Indian Journal of Weed Science 52(4): 358–361, 2020

Print ISSN 0253-8040 Online ISSN 0974-8164

Weed management in non-cropped areas with pre-mix of indaziflam and glyphosate in Punjab

Navjyot Kaur*, Renu Sethi and Makhan S. Bhullar
Punjab Agricultural University, Ludhiana, Punjab 141 004, India
**Email: navjyot_grewal@yahoo.com*

Article information

DOI: 10.5958/0974-8164.2020.00071.4

Type of article: Research article

Received : 21 June 2020
Revised : 8 December 2020
Accepted : 11 December 2020

Key words
Glyphosate
Herbicide
Indaziflam
Non-cropped area
Weed control

ABSTRACT

Non-cropped areas are infested with diverse weed flora including annual and perennial grasses, sedges and broad-leaf weeds. The field efficacy of pre-mix of indaziflam plus glyphosate was evaluated for effective weed management in these areas. The field experiment was conducted over two years in Ludhiana (India). Seven treatments including pre-mix formulation of indaziflam-20 + glyphosate 400-420 SC (60 + 1200, 70 + 1400 and 80 + 1600 g/ha), glyphosate (1230 and 1600 g/ha) and indaziflam (80 g/ha) along with untreated control were evaluated. Major weed species at the experimental site were *Cannabis sativa*, *Parthenium hysterophorus*, *Verbesina encelioides* and *Xanthium strumarium*. All herbicidal treatments recorded complete mortality of *C. sativa* and *P. hysterophorus* till 30 days after application (DAA) while in case of *V. encelioides* and *X. strumarium,* complete mortality was recorded till 120 DAA. Pre-mix of indaziflam plus glyphosate at 80 + 1600 g/ha had >80% control of all weed species during both years till 60 DAA, and it was at par to its lower dose of 70 + 1400 g/ha; results with sole application of indaziflam and glyphosate were inconsistent.

INTRODUCTION

Weeds are one of the major biological constraints to agricultural production system causing damage in cropped and non-cropped lands. Many weeds like *Cannabis sativa*, *Parthenium hysterophorus*, *Verbesina encelioides* and *Xanthium strumarium* infest non-cropped areas and roadsides of Punjab. Among these, *P. hysterophorus* (common ragweed) is the most noxious weed, which rapidly colonizes urban areas thereby replacing the native vegetation (Bajwa *et al.* 2016). Fast growth rate, high reproductive potential and interference via allelopathy are the major factors responsible for its wide spread infestation in waste lands/non-cropped areas as well as cultivated fields (Kohli *et al.* 2006 and Sushilkumar 2014). *V. encelioides* commonly known as golden crownbeard is a major roadside weed especially in South West Punjab districts including Ferozepur, Fazilka, Bathinda, Barnala and Sangrur (Goyal *et al.* 2019). It contains a chemical named galegine which can cause poisoning in livestock. *C. sativa* (Indian hemp) is another common weed found along roadsides and non-cropped areas of Punjab that has also started to infest wheat fields in sub-montane and central zones of Punjab including the districts Hoshiarpur, Kapurthala, Jalandhar and Ludhiana (Kaur *et al.* 2015). Ingestion of *C. sativa* can cause short term memory loss. *X. strumarium* (cocklebur) has also been reported as a major weed found along roadsides and rice fields throughout the tropical parts of India (Kamboj and Saluja 2010).The allelochemicals produced from different parts of *X. strumarium* inhibit the seed germination and seedling growth of many crops *viz.* soybean, cotton, peanut, wheat, maize, pearl millet, chickpea, rapeseed, tobacco and lettuce (Singh and Pandey 2019). Management of these weeds growing along roadsides or field boundaries is important to prevent their invasion into croplands.

Glyphosate (N-phosphonomethyl modified derivative of glycine) is the most widely used herbicide for the management of weeds growing on field bunds, field boundaries, non-cropped areas and wastelands. Glyphosate kills plants by inhibiting the enzyme 5-enolpyruvyl-shikimate-3-phosphate synthase, which catalyzes synthesis of aromatic amino acids (phenylalanine, tyrosine and tryptophan) involved in the formation of essential proteins in plants (Sammons and Gaines 2014). Resistance to this shikimate pathway inhibitor has been reported in more than 20 species from many parts of the world (Heap 2017). Paraquat (1,1′-dimethyl-4,4′-bipyridinium ion) is another major herbicide used for weed control in non-croplands. But there are many studies which report the reduced efficacy of this herbicide owing to evolution of resistant weed populations (Heap 2017). But none of these herbicides can provide long-term control of invasive weeds when used alone, resulting in rapid re-infestations by weeds (Mangold *et al.* 2015). This emphasizes the need to evaluate new herbicide formulations along with the mixture for efficient and economic control of these weeds under non-cropped situations. Indaziflam, a broad-spectrum herbicide belonging to the chemical class alkylazine, kills susceptible plants by inhibiting biosynthesis of cellulose (Kaapro and Hall 2012). The present study evaluated the efficacy of pre-mix of indaziflam and glyphosate against weeds infesting non-cropped areas.

MATERIALS AND METHODS

The experiment was laid out on the link road to village Lalton, Ludhiana, Punjab (India) which is situated at 30°84'N latitude and 75°78'E longitude. The study was conducted during 2015 and 2016 with seven treatments in randomized complete block design. The herbicide treatments included three doses of pre-mix formulation of indaziflam-20 plus glyphosate 400-420 SC (60 + 1200, 70 + 1400 and 80 + 1600 g/ha), two doses of glyphosate (1230 and 1600 g/ha) and one dose of indaziflam (80 g/ha) along with untreated control. The herbicides were sprayed along roadsides with knap-sack sprayer fitted with flat-fan nozzle using 500 L/ha spray volume at peak growth of weeds before flowering/setting seeds. Weed density and dry biomass were recorded from three spots at 30, 60, 90 and 120 days after application (DAA) from one m^2 area. For recording weed biomass, three plants from each plot were uprooted; dried in sunlight and then oven dried at 60°C for 48 hours. Dry weight was taken till constant weight was achieved.

RESULTS AND DISCUSSION

The dominant weed flora at experimental area included *C. sativa*, *P. hysterophorus* and *X. strumarium* in 2015 and, *C. sativa*, *P. hysterophorus* and *V. encelioides* during 2016.The percent composition of weed spp., *viz. C. sativa*, *P. hysterophorus* and *X. strumarium* was 49, 28 and 23, respectively during 2015. In 2016, per cent composition of *C. sativa*, *P. hysterophorus* and *V. encelioides* was 15, 24 and 60, respectively. At 30 days after application (DAA), indaziflam and glyphosate sole and as pre-mix, at all doses, gave complete kill of all the four weed species and in both years, and in case of *V. encelioides* and *X. strumarium* the complete kill was recorded till 120 DAA. At 60 DAA, indaziflam plus glyphosate at all doses and indaziflam and glyphosate sole recorded significantly lower density of all weeds as compared to untreated control (**Table 1** and **2**). Re-emergence of *C. sativa* and *P. hysterophorus* was, however, observed at 45 DAA under all treatments. Density of all weed species decreased with every increase in dose of indaziflam plus glyphosate. At 90 and 120 DAA, density of *C. sativa* and *P. hysterophorus* in all herbicide treatments was at par with untreated control (**Table** 1 and **2**). There was no emergence of *V. encelioides* and *X. strumarium* after herbicides application. Indaziflam plus glyphosate at 80 + 1600 g/ha gave >80% control of all weeds as compared to untreated control till 60 DAA in both the years, however, the results were not consistent with sole application of indaziflam and glyphosate. Ko *et al.* (2019) reported that glyphosate applied alone at 1.0 X (3 L/ha) and 0.5 X (1.5 L/ha) doses was not effective for control of *Oenothera biennis* (evening primrose) with < 70 and 50% weed control efficiency. Singh *et al.* (2004) reported that under non-cropped situation, 2,4-D, atrazine,

Table 1. Effect of pre-mix of indaziflam plus glyphosate on weed density in 2015

Treatment	Dose (g/ha)	Weed density (no./m^2) DAA											
		Cannabis sativa				*Parthenium hysterophorus*				*Xanthium strumarium*			
		30	60	90	120	30	60	90	120	30	60	90	120
Indaziflam + glyphosate	60+1200	1.0 (0)	2.31 (4.3)	3.91 (14.3)	4.51 (19.3)	1.0 (0)	1.82 (2.33)	3.55 (11.7)	4.07 (15.7)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Indaziflam + glyphosate	70+1400	1.0 (0)	2.15 (3.7)	3.69 (12.7)	4.54 (19.7)	1.0 (0)	1.72 (2.0)	3.58 (12.0)	4.24 (17.0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Indaziflam + glyphosate	80+1600	1.0 (0)	1.99 (3.0)	3.55 (11.7)	4.51 (19.3)	1.0 (0)	1.63 (1.7)	3.37 (10.3)	4.28 (17.3)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Indaziflam	80	1.0 (0)	2.08 (3.3)	3.55 (11.7)	4.47 (19.0)	1.0 (0)	1.72 (2.0)	3.65 (12.3)	4.00 (17.3)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Glyphosate	1230	1.0 (0)	1.99 (3.0)	3.46 (11.0)	4.61 (20.3)	1.0 (0)	2.16 (3.7)	3.74 (13.0)	4.36 (18.0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Glyphosate	1600	1.0 (0)	2.08 (3.3)	3.83 (13.7)	4.65 (20.7)	1.0 (0)	2.38 (4.7)	3.79 (13.0)	4.47 (19.0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Untreated control	-	2.58 (5.7)	3.15 (9.0)	3.78 (13.3)	4.54 (19.7)	2.08 (3.3)	2.51 (5.3)	3.36 (10.3)	4.00 (15.0)	1.91 (2.7)	2.16 (3.7)	2.23 (4.0)	2.44 (5.0)
LSD (p=0.05)		0.15	0.37	NS	NS	0.09	0.34	NS	NS	0.10	0.09	0.15	0.15

Parentheses are original values; data was square root ($\sqrt{x+1}$) transformed before analysis, DAA-Days after application metribuzin, metsulfuron and glufosinate failed to control *P. hysterophorus* while glyphosate at 2.7 and 5.4 kg/ha provided > 90% control even after 18 weeks of treatment. Sebastian *et al.* (2017) reported that indaziflam tank mixed with imazapic and picloram provided > 90% control of *Linaria dalmatica* (dalmatian toadflax) and *Bromus tectorum* (downy brome) as compared to treatments without indaziflam which had < 70 and 25% control of dalmatian toadflax and downy brome, respectively.

At 30 DAA, all herbicidal treatments gave complete kill of all weed species, hence, no weed biomass was recorded. All weed control treatments continued to provide complete kill of *V. encelioides* and *X. strumarium* till 120 DAA during both the years and, so no weed biomass of these weeds was recorded. At 60 DAA, all weed control treatments including indaziflam plus glyphosate at all doses and indaziflam and glyphosate alone recorded significantly lower biomass of all weeds as compared to untreated control (**Table 3** and **4**). At 60 DAA, indaziflam plus glyphosate at 80 g + 1600 g/ha reduced biomass of all weeds by > 80% during both the years and it was at par to its lower dose of 70 + 1400 g/ha, in 2015. The results, however, were not consistent when indaziflam and glyphosate used alone. At 90 and 120 DAA, dry biomass of *C. sativa* and *P. hysterophorus* under all herbicide treatments was at par with untreated control. Sikkema *et al.* (2008) reported that glyphosate at 900 g/ha provided > 80% reduction in dry biomass of cocklebur than untreated check. Gaikwad *et al.* (2008) reported that glyphosate (0.50 and 0.75%), atrazine (0.2 and 0.3%) and 2,4-D-ethyl ester (EE) (0.2 and 0.3%) caused significant reduction in density and biomass of *Parthenium* at 30 DAA. Khan *et al.* (2012) reported that glyphosate and metribuzin applied at rosette and bolting stages of *P. hysterophorus* gave > 90 and 70% mortality at 30 DAA than 2,4-D, atrazine plus s-metolachlor, atrazine, s-metolachlor. Clark *et al.*

Table 2. Effect of pre-mix of indaziflam plus glyphosate on weed density in 2016

Treatment	Dose (g/ha)	Weed density (no./m^2) DAA											
		Cannabis sativa				*Parthenium hysterophorus*				*Verbesina encelioides*			
		30	60	90	120	30	60	90	120	30	60	90	120
Indaziflam + glyphosate	60+1200	1.0 (0)	2.08 (3.3)	3.46 (11.0)	4.51 (19.3)	1.0 (0)	2.44 (5.0)	3.37 (10.3)	4.86 (22.7)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Indaziflam + glyphosate	70+1400	1.0 (0)	1.99 (3.0)	3.31 (10.0)	4.43 (18.7)	1.0 (0)	2.44 (5.0)	3.46 (11.0)	5.13 (25.3)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Indaziflam + glyphosate	80+1600	1.0 (0)	2.08 (3.3)	3.37 (10.3)	4.43 (18.7)	1.0 (0)	2.22 (4.0)	3.41 (10.7)	4.78 (22.0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Indaziflam	80	1.0 (0)	1.82 (2.3)	3.36 (10.3)	4.50 (19.3)	1.0 (0)	1.91 (2.7)	3.55 (11.7)	4.65 (20.7)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Glyphosate	1230	1.0 (0)	2.23 (4.0)	3.35 (10.3)	4.54 (19.7)	1.0 (0)	2.82 (7.0)	3.26 (9.7)	4.75 (21.7)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Glyphosate	1600	1.0 (0)	2.23 (4.0)	3.35 (10.3)	4.51 (19.3)	1.0 (0)	2.23 (4.0)	3.69 (12.7)	5.00 (24.0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Untreated control	-	1.63 (1.7)	2.44 (5.0)	3.60 (12.0)	4.47 (19.0)	1.91 (2.7)	3.16 (9.0)	3.46 (11.0)	4.75 (21.7)	2.76 (6.7)	2.94 (7.7)	2.94 (7.7)	3.25 (9.7)
LSD (p=0.05)	-	0.12	NS	NS	NS	0.10	0.35	NS	NS	0.14	0.07	0.07	0.26

Parentheses are original values; data was square root ($\sqrt{x+1}$) transformed before analysis, DAA-Days after application

Table 3. Effect of pre-mix of indaziflam plus glyphosate on weed biomass in 2015

Treatment	Dose (g/ha)	Weed biomass (g/m^2) DAA											
		Cannabis sativa				*Parthenium hysterophorus*				*Xanthium strumarium*			
		30	60	90	120	30	60	90	120	30	60	90	120
Indaziflam + glyphosate	60+1200	1.0 (0)	3.37 (10.5)	7.16 (50.4)	7.72 (58.6)	1.0 (0)	2.22 (3.9)	5.45 (28.9)	6.24 (38.0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Indaziflam + glyphosate	70+1400	1.0 (0)	2.57 (5.8)	6.89 (46.8)	7.81 (60.1)	1.0 (0)	1.97 (3.0)	5.30 (27.9)	6.33 (39.1)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Indaziflam + glyphosate	80+1600	1.0 (0)	2.14 (3.7)	6.99 (47.9)	7.87 (60.9)	1.0 (0)	1.75 (2.1)	5.20 (26.1)	6.35 (39.3)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Indaziflam	80	1.0 (0)	3.07 (8.5)	6.71 (44.2)	7.70 (59.4)	1.0 (0)	3.21 (9.4)	5.46 (29.1)	6.23 (37.8)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Glyphosate	1230	1.0 (0)	2.63 (6.0)	6.88 (46.5)	7.86 (60.9)	1.0 (0)	2.96 (7.9)	5.88 (33.7)	6.24 (37.9)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Glyphosate	1600	1.0 (0)	2.29 (4.3)	7.60 (56.8)	7.84 (60.4)	1.0 (0)	1.75 (2.1)	5.82 (32.9)	6.18 (37.3)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Untreated control	-	3.89 (14.2)	5.46 (28.9)	7.40 (53.9)	7.70 (58.3)	2.59 (5.7)	3.99 (15.0)	5.72 (32.0)	6.26 (38.2)	3.43 (10.8)	4.63 (20.5)	5.68 (31.7)	6.67 (43.5)
LSD (p=0.05)	-	0.18	0.70	NS	NS	0.07	0.58	NS	NS	0.15	0.45	0.56	0.07

Parentheses are original values; data was square root ($\sqrt{x+1}$) transformed before analysis, DAA-Days after application

Table 4. Effect of pre-mix of indaziflam plus glyphosate on weed biomass in 2016

Treatment	Dose (g/ha)	Weed biomass (g/m^2) DAA											
		Cannabis sativa				*Parthenium hysterophorus*				*Verbesina encelioides*			
		30	60	90	120	30	60	90	120	30	60	90	120
Indaziflam + glyphosate	60+1200	1.0 (0)	2.82 (6.9)	5.38 (28.0)	6.22 (37.8)	1.0 (0)	2.22 (3.9)	4.39 (18.3)	5.43 (28.5)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Indaziflam + glyphosate	70+1400	1.0 (0)	2.38 (4.7)	4.97 (23.9)	6.30 (38.7)	1.0 (0)	2.01 (3.1)	4.17 (16.4)	5.21 (26.3)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Indaziflam + glyphosate	80+1600	1.0 (0)	1.86 (2.6)	5.30 (27.2)	6.18 (37.3)	1.0 (0)	1.79 (2.2)	3.90 (14.4)	5.47 (29.0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Indaziflam	80	1.0 (0)	1.84 (2.4)	4.94 (23.6)	6.37 (39.6)	1.0 (0)	1.49 (1.2)	4.10 (15.8)	5.29 (27.1)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Glyphosate	1230	1.0 (0)	2.87 (7.3)	5.13 (25.7)	6.30 (38.8)	1.0 (0)	2.74 (6.6)	4.23 (17.0)	5.35 (27.7)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Glyphosate	1600	1.0 (0)	2.71 (6.3)	5.28 (27.1)	6.44 (40.4)	1.0 (0)	1.97 (2.9)	4.51 (19.6)	5.35 (27.7)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Untreated control	-	2.54 (5.5)	3.87 (14.1)	5.45 (28.8)	6.20 (37.5)	2.51 (5.3)	3.52 (11.5)	4.47 (19.0)	5.42 (28.4)	5.09 (25.1)	6.75 (44.7)	7.27 (51.9)	8.27 (67.3)
LSD (p=0.05)	-	0.11	0.47	NS	NS	0.11	0.38	NS	NS	0.35	0.31	0.27	0.13

Parentheses are original values; data was square root ($\sqrt{x+1}$) transformed before analysis, DAA-Days after application

(2019) reported that indaziflam can provide multiyear control of downy brome (*Bromus tectorum* L.) in non-cropped sites without any impact to native perennial species.

The study concluded that pre-mix of indaziflam plus glyphosate at 70 + 1400 g/ha could provide efficient weed management of *Cannabis sativa* and *Parthenium hysterophorus* until up to 60 DAA, and of *Xanthium strumarium* and *Verbesina encelioides* even for longer time (120 DAA) in non-cropped areas.

REFERENCES

Bajwa AA, Chauhan BS, Farooq M, Shabbir A and Adkins SW. 2016. What do we really know about alien plant invasion? A review of the invasion mechanism of one of the world's worst weeds. *Planta* **244**: 39–57.

Belz RG, Reinhardt CF, Foxcroft LC and Hurle K. 2007. Residue allelopathy in *Parthenium hysterophorus* L.- Does parthenin play a leading role? *Crop Protection* **26**: 237–245.

Clark SL, Sebastian DJ, Nissen SJ and Sebastian JR. 2019. Effect of indaziflam on native species in natural areas and rangeland. *Invasive Plant Science and Management* **12**: 60–67.

Gaikwad CB, Kasture MC and Lambade BM. 2008. Evaluation of herbicides for control of *Parthenium* in waste land. *Indian Journal of Weed Science* **40**: 79–81.

Goyal D, Kaur N and Chauhan B. 2019. Effects of environmental factors and ageing on germination of golden crown beard (*Verbesina encelioides*)-A wide spread weed of Northern India. *Indian Journal of Weed Science* **51**: 372-380.

Heap I. 2017. International survey of herbicide resistant weeds. www.weedscience.org

Kaapro J and Hall J. 2012. Indaziflam, a new herbicide for pre-emergent control of weeds in turf, forestry, industrial vegetation and ornamentals. *Pakistan Journal of Weed Science Research* **18**: 267–270.

Kamboj A and Saluja AK. 2010. Phytopharmacological review of *Xanthium strumarium* L. (Cocklebur). *International Journal of Green Pharmacy* **4**: 129–139**.**

Kaur N, Kaur P and Bhullar MS. 2015. Indian hemp: An emerging weed of wheat fields in Punjab. *Indian Journal of Weed Science* **47**: 425–427.

Khan H, Marwat KB, Hassan G and Khan MA. 2012. Chemical control of *Parthenium hysterophorus* L. at different growth stages in non-cropped area. *Pakistan Journal of Botany* **44**: 1721–1726.

Ko JW, Kim YN, Park SM, Park CW, Park HS, Park YG and Lee IJ. 2019. Germination and early growth characteristics of evening primrose (*Oenothera biennis*) and herbicides selection for its chemical control. *Weed and Turfgrass Science* **8**: 207–219.

Kohli RK, Batish DR, Singh H and Dogra KS. 2006. Status, invasiveness and environmental threats of three tropical American invasive weeds (*Parthenium hysterophorus* L., *Ageratum conyzoides* L., *Lantanacamara* L.) in India. *Biological Invasions* **8**: 1501–1510.

Mangold J, Orloff N, Parkinson H and Halstvedt M. 2015. Integrating herbicides and re-seeding to restore rangeland infested by an invasive forb-annual grass complex. *Ecological Restorations* **33**: 16–19.

Sammons RD and Gaines TA. 2014. Glyphosate resistance: state of knowledge. *Pest Management Science* **70**: 1367–1377.

Sebastian DJ, Nissen SJ, Sebastian JR, Meiman PJ and Beck KG. 2017. Pre-emergence control of nine invasive weeds with aminocyclopyrachlor, aminopyralid, and indaziflam. *Invasive Plant Science Management* **10**: 99–109.

Sikkema PH, Kramer C, Vyn JD and Soltani N. 2008. Control of common cocklebur (*Xanthiumstrumarium* L.) with pre- and postemergence herbicides in soybean. *Canadian Journal of Plant Science* **88**: 1127–1131.

Singh AK and Pandey AK. 2019. Preliminary screening of isolated mycoherbicidal fungi for the management of noxious weed *Xanthium strumarium*. *Journal of Agri Search* **6**: 92–95.

Singh S, Yadav A, Balyan RS, Malik RK and Singh M. 2004. Control of ragweed parthenium (*Parthenium hysterophorus*) and associated weeds. *Weed Technology* **18**: 658–664.

Sushilkumar. 2014. Spread, menace and management of Parthenium. *Indian Journal of Weed Science* **46**(3): 205–219.