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Residual effect of weed management practices adopted in preceding maize on yield attributes and yield of succeeding chickpea

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Abstract
A field experiment was conducted during the two consecutive *kharif* and *rabi* season of 2016-17 and 2017-18 at Agriculture Farm of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna (M.P.) to know the residual effect of different herbicides applied in maize on succeeding chickpea. The results revealed that lower density and dry weight of total weeds and superior values of yield attributes and yield were recorded in plots receiving under weed free condition and pre emergence application of Pendimethalin 1.0 kg/ha fb Atrazine (0.75 kg/ha)+ 2,4-D Amine 0.4 kg/ha at 25 DAS as post emergence in maize.

Keywords: Chickpea, weight, yield, weed, herbicides, maize

1. Introduction
Maize is one of the major cereal crops as of cereals after rice and wheat, contributing enough food security and farm income in India. Maize-Chickpa is the predominant cropping system in many places in our country particularly in rainfed areas. In India, there is substantial scope for *rabi* chickpea after harvesting of *kharif* crop of maize due to its short duration, deep root system and capacity to grow under residual moisture and limited irrigation also. Weeds are probably the most important class of crop pests and cause massive crop failures over vast areas. Weeds, being hardier in nature, compete with crop plants for nutrients, moisture, sunlight and space during entire vegetative and early reproductive stages of crop growth and their relative density plays a significant role in reducing the yield of crops (Dash *et al.*, 2018) [1]. Hand weeding and mechanical operations are still widely adopted to keep the crop weed free during the critical period, but these are more expensive and at times not possible due to acute shortage of labour. Therefore, the use of pre and post emergence herbicides is an ideal means to tackle the problem of weeds. Application of herbicides at recommended rates in *kharif* maize may collapse weeds within a few days or weeks and inflict no limitations on cropping options in the next season or year. However, some herbicides do not degrade quickly even at recommended rates of application in maize and can remain in the soil for weeks, months or years after treatment and may inhibit the growth of succeeding crops (Singh *et al.*, 2012) [2]. Field studies on persistence and effect of new generation herbicide molecules on succeeding crop are lacking particularly in chickpea following their application in preceding maize. Keeping the above facts in view, an investigation was carried out to study the effectiveness of herbicides for broad spectrum weed control in maize and their residual effect on succeeding chickpea.

2. Materials and Methods
A field experiment was conducted during the two consecutive *kharif* and *rabi* seasons of 2016-17 and 2017-18 at Agricultural Farm, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna (M.P.). The experiment consisted of twelve treatments *viz*., weedy check (control) (T_1), Weed free (T_2), Mechanical weeding (02 hand weeding) (T_3), Pendimethalin @ 1.0 kg a.i./ha PE (T_4), Atrazine @ 1.0 kg a.i./ha PE (T_5), Atrazine @ 0.75 kg a.i./ha + Pendimethalin @ 0.75 kg a.i./ha PE (T_6), Atrazine @ 1.0 kg a.i./ha fb 2,4-D Amine 0.4 kg a.i./ha at 25 DAS (T_7), Halosufuron 0.09 kg/ha at 25 DAS (T_8), Atrazine @ 1.0 kg a.i./ha PE fb Halosufuron 0.09 kg/ha at 25 DAS (T_9), Tembotrione (Laudis) @ 0.12 kg a.i./ha at 25 DAS (T_{10}), Pendimethalin @ 1.0 kg a.i./ha PE fb Atrazine (0.75 kg a.i./ha) + 2,4-D Amine 0.4 kg a.i./ha at 25 DAS (T_{11}) and Atrazine @ 1.0 kg a.i./ha PE fb Tembotrione

(Laudis) 0.12 kg a.i./ha at 25 DAS (T_{12}), were laid out in a randomized block design with three replications. The pre emergence herbicide was applied on next day after sowing and post emergence herbicides were applied at 25 DAS, when the weeds were of 2-3 leaf stage in maize. Chickpea variety DCP-92-3 was sown in undisturbed layout of the experimental field as a residual crop after field preparation, at a spacing of 30 cm x 10 cm to observe the residual effect of pre and post emergence herbicides applied in *kharif* maize during both the years on 4th November and harvested on 20th and 11th March during *rabi*, 2016-17 and 2017-18 respectively. A uniform basal dose of 20 kg N, 50 kg of P_2O_5 and 20 kg K_2O /ha was applied through DAP and MOP to all the plots. Weeding was not performed in chickpea plots since the crop was raised to study the residual effect of herbicides applied in maize crop and all other recommended management practices were adopted to raise the chickpea crop.

Weed sampling was done at random by placing a quadrat of 1 m x 1 m in each plot and the number of weeds were counted and expressed as number per square meter and dry weight of weeds was recorded after drying them to a constant temperature i.e. 70 ± 1^0C and expressed as g m^{-2}. In view of larger variation in the recorded values of density and dry weight of weeds, data were analyzed after subjecting the original data to square root transformation $\sqrt{x}$ +1 and the treatment effects were compared using transformed values. Observations on growth and yield attributes of chickpea were recorded at the time of harvest and data were statistically analyzed using analysis of variance for randomized block design.

3. Results and Discussion

3.1 Weed density and weed biomass of succeeding chickpea

The highest weed density and their dry weight were recorded in weedy check at 25 DAS and harvest due to uninterrupted germination and emergence of weeds in weedy check plots as no other weed control measures were adopted. But weed density was lowest (78.89/m^2) at 25 DAS and harvest (17.89/m^2) in chickpea following weed free condition and pre emergence application of Pendimethalin @ 1.0 kg/ha fb Atrazine (0.75 kg/ha) + 2,4-D Amine 0.4 kg/ha at 25 DAS as PoE (79.22/m^2 and 18.50/m^2) at 25 DAS and harvest stage in maize respectively. Similarly dry weight of weeds was lowest (12.06 g/m^2 and 12.42 g/m^2) in chickpea weed free condition and Pendimethalin @ 1.0 kg/ha PE fb Atrazine (0.75 kg/ha) + 2,4-D Amine 0.4 kg/ha at 25 DAS as PoE, at 25 DAS and harvest in maize. This might be due to effective control of weeds, reduced weed seed bank in soil in weed free plots and residual effect of Pendimethalin @ 1.0 kg/ha PE fb Atrazine (0.75 kg/ha) + 2,4-D Amine 0.4 kg/ha applied in maize as Post emergence at 25 DAS might have led poor weed seed formation and dispersal, which in turn ensured lower weed count in succeeding chickpea. The results are in conformity with the finding of Nazreen *et al.* (2018) [3], Rani *et al.* (2019) [4] and Varma *et al.* (2009) [5].

3.2 Plant population of succeeding chickpea

The plant population of chickpea was not influenced significantly due to residual effect of weed control measures adopted in preceding maize crop. The plant population of chickpea was similar in all plots receiving weed control of measures in maize including weedy check plots during both the years at 25 DAS and harvest (Table 1) because herbicidal residues were not present in soil in lethal concentration (Table 1). The present results corroborated the finding of Chand *et al.* (2014) [6] and Zahan *et al.* (2016) [7].

3.3 Yield attributes of succeeding chickpea

Yield attributes of chickpea such as primary, secondary and tertiary branches/plant were statistically same in all treatments of weed control applied in preceding crop but primary and tertiary branches were maximum of (3.73 and 4.67 per plant) under weed free, respectively. The pods/plant, seeds/pod, seed weight/plant and 100-seed weight were significantly higher (58.57/plant, 1.98 seeds/pod, 15.51 g/plant and 15.82 g) under weed free followed by Pendimethalin @ 1.0 kg/ha PE fb Atrazine (0.75 kg/ha) + 2,4-D Amine 0.4 kg/ha at 25 DAS as PoE, (58.50/plant, 1.93 seeds/pod, 13.47 g/plant and 15.10 g) following their application in maize respectively. The higher values of yield attributes in both the treatments than weedy check was due to lower weed competition in chickpea. Whereas, reverse was true in case of weedy check plots and therefore recorded the inferior values of yield attributes. The results are in close conformity to that of Rani *et al.* (2021) [4].

3.4 Yield of succeeding chickpea

Seed yield and haulm yield of chickpea (Table 2) were significantly superior when grown on plots receiving weed control treatments in preceding maize than weedy check. Significantly higher seed yield (16.04 q/ha) of succeeding chickpea was recorded under weed free being at par to Pendimethalin @ 1.0 kg/ha PE fb Atrazine (0.75 kg/ha)+ 2,4-D Amine 0.4 kg/ha at 25 DAS as PoE (14.46 q/ha) and Halosulfuron @ 0.09 kg/ha at 25 DAS (13.28 q/ha) applied in maize. This could be ascribed due to superior yield attributes under aforesaid treatments. Similarly, significantly maximum haulm yield (31.40 q/ha) of succeeding chickpea was recorded under weed free and Pendimethalin @ 1.0 kg/ha PE fb Atrazine (0.75 kg/ha)+ 2,4-D Amine 0.4 kg/ha at 25 DAS as PoE (28.49 q/ha), Halosulfuron @ 0.09 kg/ha at 25 DAS (27.30 q/ha) and Atrazine (1.0 kg/ha) - PE fb Tembotrione 0.12 kg/ha PoE at 25 DAS (25.61 q/ha) applied in preceding maize due to better growth and development of chickpea owing to suppression of weeds under weed free and said herbicidal treatments. The results are in conformity with the finding of Rani *et al.* (2019) [4].

Table 1: Weed density, weed dry weight and plant population of chickpea as influenced by weed management practices adopted in preceding maize (pooled data of 2016-17 and 2017-18).

Treatment	Weed density		Weed dry weight (g m^{-2})		Plant population/m^2	
	At 25 DAS	At harvest	At 25 DAS	At harvest	At 25 DAS	At harvest
T_1: Control (Weedy check)	16.67 (277.22)	6.14 (36.89)	7.52 (55.66)	5.15 (25.53)	33.72	28.22
T_2:Weed free	8.85 (78.89)	4.31 (17.89)	3.60 (12.06)	3.66 (12.42)	32.67	27.83

T_3:Mechanical weeding 2 HW	11.93 (141.61)	4.92 (23.28)	6.48 (41.04)	3.91 (14.38)	32.89	28.17
T_4:Pendimethalin @ 1.0 kg/ha - PE	11.25 (125.89)	5.68 (31.28)	5.62 (31.60)	4.51 (19.63)	30.11	26.28
T_5:Atrazine @ 1.0 kg/ha - PE	9.86 (99.22)	4.96 (24.17)	4.50 (20.22)	3.95 (14.73)	32.56	29.67
T_6:Atrazine (0.75 kg/ha) + Pendimethalin (0.75 kg/ha) - PE	13.42 (183.06)	5.24 (26.61)	6.51 (41.34)	4.16 (16.40)	31.50	26.67
T_7:Atrazine (1.0 kg/ha) fb 2,4-D Amine 0.4 kg/ha - PoE	12.28 (150.06)	5.27 (27.00)	5.63 (31.40)	4.72 (21.36)	32.61	27.78
T_8:Halosulfuron @ 0.09 kg/ha at 25 DAS	11.22 (125.06)	5.89 (33.72)	5.36 (27.90)	4.23 (17.19)	33.78	28.83
T_9:Atrazine (1.0 kg /ha) PE fb Halosulfuron @ 0.09 kg/ha – 25 DAS	12.72 (161.33)	5.28 (27.00)	6.13 (36.65)	4.29 (17.49)	33.28	27.50
T_{10}:Tembotrione 0.12 kg/ha PoE at 25 DAS	12.84 (166.06)	5.17 (25.89)	5.60 (31.67)	4.39 (18.49)	33.72	29.17
T_{11}:Pendimethalin @ 1.0 kg/ha PE fb Atrazine (0.75 kg/ha)+ 2,4-D Amine 0.4 kg/ha at 25 DAS as PoE	8.95 (79.22)	4.38 (18.50)	3.81 (13.64)	3.74 (13.13)	34.06	29.00
T_{12}:Atrazine (1.0 kg/ha) - PE fb Tembotrione 0.12 kg/ha PoE	12.13 (147.89)	5.58 (30.39)	5.70 (32.35)	4.41 (18.45)	31.94	27.89
S.Em±	0.54	0.28	0.37	0.19	1.65	1.55
CD at 5%	1.55	0.80	1.04	0.53	NS	NS

Table 2: Residual effect of weed control treatment applied in maize on yield attributes and yield of succeeding chickpea (pooled data of 2016-17 and 2017-18)

Treatment	Primary branch	Secondary branch	Tertiary branch	Pods/ plant	Seeds/ pod	Seed weight /plant (g)	100 seed weight (g)
T_1: Control (Weedy check)	3.10	8.10	3.73	40.03	1.63	7.20	13.10
T_2:Weed free	3.73	9.53	4.67	58.57	1.98	15.51	15.82
T_3:Mechanical weeding 2 HW	3.43	8.40	3.90	40.87	1.68	7.59	13.27
T_4:Pendimethalin @ 1.0 kg/ha - PE	3.50	8.93	4.27	56.07	1.88	10.30	14.47
T_5:Atrazine @ 1.0 kg/ha - PE	3.43	9.17	4.10	42.63	1.80	8.19	14.15
T_6:Atrazine (0.75 kg/ha) + Pendimethalin (0.75 kg/ha) - PE	3.70	8.93	4.30	54.00	1.79	10.13	14.75
T_7:Atrazine (1.0 kg/ha) fb 2,4-D Amine 0.4 kg/ha - PoE	3.43	9.00	4.23	56.13	1.73	9.28	14.48
T_8:Halosulfuron @ 0.09 kg/ha at 25 DAS	3.30	9.17	4.40	56.00	1.75	12.22	13.93
T_9:Atrazine (1.0 kg /ha) PE fb Halosulfuron @ 0.09 kg/ha – 25 DAS	3.57	8.80	4.27	56.40	1.80	12.94	13.62
T_{10}:Tembotrione 0.12 kg/ha PoE at 25 DAS	3.43	8.93	4.40	52.70	1.90	9.73	14.22
T_{11}:Pendimethalin @ 1.0 kg/ha PE fb Atrazine (0.75 kg/ha)+ 2,4-D Amine 0.4 kg/ha at 25 DAS as PoE	3.33	9.33	4.53	58.50	1.93	13.47	15.10
T_{12}:Atrazine (1.0 kg/ha) - PE fb Tembotrione 0.12 kg/ha PoE	3.43	8.93	4.30	54.53	1.83	13.03	13.73
S.Em±	0.25	0.44	0.39	2.76	0.05	0.74	0.25
CD at 5%	NS	NS	NS	7.86	0.13	2.11	0.73

4. Conclusion

It can be concluded that productivity of succeeding chickpea was higher following weed free condition and pre emergence application of Pendimethalin 1.0 kg/ha fb Atrazine (0.75 kg/ha)+ 2,4-D Amine 0.4 kg/ha at 25 DAS as post emergence in preceding crop of maize during kharif season.

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