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Comparative efficacy of herbicides and hand weeding to control weeds in onion

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ABSTRACT

Effective and efficient weed management strategies are essential to raise a successful onion crop. Therefore, to find out the economically feasible weed management practice, a field experiment was conducted at Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, during 2015-16 and 2016-17. Five herbicides namely pendimethalin1.0 kg/ha, oxyfluorfen 0.15 kg/ha, alachlor 1.0 kg/ha, butachlor 1.0 kg/ha and quizalofop-ethyl 0.05 kg/ha were applied alone or in different combinations replicated thrice in randomized block design. Data was recorded on weed density, dry matter accumulation of weeds, weed control efficiency, weed index, herbicide efficiency index and yield parameters. Pre-emergence application of oxyfluorfen 0.15 kg/ha *fb* one hand weeding at 40-60 days after transplanting recorded the highest weed control efficiency and the lowest values of weed density, dry matter accumulation of weeds and weed index. The pre-emergence application of oxyfluorfen 0.15 kg/ha *fb* post-emergence application of quizalofop-ethyl 0.05 kg/ha at 40 DAT was also found to be equally effective in controlling the weeds in onion. The yield attributing traits such as average bulb weight and total bulb yield also exhibited the same pattern. However, the highest B: C ratio was recorded with pre-emergence application of oxyfluorfen 0.15 kg/ha *fb* post-emergence application of quizalofop-ethyl 0.05 kg/ha applied 40 DAT. Hence, this treatment can be used for controlling the prevalent weed flora in onion crop under Jammu condition.

INTRODUCTION

Onion (*Allium cepa* L.) is a widely grown and most popular vegetable in India and around the World. India ranks second after China in terms of both area and production. Onion contributes 70% of the foreign exchange among the fresh vegetables. The yield level or average productivity of this crop is low due to various production constraints. Among these, weed infestation is the prime one. Due to its inherent characters such as short stature, non-branching habits and sparse foliage, onion cannot competes well with the weeds. Additionally, other cultural practices such as high fertilization and frequent irrigation helps in providing congenial environment for weed growth. The yield loss due to weed infestation has been reported to the tune of 40-80% (Channapagoudar and Biradar 2007, Sharma *et al*. 2009 and Ramalingam *et al*. 2013). Under J&K conditions particularly in Jammu province, the hand weeding is still a wide practice which is uneconomical, time consuming and often damages the crop. Moreover, due to shortage and non-availability of timely labour and unexpected rainfall during its peak growing season, it often gets delayed or left altogether. Therefore more farmers are switching towards chemical weed control as it may form an integral part of the modern crop production practices in this area. Thus, in order to eliminate crop-weed competition at all stages, there is a need to evaluate the efficacy and economics of various herbicides, its doses and time of application to obtain high yield and marketable produce.

MATERIALS AND METHODS

Field experiment was carried out during *Rabi* 2015-16 and 2016-17 at Chatha, Jammu (32-40^0 N latitude, 74-53^0 E longitude and 300 m above mean sea level). The soil of experimental site was silty loam in texture, slightly alkaline in reaction (pH 7.72), medium in available N (240 kg/ha) and P_2O_5 (12.1 kg/ha) and low in available K_2O (134 kg/ha). Fourteen

treatments comprised of application of pendimethalin 1.0 kg/ha and oxyfluorfen 0.15 kg/ha as pre-plant application, Pre-emergence application of pendimethalin 1.0 kg/ha, oxyfluorfen 0.15 kg/ha, alachlor 1.5 kg/ha and butachlor 1.0 kg/ha, combined application of pendimethalin 1.0 kg/ha (PE) *fb* post-emergence application of quizalofop-ethyl 0.05 kg/ha (40 DAT), oxyfluorfen 0.15 kg/ha (PE) *fb* quizalofop-ethyl 0.05 kg/ha, alachlor 1.5 kg/ha (PE) *fb* quizalofop-ethyl 0.05 kg/ha and butachlor 1.0 kg/ha (PE) *fb* quizalofop-ethyl 0.05 kg/ha, Directorate of Onion and Garlic (DOGR) recommendation oxyfluorfen 0.15 kg/ha (pre-emergence) *fb* one hand weeding 40-60 DAT, three hand weeding at 20, 40 and 60 DAT. (farmers practice), weedy check and weed free (continues manual weeding), respectively.

Eight weeks old healthy seedlings of onion cv. *N-53* were transplanted in second week of December at a spacing of 20 × 10 cm. The crop was fertilized with 100 kg urea, 50 kg P_2O_5 and 50 kg K_2O per hectare and a basal dose of 20 tonnes farm yard manure per hectare. All cultural operations and plant protection measures were adopted to maintain uniform plant population and ideal condition for proper growth and development of the crop. Observations on various weed parameters such as weed density (plant/m^2), weed dry matter accumulation (g/ha) was recorded and weed control efficiency (%) and weed index was determined. Crop phytotoxicity effect was also recorded visually by three persons without knowing the layout of the experiment at 5, 10, 15 and 20 DAHS. Its rating was done by using 0-10 scale given by Gupta (2010).

RESULTS AND DISCUSSION

Weed studies

The prominent weed species observed in experimental site were *Cyperus rotundus, Chenopodium album*, *Coronopus didymus, Chenopodium murale, Cynadon dactylon, Melilotus indica, Cannabis sativa, Anagallis arvensis, Parthenium hysterophorus, Rumex dentatus, Portulaca oleracea and Euphorbia hirta.* The lowest weed density was recorded in the herbicidal treatment plots with application of pre-emergence oxyfluorfen 0.15 kg/ha *fb* one hand weeding which were statistically at par with pre-emergence application of oxyfluorfen *fb* post-emergence quizalofop-ethyl at both 60 days after transplanting and harvesting time. Weed dry matter accumulation is the most important parameter to assess the weed competitiveness for the crop growth and productivity. All the herbicidal treatments significantly influenced the dry matter accumulation of both monocot and dicot weeds and significantly lowest dry matter was recorded in the treatments, *viz.* three hand weeding, pre-emergence application of oxyfluorfen 0.15 kg/ha *fb* one hand weeding 40-60 DAT and pre-emergence application of oxyfluorfen 0.15 kg/ha *fb* quizalofop-ethyl 0.05

Table 1. Effect of herbicidal treatments on weed density, dry matter of monocot weeds, dry matter of dicot weeds in onion (pooled data for two years)

Treatment	Weed density (plants/m^2)		Dry matter of monocot weeds (g/m^2)		Dry matter of dicot weeds (g/m^2)	
	60 DAT	At harvest	60 DAT	At harvest	60 DAT	At harvest
Pendimethalin 1.0 kg/ha PP	13.7(186)	12.0(143)	113.5	104.0	42.0	30.7
Oxyfluorfen 0.15 kg/ha PP	12.7(161)	11.8(138)	111.5	101.0	43.8	35.3
Pendimethalin 1.0 kg/ha PE	11.2(125)	10.4(108)	61.5	78.0	30.8	30.5
Oxyfluorfen 0.15 kg/ha PE	11.3(126)	10.3(105)	51.7	70.5	32.3	31.0
Alachlor 1.5 kg/ha PE	13.0(169)	11.9(139)	84.7	81.7	33.7	33.5
Butachlor 1.0 kg/ha PE	12.9(165)	11.6(134)	99.7	99.3	42.2	25.5
Pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT	9.1(82)	8.7(75)	40.5	38.7	17.0	11.2
Oxyfluorfen 0.15 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT	8.7(75)	8.2(67)	44.2	37.5	12.0	11.8
Alachlor 1.5 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT	10.5(110)	9.7(93)	48.5	63.3	12.0	21.5
Butachlor 1.0 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT	10.9(116)	10.0(98)	49.5	58.7	15.8	21.2
Oxyfluorfen 0.15 kg/ha PE *fb* one HW 40-60 DAT	8.5(70)	8.0(68)	40.7	36.0	16.7	11.3
Three HW 20, 40 and 60 DAT	6.6(41)	7.8(60)	35.7	35.8	11.7	10.2
Weedy check	16.8(279)	14.3(204)	140.0	125.0	40.7	50.2
Weed free	1.0	1.0	-	-	-	-
LSD (p=0.05)	0.28	0.32	5.4	4.8	4.6	3.3

PP= pre-plant application; PE=pre-emergence, DAT=days after transplanting, *fb*=followed by, value in parentheses are original mean

kg/ha 40 DAT which were statistically at par with each other (**Table 1**). Comparatively lower weed dry matter accumulation was observed at harvesting stage than at 60 days after transplanting of the crop.

Weed control efficiency of different treatments ranged from (18.8-71.0%) at 60 days after transplanting and (18.3-62.8%) at harvesting stage (**Table 2**). Among different herbicidal treatments, treatments such as three hand weeding at 20, 40 and 60 DAT, pre emergence application of oxyfluorfen *fb* one hand weeding 40-60 DAT and pre-emergence application of oxyfluorfen *fb* post-emergence quizalofop-ethyl at 40 DAT were found equally effective at both stages of the crop after weed free plots. These results are in conformity with the studies conducted by Panse *et al*. (2014) and Sampat *et al.* (2014).

Weed index is the indicator of losses in the yield due to presence of the weeds and the lowest values of weed index were recorded in three hand weeding plots, pre-emergence application of oxyfluorfen *fb* one hand weeding and pre emergence application of oxyfluorfen *fb* post-emergence quizalofop-ethyl both at 60 days after transplanting and harvesting (**Table 2**). Maximum value was in weedy check plots due to prominent weed-crop competition, suppression of crop plants by the emerging weeds and more utilization of nutrients and moisture by the weed canopy. Kolse *et al.* (2010) also reported maximum weed index values (57.95%) under weedy check plots of onion under Maharashtra conditions. However, among the herbicidal treatments, the highest herbicide efficiency index (4.71) was recorded with application of pre-emergence application of oxyfluorfen 0.15 kg/ha *fb* post-emergence application of quizalofop-ethyl 0.05 kg/ha (**Table 2**).

All the weed management practices caused significant reduction in weed population compared with the weedy check during both year 2015-16 and 2016-17. However, magnitude of reduction in density and biomass of weed varied depending on the control measures adopted. The periodical weed density, weed dry matter accumulation and weed control efficiency varied at different stages of the crop. At 60 DAT, density and dry matter of weeds were more as compared to harvesting stage. But, in case of weed control efficiency it was found higher at 60 DAT than at harvesting, it might be due to the fate of herbicides like leaching, volatile movement and decomposition which ultimately decreases its efficiency with passage of the time. Similar results were reported by Kolse *et al.* (2010) and Sampat *et al.* (2014).

Crop phytotoxicity

None of the herbicidal treatments caused any phytotoxic symptoms in terms of leaf yellowing, leaf curling, leaf tip drying *etc*. and did not decreased the bulb yield. However, slight effect was observed in some treatments such as pendimethalin 1.0 kg/ha as pre-emergence *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT, oxyfluorfen 0.15 kg/ha as pre-emergence *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT and oxyfluorfen 0.15 kg/ha pre-emergence *fb* 1 HW 40-60 DAT at 5 days and 10 days after herbicidal spray

Table 2. Effect of herbicidal treatments on weed index, herbicide efficiency index (HEI; %), weed control efficiency (WCE; %) and crop phytotoxicity in onion (pooled data for two years)

Treatment	Weed index	HEI	WCE		Crop phytotoxicity		
			At 60 DAT	At harvest	5 DAHS	10 DAHS	15 DAHS
Pendimethalin 1.0 kg/ha PP	37.99	0.81	29.21	27.65	0	0	0
Oxyfluorfen 0.15 kg/ha PP	37.52	0.84	34.36	25.51	0	0	0
Pendimethalin 1.0 kg/ha PE	31.24	1.74	42.32	38.55	1	1	0
Oxyfluorfen 0.15 kg/ha PE	28.46	2.17	43.98	39.79	1	1	0
Alachlor 1.5 kg/ha PE	39.19	1.06	20.78	19.61	0	0	0
Butachlor 1.0 kg/ha PE	39.45	0.85	18.86	18.36	0	0	0
Pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT	13.16	4.51	68.22	57.08	1	1	0
Oxyfluorfen 0.15 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT	11.66	4.70	71.08	58.91	1	1	0
Alachlor 1.5 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT	16.84	3.90	50.38	46.66	0	0	0
Butachlor 1.0 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT	24.0	3.20	48.17	44.35	0	0	0
Oxyfluorfen 0.15 kg/ha PE *fb* one HW 40-60 DAT	10.56	-	68.32	58.29	1	1	0
Three HW 20, 40 and 60 DAT	9.19	-	68.98	62.82	-	-	-
Weedy check	63.69	-	-	-	-	-	-
Weed free	-	-	-	-	-	-	-
LSD (p=0.05)	4.85	-	3.74	2.99			

DAHS= days after herbicidal spray, 0 = none, 1-3 = slight; PP= pre-plant application; PE=pre-emergence

but later on crop was fully recovered (**Table 2**). None of the studied herbicides had shown any phytotoxicity effect on crop and did not reduce yield and affect its quality. So all the herbicides used were found safer. Similar findings were reported by Kalthlen and Jeffery (1990) and Ramalingam *et al*. (2013).

Yield

Various yield attributes were significantly influenced by different herbicidal treatments. The yield attributes recorded higher values in weed free plots and minimum being recorded in weedy check (**Table 3**). More yields in weed free plots seems to be due to the favorable environment created by the clean crop culture resulting in more absorption of solar radiation and plant nutrients resulting in more photosynthetic rates and more dry matter accumulation. Among the herbicidal treatments, maximum yield attributes being recorded in the treatments plots of oxyfluorfen 0.15 kg/ha *fb* one hand weeding 40-60 DAT followed by pre-emergence application of oxyfluorfen 0.15 kg/ha *fb* post-emergence application of quizalofop-ethyl 0.05 kg/ha during both the year 2015-16 and 2016-17. Due to their ability to inhibit emerging weeds like broad-leaves, grasses and to some extent sedges also (**Table 3**). The yield attributes results are in conformity with the Kalhapure *et al.* (2014). The lowest yield attributes were recorded in weedy check plots owing to low chlorophyll content and photosynthetic rate due to unchecked weed growth there by reducing the availability of moisture, light and nutrients to the crop thus resulting in loss of yield. (Channappagoudar and Biradar 2007).

Table 3. Effect of herbicidal treatments on average bulb weight and total bulb yield in onion

Treatment	Avg. Bulb weight (g)	Total bulb yield (t/ha)		
		2015-16	2016-17	Mean
Pendimethalin 1.0 kg/ha PP	34.17	16.9	16.4	16.6
Oxyfluorfen 0.15 kg/ha PP	35.00	16.9	16.9	16.9
Pendimethalin 1.0 kg/ha PE	43.87	18.7	18.5	18.6
Oxyfluorfen 0.15 kg/ha PE	48.73	19.5	19.6	19.6
Alachlor 1.5 kg/ha PE	33.37	16.4	16.7	16.6
Butachlor 1.0 kg/ha PE	31.67	16.4	16.4	16.4
Pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT	69.50	23.7	23.5	23.6
Oxyfluorfen 0.15 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT	70.78	24.1	24.4	24.3
Alachlor 1.5 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT	64.40	22.6	22.5	22.6
Butachlor 1.0 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT	58.33	21.4	21.4	21.4
Oxyfluorfen 0.15 kg/ha PE *fb* one HW 40-60 DAT	72.47	24.6	24.6	24.6
Three HW 20, 40 and 60 DAT	73.33	24.8	25.2	25.0
Weedy check	24.23	9.7	9.9	9.8
Weed free	84.10	27.5	27.7	27.6
LSD (p=0.05)	4.15	3.0	5.2	4.1

Table 4. Effect of herbicidal treatments on economics of onion

Treatment	Cost of cultivation ($x10^3$/ha)	Gross returns ($x10^3$/ha)	Net returns ($x10^3$/ha)	B: C ratio
Pendimethalin 1.0 kg/ha pre plant	56.4	179.3	122.9	2.17
Oxyfluorfen 0.15 kg/ha pre plant	52.8	180.3	127.5	2.41
Pendimethalin 1.0 kg/ha PE	56.4	198.4	141.0	2.50
Oxyfluorfen 0.15 kg/ha PE	52.8	206.8	154.1	2.92
Alachlor 1.5 kg/ha PE	53.9	175.0	122.0	2.26
Butachlor 1.0 kg/ha PE	51.8	175.0	123.2	2.37
Pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT	57.4	250.4	191.3	3.33
Oxyfluorfen 0.15 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT	54.4	254.6	200.2	3.68
Alachlor 1.5 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT	55.9	239.7	185.1	3.31
Butachlor 1.0 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha at 40 DAT	53.5	228.1	174.5	3.26
Oxyfluorfen 0.15 kg/ha PE *fb* one hand weeding 40-60 DAT	60.2	257.8	197.5	3.28
Three hand weeding 20, 40 and 60 DAT	73.6	262.0	188.4	2.55
Weedy check	51.1	103.9	52.8	1.03
Weed free	81.1	288.6	207.4	2.55

Economics

Significantly highest cost of cultivation, maximum gross return and net return were recorded in weed free plots, which was closely followed by herbicidal treatments plots of oxyfluorfen 0.15 kg/ha (pre-emergence) *fb* by one hand weeding (in case of gross return) and oxyfluorfen 0.15 kg/ha applied as pre-emergence *fb* quizalofop-ethyl 0.05 kg/ha (in case of net return). However, maximum benefit: cost ratio (3.68) was recorded in plots with pre emergence application of oxyfluorfen 0.15 kg/ha *fb* quizalofop-ethyl 0.05 kg/ha as post-emergence (**Table 4**). Minimum benefit: cost ratio (1.03) was observed in weedy check. In accordance with our findings Kalhapure *et al.* (2014) and Sampat *et al.* (2014) also got minimum B: C ratio under the unweeded plots.

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