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RESEARCH ARTICLE

Complex weed flora management through herbicides in nursery and transplanted onion

D.D. Chaudhari, V.J. Patel*, H.K. Patel and B.D. Patel

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ABSTRACT

Onion nursery is severely affected by the weed which hampers the growth of seedlings and further delayed in transplanting and thereby yield. For obtaining potential yield of onion, producing and transplanting of healthy seedlings and timely control of complex weed flora is necessary in onion nursery. An experiment was carried out during two consecutive *Rabi* (winter) season of the year 2020-21 and 2021-22 at B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat (India). In this study, total 12 different treatments each in nursery and in transplanted onion were tested in a randomized block design (RBD) having three replications. Early post-emergence application (EPoE) of propaquizafop + oxyfluorfen (pre-mix) 43.75 + 105 g/ha, oxyfluorfen 80 g/ha EPoE, pendimethalin 300 g/ha as pre-emergence (PE) and twice hand weeding at 15 and 30 days after sowing (DAS) significantly reduced the dry biomass of weeds, recorded higher weed control efficiency, fresh weight of 100 seedlings, higher number of transplantable seedlings and better economic returns than rest of the treatments. All the herbicides applied in onion nursery were found safe for succeeding wheat, chickpea and mustard crop under bioassay study. In transplanted onion, pre-plant incorporation of pendimethalin 580.5 g/ha followed by (*fb)* oxyfluorfen 120 g/ha applied as post-emergence (PoE) and pre-emergence (PE) application of oxyfluorfen 120 g/ha *fb* propaquizafop + oxyfluorfen 43.75 +105 g/ha applied as post-emergence and propaquizafop + oxyfluorfen 43.75 +105 g/ha as post-emergence recorded significantly lower weed dry biomass, higher weed control efficiency, onion bulb yield, net return and benefit cost ratio.

Keywords: Herbicide, Onion nursery, Phytotoxicity, Seedling, Transplanted onion, Weed management

INTRODUCTION

Onion (*Allium cepa*) is an important vegetable cum spice crop, serving as a staple ingredient in many Indian dishes. The demand for onions in India is very high and the crop is an important source of income for many farmers in the country. It can be grown mostly by the transplanting of seedling raised in the nursery beds. hence, transplanting of healthy seedling is required for better establishment of plant and obtaining higher bulb production. Among various factor affecting growth of onion seedlings, weeds pose greater role, as weed compete for available resources which leads to curtail the uptake of nutrient by seedlings and there by the growth of seedlings become poor and produced weak seedlings. Further, onion nursery is heavily infested by the weeds due to its slow growth, non-branching habit and very less and erect plant canopy. Frequent irrigation and incorporation of FYM in the nursery field provide congenial condition for early germination and luxuriant growth of weed (Sharma *et al.*, 2009). Various approaches have been tried to control the weeds wherein, hand weeding is effective, but it is time consuming and uneconomical due to closer spacing and shallow root system of the crop and may pose the disease problem due to mechanical injury to the seedlings during hand weeding process in the main field. Therefore, weed management in nursery is important to produced vigorous and healthy onion seedling. Further, transplanted onion exhibits greater susceptibility to weed competition as compared to the other crops due to its inherent characteristics such as their slow growth, short stature, shallow roots and lack of dense foliage (Dhananivetha *et al*. 2017). Crop losses due to weeds vary from 30 to 95% in onion (Kumar 2014) and the critical period of crop-weed competition ranges from 30 to 40 days (Sathyapriya *et al.* 2017). Ramalingam *et al.* (2013) observed that reduction in onion bulb yield depends on intensity and duration of weed growth but average yield reduction was observed to the tune of 40-80% in weedy check. In the present-day situation, number of herbicides available in the market for effective control of complex weed flora in various crops with

AICRP on Weed Management, B.A. College of Agriculture, Anand Agricultural University, Anand, Gujarat 388110, India

* Corresponding author email: avjpatel28@aau.in

high potency and environmental safety. The combine application of pre-and post-emergence herbicide is one of the options left with the farmers to eliminate crop weed competition at early and later stages of the crop and to achieve higher weed control efficiency. Looking to this, use of herbicides is the best option to raise weed free nursery and also provide better control of weeds in transplanted onion crop thus, the present study was planned to assess the efficacy of herbicides against complex weed flora in onion nursery and transplanted onion.

MATERIALS AND METHODS

An experiment was carried out during two consecutive *Rabi* (winter) season of 2020-21 and 2021-22 under AICRP on Weed Management operating at B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. The soil of the experimental field was low in organic carbon (0.38%) and medium in available phosphorous (30.58 kg/ha) and high in potassium (281.3 kg/ha). In the nursery experiment, twelve weed management practices consisted of pendimethalin 38.7% CS 200 g/ha as pre-plant incorporation (PPI), pendimethalin 38.7% CS 300 g/ha PPI, pendimethalin 30% EC 200 g/ha as pre-emergence (PE), pendimethalin 30% EC 300 g/ha PE, oxyfluorfen 23.5% EC 80 g/ha PE, oxyfluorfen 23.5% EC 120 g/ha PE, oxadiargyl 6% EC 42 g/ha PE, oxadiargyl 6% EC 60 g/ha PE, oxyfluorfen 23.5% EC 80 g/ha early post-emergence (EPoE), propaquizafop 5%+ oxyfluorfen 12% w/w EC (pre-mix) 43.75 + 105 g/ha EPoE, hand weeding at 15 and 30 DAS and weedy check were laid out in randomized block design with three replications. While in transplanted onion experiment, twelve weed management practices consisted of pendimethalin 38.7% CS 580.5 g/ha PPI, pendimethalin 38.7% CS 580.5 g/ha PPI followed by *(fb)* oxyfluorfen 23.5% EC 120 g/ha post-emergence (PoE), pendimethalin 38.7% CS 580.5 g/ha PPI *fb* oxadiargyl 6% EC 75 g/ha PoE, oxyfluorfen 23.5% EC 120 g/ha PE *fb* clodinafop 12.25% + oxyfluorfen 14.7% EC (pre-mix) 122.5+147 g/ha PoE, oxadiargyl 6% EC 75 g/ha PE *fb* clodinafop 12.25% + oxyfluorfen 14.7% EC (pre-mix) 122.5+147 g/ha PoE, oxyfluorfen 23.5% EC 120 g/ha PE *fb* propaquizafop 5% + oxyfluorfen 12% w/w EC (pre-mix) 43.75 +105 g/ha PoE, oxyfluorfen 23.5% EC 150 g/ha PoE, oxadiargyl 6% EC 90 g/ha PoE, clodinafop 12.25% + oxyfluorfen 14.7% EC (pre-mix) 122.5+147 g/ha PoE, propaquizafop 5% + oxyfluorfen 12% w/w EC (pre-mix) 43.75 +105 g/ha PoE, hand weeding at 20 and 40 DATP and weedy check were laid out in randomized block design with three replications. onion cv. *'Gujarat Anand White Onion 2'* were sown in the nursery on 6 and 1 November, 2020 and 2021, respectively keeping spacing of 10 cm between row. The nursery was raised for 45 days during both the years and observations was taken upto 45 days and then bioassay study was taken keeping as such layout. PPI, pre- and post-emergence herbicides were applied by using battery operated knapsack sprayer fitted with flat-fan nozzle by mixing in 500 litre of water/ha as per treatments. The crop was fertilizer with 50 kg N, 25 kg P and 25 kg K/ha in the form of urea, single super phosphate and murate of potash, respectively. The rest of the recommended package of practices was adopted to raise the crop. The seedlings were uprooted on 21 and 16 December 2020 and 2021, respectively.

Whereas, healthy seedling obtained from the onion nursery experiment were transplanted on 18 and 21 December, 2020 and 2021, respectively keeping spacing of 15 x 10 cm. The crop was harvested on 22 and 24 April, 2021 and 2022, respectively. PPI, Pre- and post-emergence herbicides were applied by using battery operated knapsack sprayer fitted with flat-fan nozzle by mixing in 500 litre of water/ha as per treatments. The crop was fertilizer with 100 kg N, 75 kg P and 75 kg K/ha in the form of urea, single super phosphate and murate of potash, respectively. The rest of the recommended package of practices was adopted to raise the crop. Density and dry weight of weeds were recorded from randomly selected four spots by using 0.25 m^2 iron quadrate from net plot through destructive sampling from both the experiment. Weed control efficiency (WCE) was calculated on the basis of standard formula as suggested by Maity and Mukherjee (2011). The yield reduction (%) owing to the presence of weeds was estimated by using the formula suggested by Kumar and Gill (1969) and expressed as Weed Index (WI). Other growth and yield attributing observation were also recorded from net plot area. Before statistical analysis, the data on weed dry biomass were subjected to square root $(\sqrt{x+1})$ transformation to improve the homogeneity of the variance (ANOVA). Data on various observations during the experiment period was statistically analysed as per the standard procedure developed by Cochran and Cox (1957).

RESULTS AND DISCUSSION

Nursery experiment

Effect on weed: It was observed from the two years' experimentation that dominance of dicot weed was recorded at 15 DAS of onion nursery in which

Chenopodium album (68.1%), *Melilotus indica* (13.2%), *Chenopodium murale* (8.34%) and *Trianthema monogyna* (1.50%) as dicot while *Eleusine indica* (3.13%), *Digitaria sanguinalis* (1.17%), *Setaria glauca* (1.11%) and *Dactyloctenium aegyptium* (0.72%) as monocot weed dominated in the field.

Significantly lower dry biomass of monocot and total weed (1.64 and 3.15 g/m^2, respectively) and dicot weed (1.87 g/m^2) was recorded at 45 days after sowing (DAS) under propaquizafop + oxyfluorfen (PM) 43.75+105 g/ha early post-emergence (EPoE) and twice hand weeding at 15 and 30 DAS, respectively but it remains statistically at par with oxyfluorfen 120 g/ha PE, pendimethalin 300 g/ha PE and oxadiargyl 60 g/ha (**Table 1**). Early post-emergence application of oxyfluorfen 80 g/ha reduced the dry matter of dicot weed significantly as compared to pre-emergence application at 80 and 120 g/ha. Pre-emergence application of pendimethalin 300 g/ha reduced the dry matter production of total weeds as compared to pre-plant incorporation at 200 and 300 g/ha. The results confirm the findings of Sharma *et al.* (2009). Application of pendimethalin either pre-plant incorporation or pre-emergence at both 300 g/ha recorded higher weed control efficiency of dicot weed (71.9 to 91.0%) as compared to WCE of monocot weed (57.5 to 70.9%). Similarly, pre-emergence application of oxyfluorfen recorded more than 92% weed control efficiency of monocot weed at 80 and 120 g/ha while early post-emergence application of oxyfluorfen 80 g/ha recorded 92.5% weed control efficiency of dicot weed. As dominancy of dicot weed was more in onion nursery hence, application of oxyfluorfen as early post-emergence was better than pre-emergence application. Under twice hand weeding, complete removal of weeds resulted in the highest weed control efficiency. Similar line of findings was also reported by Sathyamoorthy *et al.* (2022).

Phytotoxicity: Based on the visual observation, it was noticed that application of different herbicides showed slightly phytotoxic effect on onion seedlings at 7 days after herbicide application. Pendimethalin applied either as PPI or PE showed wilting symptoms at 7 days after herbicide application (DAHA) but recovered at 14 DAHA. Pre-emergence and early post-emergence application of oxyfluorfen showed leaf injury and necrosis symptoms on onion seedlings up to 14 DAHA. Further, application of oxyfluorfen 80 g/ha EPoE and propaquizafop + oxyfluorfen (PM) 43.75 + 105 g/ha EPoE showed slightly toxic up to 7 days after herbicide application (DAHA) and later on the seedlings were recovered from the toxicity.

Effect on seedling: Twice hand weeding carried out at 15 and 30 DAS performed better by recording significantly higher plant stand (908/m^2), fresh weight of 100 seedlings (352 g) and number of transplantable seedling (837/m^2), but it was statistically at par with the seedlings raised with the application of propaquizafop + oxyfluorfen (PM) 43.75+105 g/ha EPoE, oxyfluorfen 80 g/ha EPoE and pendimethalin 300 g/ha PE at 45 DAS. It may be concrete that keeping the onion nursery free of weeds either through mechanical or chemical method will result in production of healthiest seedlings. Sathyamoorthy *et al.* (2022) also recorded higher and healthy transplantable seedlings under hand weeding

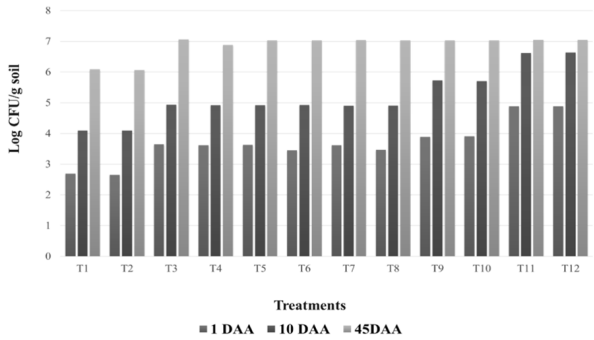
Table 1. Dry biomass of weeds and WCE as influenced by weed management practices in onion nursery at 45 DAS (pooled data for two years)

Treatment	Weed dry biomass of monocot (g/m^2)	Weed dry biomass dicot (g/m^2)	Weed dry biomass total (g/m^2)	WCE (%)			Weed index (%)
				Monocot weed	Dicot weed	Total weed	
Pendimethalin 200 g/ha PPI	4.27(17.7)	7.99(63.5)	9.00(81.0)	57.5	71.9	69.8	30.1
Pendimethalin 300 g/ha PPI	3.73(13.7)	6.86(46.9)	7.79(60.7)	67.1	79.3	77.4	35.2
Pendimethalin 200 g/ha PE	3.86(14.5)	6.37(40.5)	7.46(55.0)	65.1	82.1	79.5	21.6
Pendimethalin 300 g/ha PE	3.56(12.1)	4.46(20.3)	5.72(32.4)	70.9	91.0	87.9	6.9
Oxyfluorfen 80 g/ha PE	1.95(3.00)	9.26(85.9)	9.41(88.9)	92.8	62.0	66.8	43.1
Oxyfluorfen 120 g/ha PE	1.77(2.25)	8.10(67.0)	8.23(69.2)	94.6	70.4	74.2	36.7
Oxadiargyl 42 g/ha PE	4.21(19.2)	7.78(63.2)	8.81(82.4)	53.9	72.0	69.3	26.2
Oxadiargyl 60 g/ha PE	3.37(13.3)	6.41(48.1)	7.16(61.3)	68.0	78.7	77.1	28.9
Oxyfluorfen 80 g/ha EPoE	4.49(19.2)	4.05(17.0)	6.03(36.2)	53.9	92.5	86.5	6.1
Propaquizafop + oxyfluorfen 43.75 + 105 g/ha EPoE	1.64(1.75)	2.86(7.55)	3.15(9.30)	95.8	96.7	96.5	2.9
Hand weeding at 15 and 30 DAS	3.17(10.7)	1.87(2.80)	3.54(13.5)	74.3	98.8	95.0	-
Weedy check	6.35(41.6)	14.8(226)	16.1(268)	-	-	-	93.9
LSD (p=0.05)	1.60	3.70	3.65	-	-	-	-
CV%	15.4	11.5	10.2	-	-	-	-

Note: Data subjected to $(\sqrt{x+1})$ transformation. Figures in parentheses are means of original values.

method. Significantly the lowest plant stand, fresh weight of 100 seedlings and number of transplantable seedlings was recorded under weedy check. Plant height of onion seedling showed non-significant effect (**Table 2**). In general, all the herbicidal treatments significantly improved the fresh weight of 100-seedling and overall transplantable seedlings as compared to the unweeded control. This may be due to the reduced crop competition due to less germination of weeds under pre-emergence herbicide while early post-emergence herbicide controls the germinated weeds effectively. Significant reduction in total number of seedlings was recorded in pre-emergence application of oxyfluorfen at 80 and 120 g/ha due to their phytotoxic effect. Significantly the lowest plant stand, fresh weight of 100 seedlings and number of transplantable seedlings was observed under weedy check. This may be attributed to severe crop weed competition at critical stages resulting in unfavourable environment for growth and development of onion seedlings. The results are in accordance with the results of Sharma *et al*. (2009).

Microbial study: Initially there was some harmful effect of herbicides on soil microbial population, but gradually it was reduced (**Figure 1**). However, application of pendimethalin 200 g/ha and 300 g/ha as pre-plant incorporation (PPI) suppression effect on microbial population even at 45 days after sowing of onion seed. Application of pendimethalin also affects soil microorganisms. The initial reduction of soil microorganisms after application of pendimethalin into soil and stimulation of soil microorganisms at 50 and 75 days after pendimethalin application was reported by Nayak *et al*. (1994).



T_1: Pendimethalin 200 g/ha PPI; T_2: Pendimethalin 300 g/ha PPI; T_3: Pendimethalin 200 g/ha PE; T_4: Pendimethalin 300 g/ha PE; T_5: Oxyfluorfen 80 g/ha PE; T_6: Oxyfluorfen 120 g/ha PE; T_7: Oxadiargyl 42 g/ha PE; T_8: Oxadiargyl 60 g/ha PE; T_9: Oxyfluorfen 80 g/ha EPoE; T_{10}: Propaquizafop + oxyfluorfen 43.75 + 105 g/ha EPoE; T_{11}: Hand weeding at 15 and 30 DAS and T_{12}: Weedy check

Figure 1. Total soil microbial count as influenced by weed management practices in onion nursery

Economics: Economics of various weed management practices in 1000 m^2 area of onion nursery indicated that maximum gross return of ₹ 2,51,100 was achieved under twice hand weeding at 15 and 30 DAS followed by propaquizafop + oxyfluorfen (PM) 43.75 + 105 g/ha EPoE (₹ 2,43,900), oxyfluorfen 80 g/ha EPoE (₹ 2,35,800) and pendimethalin 300 g/ha PE (₹ 233700). While maximum net return of ₹ 2,24,230 and benefit cost ratio of 12.4 was observed under propaquizafop + oxyfluorfen 12 (PM) 43.75 + 105 g/ha EPoE which was followed by oxyfluorfen 80 g/ha EPoE, pendimethalin 300 g/ha PE and twice hand weeding at 15 and 30 DAS.

Transplanted onion experiment

Effect on weed: Based on the two years of experimentation, it was noticed that *Eleusine indica*,

Table 2. Growth, number of seedlings and economics as influenced by weed management practices in onion nursery (pooled data for two years)

Treatment	Plant stand (no./m^2) at 45 DAS	Height of onion seedling (cm)		Fresh weight (g) of 100 seedlings at 45 DAS	Transplantable seedlings (no./m^2) at 45 DAS	1000 m^2 area				B:C
		30 DAS	45 DAS			Transplantable onion seedlings	Total cost of cultivation (x10^3 `/ha)	Gross return (x10^3 `/ha)	Net return (x10^3 `/ha)	
Pendimethalin 200 g/ha PPI	691	22.2	41.3	302	585	585000	19.46	175.50	156.04	9.02
Pendimethalin 300 g/ha PPI	707	21.3	40.8	299	542	542000	19.49	162.60	143.11	8.34
Pendimethalin 200 g/ha PE	858	23.8	41.0	299	656	706000	19.45	196.80	177.35	10.1
Pendimethalin 300 g/ha PE	877	23.2	39.6	307	779	779000	19.47	233.70	214.23	12.0
Oxyfluorfen 80 g/ha PE	706	22.7	38.1	262	476	476000	19.51	142.80	123.29	7.32
Oxyfluorfen 120 g/ha PE	698	21.6	37.8	259	530	530000	19.56	159.00	139.44	8.13
Oxadiargyl 42 g/ha PE	738	22.3	40.6	306	618	618000	19.50	185.40	165.90	9.51
Oxadiargyl 60 g/ha PE	732	22.2	39.3	314	595	595000	19.54	178.50	158.96	9.14
Oxyfluorfen 80 g/ha EPoE	890	24.5	39.4	333	786	786000	19.51	235.80	216.9	12.1
Propaquizafop + oxyfluorfen 43.75 + 105 g/ha EPoE	894	24.3	38.2	343	813	813000	19.67	243.90	224.23	12.4
Hand weeding at 15 and 30 DAS	908	25.1	41.5	352	837	837000	27.98	251.10	223.12	8.97
Weedy check	507	25.6	43.2	122	50.7	50700	19.31	15.21	-4.10	0.79
LSD (p=0.05)	131.0	1.77	NS	28.5	145	-	-	-	-	-
CV%	9.1	7.3	8.4	8.9	13.1	-	-	-	-	-

Note: Data subjected to $(\sqrt{x+1})$ transformation. Figures in parentheses are means of original values

Asphodelus tenuifolius, *Dactyloctenium aegyptium*, *Setaria glauca* and *Digitaria sanguinalis* as monocot weed while *Chenopodium album*, *Melilotus indica*, *Chenopodium murale* and *Boerhavia erecta* as dicot weed dominated in the field as per mean results.

All the herbicidal treatments significantly influenced the dry matter production of monocot, dicot and total weeds (**Table 3**). Significantly lower dry matter of monocot weed was recorded under oxyfluorfen 120 g/ha as pre-emergence (PE) followed by (*fb)* clodinafop + oxyfluorfen 122.5+147 g/ha as post-emergence (PoE) followed by oxadiargyl 75 g/ha as PE *fb* clodinafop + oxyfluorfen 122.5+147 g/ha as PoE, pendimethalin 580.5 g/ha as pre-plant incorporation (PPI) *fb* oxyfluorfen 120 g/ha PoE, oxyfluorfen 120 g/ha PE *fb* propaquizafop + oxyfluorfen 43.75 +105 g/ha PoE, clodinafop + oxyfluorfen 122.5+147 g/ha PoE, propaquizafop + oxyfluorfen 43.75 +105 g/ha PoE but were statistically at par with each other. This indicated that integration of more than one herbicide as sequential application provide excellent control of monocot weed as compared to alone application of herbicide. Lower dry biomass of weeds due to sequential application of herbicide in onion was also reported by Angmo and Chopra (2020). Whereas, significantly lower dry matter of dicot weed was noticed in pre-plant incorporation of pendimethalin 580.5 g/ha PPI *fb* oxyfluorfen 120 g/ha PoE followed by pendimethalin 580.5 g/ha PPI *fb* oxadiargyl 6% EC 75 g/ha PoE, oxyfluorfen 120 g/ha PE *fb* clodinafop + oxyfluorfen 122.5+147 g/ha PoE, oxadiargyl 75 g/ha PE *fb* clodinafop + oxyfluorfen 122.5+147 g/ha PoE and oxyfluorfen 120 g/ha PE *fb* propaquizafop 5% + oxyfluorfen 43.75 + 105 g/ha PoE. Comparatively, pre-plant incorporation of pendimethalin 580.5 g/ha as PPI *fb* oxyfluorfen 120 g/ha as PoE provide effective control of monocot and dicot weeds hence, dry matter of total weed was recorded significantly lower as compared to other treatment. Application of pendimethalin, oxadiargyl and oxyfluorfen as pre-emergence followed by post-emergence application of herbicide provide better control of monocot weed as compared to dicot weed. The highest weed biomass was noted in the weedy check due to the increased weed density was also observed by Hembrom *et al*. (2023) in onion.

Weed control efficiency of monocot, dicot and total weed in different treatments varied from 37.8 to 95.8, 91.4 to 98.9 and 87.8 to 98.0% at harvest, respectively (**Table 3**). In general, all the herbicide provides better control of dicot weed as compared to monocot weed which reflected in recording higher weed control efficiency. Pre-plant incorporation of pendimethalin 580.5 g/ha *fb* oxyfluorfen 120 g/ha as PoE provide higher weed control efficiency of 98.0% which was closely followed by pendimethalin 580.5 g/ha PPI *fb* oxadiargyl 75 g/ha PoE and oxadiargyl 75 g/ha PE *fb* clodinafop + oxyfluorfen 122.5+147 g/ha PoE. These results are in accordance with the results reported by Sampat *et al*. (2014).

Weed index denotes the yield losses due to presence of weeds and the highest values of weed index were recorded in weedy check to the tune of 89%. James and Harlen (2010) reported that uncontrolled weed growth caused 49-86% reduction

Table 3. Dry biomass of weeds and WCE as influenced by weed management practices in transplanted onion at harvest (pooled data for two years)

Treatment	Weed dry biomass of monocot (g/m^2)	Weed dry biomass dicot (g/m^2)	Weed dry biomass total (g/m^2)	WCE (%)			Weed index (%)
				Monocot weed	Dicot weed	Total weed	
Pendimethalin 580.5 g/ha PPI	4.44(19.7)	6.65(44.6)	8.37(70.7)	77.9	93.8	91.3	13.3
Pendimethalin 580.5 g/ha PPI *fb* oxyfluorfen 120 g/ha PoE	2.51(7.65)	2.88(8.17)	3.72(15.8)	91.4	98.9	98.0	-
Pendimethalin 580.5 g/ha PPI *fb* oxadiargyl 75 g/ha PoE	2.36(6.70)	3.26(10.4)	3.93(17.1)	92.5	98.6	97.9	13.3
Oxyfluorfen 120 g/ha PE *fb* clodinafop + oxyfluorfen (PM) 122.5+147 g/ha PoE	1.94(3.78)	5.97(35.9)	6.24(39.7)	95.8	95.0	95.1	13.8
Oxadiargyl 75 g/ha PE *fb* clodinafop + oxyfluorfen (PM) 122.5+147 g/ha PoE	2.30(4.87)	4.34(18.1)	4.87(23.0)	94.5	97.5	97.2	12.2
Oxyfluorfen 120 g/ha PE *fb* propaquizafop + oxyfluorfen (PM) 43.75 +105 g/ha PoE	2.57(5.67)	5.53(30.1)	6.04(35.7)	93.6	95.8	95.6	5.0
Oxyfluorfen 150 g/ha PoE	6.86(47.1)	7.16(51.2)	9.88(98.4)	47.2	92.9	87.8	29.8
Oxadiargyl 90 g/ha PoE	7.44(55.5)	6.31(39.5)	9.71(95.0)	37.8	94.5	88.3	35.9
Clodinafop + oxyfluorfen (PM)122.5+147 g/ha PoE	2.75(6.60)	7.89(61.9)	8.30(68.5)	92.6	91.4	91.5	14.2
Propaquizafop + oxyfluorfen (PM)43.75 +105 g/ha PoE	3.38(10.7)	6.53(42.0)	7.30(52.7)	88.0	94.2	93.5	5.0
Hand weeding at 20 and 40 DATP	4.00^c(15.1)	6.73(44.9)	7.79(60.0)	83.1	93.8	92.6	4.7
Weedy check	9.41(89.2)	26.6(720)	28.2(809)	-	-	-	89.0
LSD (p=0.05)	1.85	3.78	4.04	-	-	-	-
CV%	10.8	11.1	10.0	-	-	-	-

Note: Data subjected to $(\sqrt{x+1})$ transformation. Figures in parentheses are means of original values

in bulb yield compared with the best herbicidal treatment. However lower weed index was observed in twice hand weeding at 20 and 40 DATP followed by application of propaquizafop + oxyfluorfen (PM) 43.75 +105 g/ha PoE and oxyfluorfen 120 g/ha PE *fb* propaquizafop + oxyfluorfen (PM) 43.75 +105 g/ha PoE.

Phytotoxicity: Application of oxyfluorfen 23.5% EC 120 g/ha PE *fb* clodinafop 12.25% + oxyfluorfen 14.7% EC (PM) 122.5+147 g/ha PoE, oxadiargyl 6% EC 75 g/ha PE *fb* clodinafop 12.25% + oxyfluorfen 14.7% EC (PM) 122.5+147 g/ha PoE, oxyfluorfen 23.5% EC 150 g/ha PoE, oxadiargyl 6% EC 90 g/ha PoE showed some phytotoxicity symptoms of leaf injury and wilting on onion plants was observed visually at 7 days after herbicide application. However, the plants recover from the phytotoxicity symptoms and none of the symptoms were observed at 14 days after herbicide application.

Effect on crop: Significantly higher plant stand (476/ net plot) was observed under pendimethalin 580.5 g/ ha PPI *fb* oxyfluorfen 120 g/ha PoE but it was statistically at par with all other treatments except weedy check at harvest. Significantly taller plant (52.7 cm) was measured under weedy check at 30 DATP but it was at par with twice hand weeding at 20 and 40 DATP, pendimethalin 580.5 g/ha PPI and oxadiargyl 75 g/ha PE *fb* clodinafop + oxyfluorfen 122.5+147 g/ha PoE**.** At 60 DATP, significantly the highest plant height (84.1 cm) was measured under weedy check while non-significant difference was observed among all the herbicidal treatment with respect to recording plant height of onion in pooled results (**Table 4**).

Onion bulb yield was significantly varied due to different weed management practices and significantly higher onion bulb yield (44.3 t/ha) was achieved under pendimethalin 580.5 g/ha PPI *fb* oxyfluorfen 120 g/ha PoE as compared to weedy check, oxadiargyl 90 g/ha PoE and oxyfluorfen 150 g/ha PoE. Hembrom *et al*. (2023) also observed better control of weeds and onion bulb yield due to application of pendimethalin. Rahman *et al*. (2011) reported that hand weeding throughout the growing season controlled all weeds and resulted in higher onion bulb yield. Weedy check reported significantly the lowest (4.55 t/ha) onion bulb yield. The lowest onion bulb yield was recorded in weedy check plots owing to severe crop-weed competition resulted in low chlorophyll content and photosynthetic rate there by reducing the availability of moisture, light and nutrients to the crop thus, resulting in loss of yield (Angmo *et al*. 2018).

Economics: Data on economics of various weed management practices indicated that maximum gross return, net return and benefit cost ratio of ₹ 5,31,600/ ha, ₹ 3,37,602/ha and 2.74, respectively was achieved under pre-plant incorporation of pendimethalin 580.5 g/ha *fb* oxyfluorfen 120 g/ha applied as post-emergence which was closely followed by pre-emergence application of oxyfluorfen 120 g/ha *fb* propaquizafop + oxyfluorfen 43.75 + 105 g/ha applied at post-emergence. Among herbicidal treatment minimum gross return, net return and benefit cost ratio of ₹ 3,40,800/ha, ₹ 1,48,850/ha and 1.78, respectively was registered under oxadiargyl 90 g/ha PoE. Among all the treatment the highest cost of cultivation was observed under twice hand weeding treatment. This might be due to more

Table 4. Growth, yield and economics as influenced by weed management practices in onion (pooled data for two years)

Treatment	Plant stand (no./net plot) at harvest	Plant height (cm)		Bulb yield (t/ha)	Total cost of cultivation (x10^3 `/ha)	Gross return (x10^3 `/ha)	Net return (x10^3 `/ha)	B:C
		At 30 DATP	At 60 DATP					
Pendimethalin 580.5 g/ha PPI	475	49.3	70.5	38.4	191.47	460.80	269.33	2.41
Pendimethalin 580.5 g/ha PPI *fb* oxyfluorfen 120 g/ha PoE	476	47.8	70.6	44.3	194.00	531.60	337.60	2.74
Pendimethalin 580.5 g/ha PPI *fb* oxadiargyl 75 g/ha PoE	470	47.1	68.2	38.4	194.12	460.80	266.68	2.37
Oxyfluorfen 120 g/ha PE *fb* clodinafop + oxyfluorfen (PM) 122.5+147 g/ha PoE	473	48.2	72.8	38.2	196.34	458.40	262.06	2.33
Oxadiargyl 75 g/ha PE *fb* clodinafop + oxyfluorfen (PM) 122.5+147 g/ha PoE	475	45.5	70.1	38.9	196.47	466.80	270.33	2.38
Oxyfluorfen 120 g/ha PE *fb* propaquizafop + oxyfluorfen (PM) 43.75 +105 g/ha PoE	471	47.5	72.7	42.1	195.18	505.20	310.0	2.59
Oxyfluorfen 150 g/ha PoE	464	46.3	71.2	31.1	191.88	373.20	181.32	1.95
Oxadiargyl 90 g/ha PoE	464	43.5	69.0	28.4	191.95	340.80	148.85	1.78
Clodinafop + oxyfluorfen (PM)122.5+147 g/ha PoE	467	44.8	71.7	38.0	193.81	456.00	262.19	2.35
Propaquizafop + oxyfluorfen (PM)43.75 +105 g/ha PoE	474	45.9	71.2	42.1	192.65	505.20	312.55	2.62
Hand weeding at 20 and 40 DATP	471	50.2	71.0	42.2	229.25	506.40	277.15	2.21
Weedy check	162	52.7	84.1	4.55	188.98	54.60	-134.38	0.29
LSD (p=0.05)	23.6	3.96	4.53	6.71	-	-	-	-
CV%	1.2	7.8	5.8	8.3	-	-	-	-

labour was engage to remove the weeds. This results in agreement with the results of Gupta *et al.* (2020).

On the basis of two years of experimentation, it can be concluded that for obtaining healthy transplantable onion seedlings, effective management of weeds and net return, application of propaquizafop + oxyfluorfen (PM) 43.75 + 105 g/ha EPoE, oxyfluorfen 80 g/ha EPoE, pendimethalin 300 g/ha PE and twice hand weeding at 15 and 30 DAS found better. While in transplanted onion, pre-plant incorporation of pendimethalin 580.5 g/ha *fb* oxyfluorfen 120 g/ha applied as post-emergence and pre-emergence application of oxyfluorfen 120 g/ha *fb* propaquizafop + oxyfluorfen 43.75 +105 g/ha applied as post-emergence and propaquizafop + oxyfluorfen 43.75 +105 g/ha as post-emergence showed better weed control, yield and economics.

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