (ready-mix).

It is inferred that glyphosate 2.0 kg/ha alone or in combination with 2,4-D amine salt 2.0 kg/ha (tank-mix) may be used to effectively minimize the weeds biomass and resurgences significantly up to 60 DAA with highest weed control efficiency in non-cropped land.

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