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Efficacy of herbicides against weed flora in onion (*Allium cepa* L.)

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ABSTRACT

Field experiment was conducted to compare different weed control methods in onion during rabi 2010-11 to 2011-12. The experiment was laid out in Randomized Block Design with eight treatments and replicated thrice. The pooled results revealed that significantly highest marketable yield (187.17 q ha^{-1}) as well as total bulb yield (217.48 q ha^{-1}) was produced by the application of oxyfluorfen 23.5% EC@2 ml l^{-1} before planting and one hand weeding at 40-60 days after transplanting (DAT) than rest of the treatments. The Weed Control Efficiency was significantly highest in T_6 (74.28) than the rest of the treatments. Thus, application of oxyfluorfen 23.5% EC@2 ml l^{-1} before planting and one hand weeding at 40-60 DAT or combined spray of pendimethalin 30% EC@2.5 ml l^{-1} and quizalofop ethyl 5% EC1.75 ml l^{-1} at the time of planting and at 30 DAT reduces the weed infestations with higher bulb yield in onion.

***Keywords*:** *Allium cepa*, economics, oxyflurofen, pendimethalin, quizalofop ethyl and weed control efficiency

Onion (*Allium cepa* L.) is one of the major five spices crops used for the flavouring purpose in our daily dietary. It is a crop of significant economic importance with higher market demand and price due to its culinary, dietary and medicinal values (Kalhapure *et al.*, 2014). Being an important commodity of mass consumption, it is grown commercially throughout India. Mahajan *et al.* (2018) reported that on the basis of an average of five years since 1976 area has increased from 2.31 lakh hectares to 12.71 lakh hectares, production from 24.44 lakh tonnes to 215.65 lakh tonnes ha^{-1}. At present India ranks 1st in the area, 2nd in production and 9th in productivity in the world by producing 215.63 lakh tones of onion from an area of 12.71 lakh ha with an average productivity of 16.12 tonne ha^{-1}. USA ranks 1st in productivity with an average productivity of 55.95 tonne ha^{-1} followed by Iran (36.93 tonne ha^{-1}), Egypt (36.58 tonne ha^{-1}),Turkey (30.70 tonne ha^{-1}), Algeria (27.95 tonne ha^{-1}), Brazil (27.82 tonne ha^{-1}), Rusian federation (23.19 tonne ha^{-1}) and China (21.85 tonne ha^{-1}) as reported by Saxena *et. al.* (2017). Even if, India stands in a superior position contributing 21.5% share in the world onion production, the productivity is mediocre as compared to other onion producing countries and remains constant since the last lustrum. Low productivity in onion crop is due to ignorance of the farmers about improved agronomic practices and appropriate protection mechanism against biotic and abiotic stresses. Weed infestation is one of the vital limiting factors for commercial cultivation of onion that causes comparatively higher losses than the losses caused by insect pests and diseases. Generally, it has been observed that continuous incorporation of undecomposed cow dung as FYM increases the weed population, as because the un-decomposed seeds of unwanted crops called "weeds" were transmitted in dormant condition through this FYM and uniformly nourished with the onion seeds. It competes with onion crop for nutrients, soil moisture, space, light and considerably reduced the bulb yield, and excellence of the crop through excess production and harvesting costs has been well documented by Hussain, (1983). Further, Appleby (1996) reported that due to smaller leaf size, slow growth and very shallow root system onion can't compete well with weeds particularly at early stages of growth. Channapagoudar and Biradar (2007) reported that due to slow initial growth and inherent characteristic of crop short stature, non-branching habit, sparse foliage, shallow root system coupled with frequent irrigation and fertilizer application at high dose, the crop exhibits greater susceptibility to weed competition than most other crops. Without weed control, onion bulb yields reduced drastically; losses due to weed infestation were recorded to the tune of 40 to 80%. As weeds decrease the profitability of onion crops, judicious weed management practices should be adopted for better bulb yield as well as economic return. A well developed weed management programme with an appropriate defence mechanism to combat the weed population is essential to obtain higher bulb production. Keeping these views, the present study was conducted to compare the effectiveness of pre and post emergence herbicides to control the weeds density in onion crop.

MATERIALS AND METHODS

Field experiments were conducted during *rabi* 2010-11 to 2011-12 to compare various weed management practices in onion under All India Network Research Project on Onion and Garlic operating at College of Horticulture, Odisha University of Agriculture and Technology, Sambalpur, Odisha, India situated at

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20°21' N latitude and 80°55' E longitude and at an altitude of 178.8 m above mean sea level. The soil of the experimental area was sandy loam having pH of 5.89; available N of 151 kg ha^{-1}, P of 15 kg ha^{-1} and K of 178 kg ha^{-1} with low sulphur content (9.75ppm). The selected experimental site was a weed prone area under Western Table Land Zone of Odisha with wide diversities of monocot and dicot weeds. Among monocots *Cynodon dactylon, Cyperus difformis, Cyperus iria, Cyperus rotundus, Digitaria sanguinalis, Echinochloa colona, Eleusine indica and Paspalum serobiculatum* are foremost whereas, *Alternanthera sesillis, Amaranthus spinosus, Amaranthus viridis, Cleome viscssa, Eclipta alba, Euphorbia hirta, Lantana camara, Mimosa pudica, Parthenium hysterophorus, Phyllanthus niruri, Physalis minima* and *Portulaca oleraceae* are the predominant dicots species found in this locality.

The climate of the experimental district was warm/ sub-humid with the temperature ranging from 9°C to 44.2°C. The mean maximum and the mean minimum temperatures of 40.5° C and 13°C are recorded in the months of May and December, respectively. Southwest monsoon plays an important role with a mean annual rainfall of 1426.2 mm in 93 rainy days. The station received around 6.7% rainfalls in February to May as pre-monsoon, 86.5% of in June to September as the monsoon and 6.8% in October to January as post-monsoon.

The experiment was laid out in Randomized Block Design with seven combinations of different pre and posts emergences herbicides along with different straight weed management practices apart from a weedy check and replicated thrice. The treatments details are presented in the table-1.

Table 1: Treatment details of weed management studies in onion

Notations	Treatment details
T_1	Oxyflurofen 23.5EC @ 2ml l^{-1} before planting and second application at 30 DAT
T_2	Oxyflurofen 23.5EC @ 2ml l^{-1} before planting and quizalofop ethyl 5EC @ 3.5 ml l^{-1} at 30 DAT
T_3	Combined spray of oxyflurofen 23.5EC @ 1ml l^{-1} and quizalofop ethyl 5EC @ 1.75 ml l^{-1}at the time of planting and at 30 DAT
T_4	Pendimethalin 30EC @ 5.0 ml l^{-1} before planting and at 30 DAT
T_5	Pendimethalin 30EC @ 5ml l^{-1} before planting + and quizalofop ethyl 5EC @ 3.5ml l^{-1} at 30 DAT
T_6	Combined spray of pendimethalin 30EC @ 2.5ml l^{-1} and quizalofop ethyl 5EC @ 1.75ml l^{-1} at the time of planting and at 30 DAT
T_7	Oxyflurofen 23.5EC @ 2ml l^{-1} before planting and one hand weeding at 40-60 DAT
T_8	Weedy check

Note: DAT – days after transplanting

From the very beginning, the field was prepared to obtain a best possible fine tillage for the better survival of young onion seedlings. Approximately six to eight weeks old onion seedlings of variety "Agrifound Dark Red" were treated for 10minites with a solution of bavistine @ 0.5gm lit^{-1} of water to protect the crop from the threat of various fungal diseases. Then the seedlings were manually transplanted with a spacing of 15cm in between lines and 10cm within the line in a plot size of 5 m x 2 m. Soon after transplanting, light irrigation was given for the quick seedling establishment. Before transplanting, the treatments were imposed as per the scheduled weed management practices in a well-randomized trial plot. Appropriate concentrations of herbicides were applied by using hand operated knapsack sprayer fitted with a flat fan type nozzle. For hand weeding, depending upon the weed intensity, weeds were removed manually by using the hand hoe with male manpower as per the scheduled dates in treatment details. Every possible package of practices was adapted uniformly with an utmost care to raise a high-quality crop.

The data on various vegetative growth parameters *i.e.* plant height and numbers of leaves were randomly recorded from ten selected plant. Later on, for yield and yield attributing parameters the harvested bulbs were allowed for field curing as well as shed drying for a week. Then the parameters like average bulb weight (g), marketable bulb yield (kg) and total bulb yield (kg) $plot^{-1}$ were recorded by using the standard digital balance and converted to q ha^{-1}. Regarding % double bulbs, % bolters %, A grade, % B grade and % C grade bulb were recorded on the basis of weight over total bulb yield, however, bulbs for different grades were selected on the basis of equatorial diameter of onion bulbs *i.e.* less than 3.5 cm "unmarketable grade", 3.5 to 4.5 cm "C grade", 4.5 to 5.5 cm "B grade", 5.5 to 6.5 "A grade" and above 6.5 cm "A+ grade".

The weed count was recorded species-wise from $1m^{-2}$ areas by using a quadrangle iron frame of 1 m x 1 m randomly from each and every plot. The weeds failing within the frames were collected, categorised into monocot and dicot, counted and the mean values were

expressed in number m^{-2}. The density of total weeds was recorded and expressed in number m^{-2}.

The fresh weights of weeds m^{-2} were recorded by using the digital balance from individual plots of each replication treatment wise and values were expressed in terms of gram m^{-2}. The weeds from each category were allowed for shed drying, later on after removal of soil particles from the weeds they were kept inside the hot air oven at 80^0 C for 48 hrs by using the thick paper envelopes. The dry weights of weeds m^{-2} were recorded at 3hrs interval till the weight becomes constant and expressed in terms of g m^{-2} separately for each category.

Weed control efficiency (WCE) was calculated as per the procedure suggested by Mani *et al.* (1973).

$$WCE\% = \frac{WDc - WDt}{WDc} X100$$

Where,

WCE- Weed control efficiency.

WDc - Weed population in the untreated / control plot.

WDt - Weed population in the treated plot.

The observed data were then subjected to statistical analysis by following the procedure for Randomized Block Design (Sukhatme and Amble,1995). Benefit-cost ratio was calculated by dividing net monetary returns by the cost of cultivation.

RESULTS AND DISCUSSION

Effect of weed management practices on vegetative growth of onion

The pooled results from the above experiments revealed significantly highest vegetative growth with the application of oxyflurofen 23.5EC @ $2ml l^{-1}$ before planting along with one hand weeding at 40-60 DAT *i.e.* T_7. The treatment recorded highest plant height of 58.52 cm closely followed by 57.21 cm with the combined spray of pendimethalin 30EC @ $2.5ml l^{-1}$ and quizalofop ethyl 5EC @ $1.75ml l^{-1}$ at the time of planting and at 30 DAT *i.e.* T_6. The same treatment *i.e.* T_7 recorded highest 13.75 numbers of leaves $plant^{-1}$ whereas a deviation was observed with the number of leaves $plant^{-1}$. Further, Maximum 12.80 number of leaves $plant^{-1}$ were recorded with the application of oxyflurofen 23.5EC @ $2ml l^{-1}$ before planting and quizalofop ethyl 5EC @ 3.5 $ml l^{-1}$ at 30 DAT *i.e.* T_2 stands second in the number of leaves $plant^{-1}$ instead of T_6. In both the treatments oxyflurofen 23.5EC @ $2ml l^{-1}$ was applied before planting of the crop. Here, it was clearly observed that the application of oxyflurofen 23.5EC @ 2 ml l^{-1} before planting significantly created an effective security mechanism and reduced the crop and weed competition by promoting an optimum vegetative plant growth in onion. Significantly shortest plant height of 45.98 cm and 48.60 cm along with minimum 11.07 and 12.08 number of leaves $plant^{-1}$ were observed in T_8 *i.e.* the treatment with weedy check followed by T_5 *i.e.* the application of pendimethalin 30EC @ $5ml l^{-1}$ before planting + and quizalofop ethyl 5EC @ $3.5ml l^{-1}$ at 30 DAT respectively. Similar findings were reported by Udit Kumar (2014), Panse *et al.* (2014) and Tripathy *et al.* (2013).

Effect of weed management practices on bulb yield and quality of onion

The results revealed that, highest 26.23percent of A grade bulbs with an average bulb weight of 80.08g were observed in T_7 followed by T_6 *i.e.* Combined spray of pendimethalin 30EC @ $2.5ml l^{-1}$ and quizalofop ethyl 5EC @ $1.75ml l^{-1}$ at the time of planting and at 30 DAT with 22.73 percent of A - grade bulbs and an average bulb weight of 72.47g, than rest of the treatments.

Similarly, the highest 26.39 per cent of B grade and 40.94 per cent of C grade bulbs were recorded in T_5 *i.e.* with the application of pendimethalin 30EC @ $5ml l^{-1}$ before planting and quizalofop ethyl 5EC @ $3.5ml l^{-1}$ at 30 DAT and T_3 *i.e.* combined spray of oxyflurofen 23.5EC @ 1ml l^{-1} and quizalofop ethyl 5EC @ 1.75 ml l^{-1}at the time of planting and at 30 DAT, respectively. Regarding the percentage of doubles and bolters, minimum 1.27 per cent of double and 5.06 per cent of bolters were observed in T_3 and T_1. However, maximum 6.81 percent of doubles and 8.76 percent of bolters were recorded in T_4 and T_6 respectively.

The results on marketable bulb yield and total bulb yield were expressed in table 2 and fig 3. Significantly highest 187.17 q ha^{-1} of marketable bulb yield and 217.48 q ha^{-1} of total bulb yield were produced by the application of oxyflurofen 23.5% EC before planting and one hand weeding at 40 to 60 days after planting *i.e.* T_7. The combined spray of pendimethalin 30%EC and quizalofop Ethyl 5% EC at the time of planting and the second application at 30 days after planting *i.e* T_6 produced maximum 173.76 q ha^{-1} of marketable bulb yield and 203.82 q ha^{-1} of total bulb yield which was statistically at par with T_7. The highest benefit:cost of 3.68 was recorded in T_6 closely followed by T_7 (3.26) and T_2 (3.27). The application of above said pre emergence herbicides provides maximum crop production with an optimum B:C ratio.

It indicates that the relevance of pre emergence herbicides like oxyflurofen 23.5EC or pendimethalin 30EC before planting or at the time of planting effectively and economically control the weed population during the critical stages of crop growth. However, another spraying of post emergence herbicide like quizalofop ethyl 5EC or one hand weeding can absolutely protect

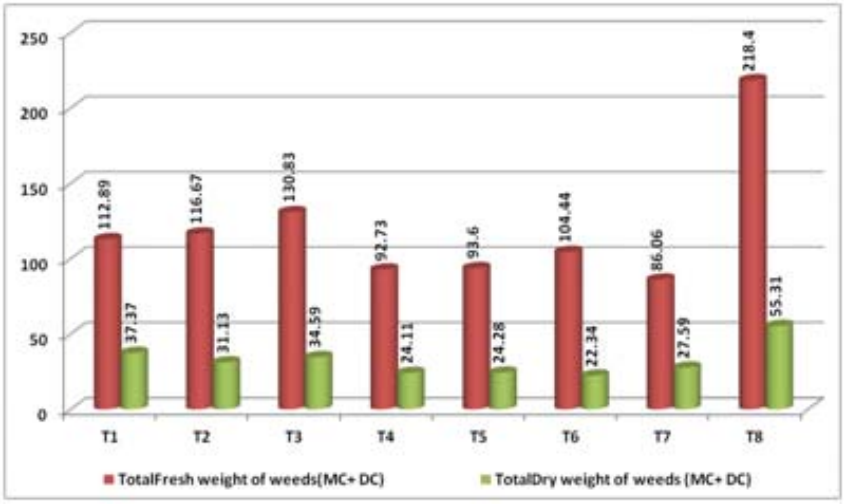

Fig. 1: Effect of weed management practices on fresh and dry weight of weeds

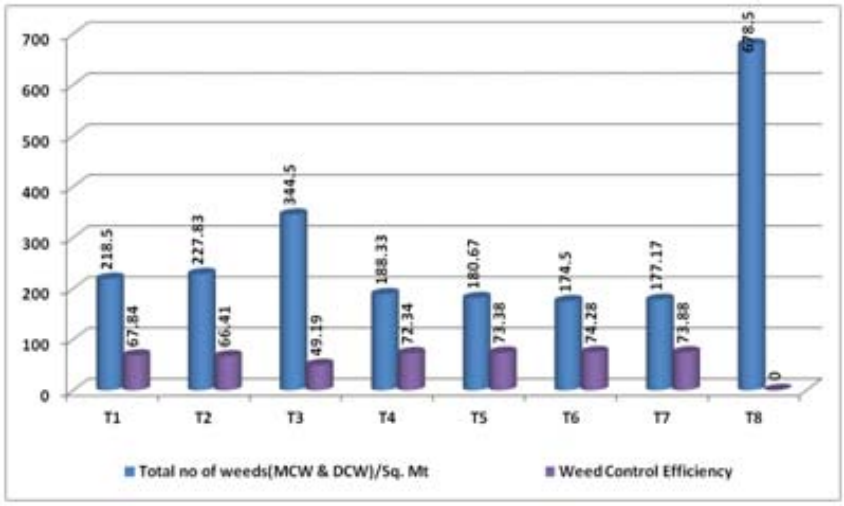

Fig. 2: Effect of weed management practices on total number of weeds and weed control efficiency

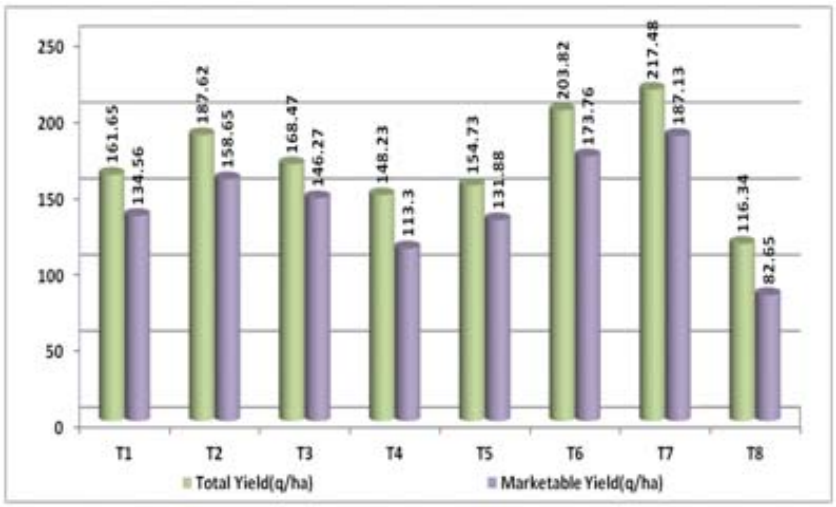

Fig. 3: Effect of weed management practices on total and marketable yield of onion

Table 2: Effect of weed management practices on growth and yield in onion

Treatment	PH (cm)	NOL	ABW (g)	% of A grade bulbs	% of B grade bulbs	% of C grade bulbs	% doubles	% bolters	TYq ha^{-1}	MYq ha^{-1}
T_1	53.70	12.32	67.20	18.60	23.12	36.26	1.73	5.06	161.65	134.56
T_2	51.60	12.80	70.70	16.51	19.90	37.06	4.12	7.71	187.62	158.65
T_3	50.67	12.42	63.27	15.60	20.71	40.94	1.27	7.87	168.47	146.27
T_4	49.85	12.62	60.50	16.28	21.12	27.50	6.81	8.25	148.23	113.30
T_5	48.60	12.08	68.60	18.09	26.39	31.55	4.79	6.77	154.73	131.88
T_6	57.21	12.75	72.47	22.73	24.89	28.21	2.23	8.76	203.82	173.76
T_7	58.52	13.75	80.08	26.23	21.63	30.82	2.85	6.01	217.48	187.13
T_8	45.98	11.07	58.51	10.56	18.65	33.24	2.17	5.80	116.34	82.65
SEm (±)	**2.26**	**0.47**	**4.56**	**2.82**	**2.68**	**3.66**	**0.74**	**1.35**	**13.01**	**9.34**
LSD (0.05)	**4.84**	**1.01**	**9.77**	**6.04**	**NS**	**7.84**	**1.60**	**NS**	**27.90**	**20.03**

Note: PH=plant height, NOL=number of leaves, ABW=average bulb weight (gm), MY=marketable yield q ha^{-1}, TY = total yield q ha^{-1}

Table 3: Effect of weed management practices on weed population and weed control efficiency in onion

Treatment	Total weeds m^{-2} (MCW and DCW)	Total fresh weight (MC+ DC) (g m^{-2})	Total dry weight (MC+ DC) (g m^{-2})	WCE	B:C
T_1	218.50	112.89	37.37	67.84	2.09
T_2	227.83	116.67	31.13	66.41	3.27
T_3	344.50	130.83	34.59	49.19	2.58
T_4	188.33	92.73	24.11	72.34	1.24
T_5	180.67	93.60	24.28	73.38	0.96
T_6	174.50	104.44	22.34	74.28	3.68
T_7	177.17	86.06	27.59	73.88	3.26
T_8	678.50	218.40	55.31	—	—
SEm (±)	**43.71**	**5.37**	**3.41**		
LSD (0.05)	**93.75**	**11.52**	**7.32**		

Note: MCW= monocot weeds, DCW= dicot weeds, WCE= weed control efficiency, B: C = benefit cost ratio

the onion crop from weed competition. This is in accordance with the result of Sankar *et al.* (2015) in *rabi* season onion under western Maharashtra conditions.

Effect of weed management practices on weed population and weed control efficiency

The results on weed population and weed control efficiency showed that different herbicides had significant effects. The weed population was effectively reduced irrespective of all weed management practices except the weedy check. However, weed control efficiency was significantly highest in T_6 (74.28) followed by T_7 (73.88) along with minimum weed populations of 174.50 and 177.17, respectively than other treatments. Significantly, minimum 86.06g of fresh weight and 22.34 g of dry weight of weeds (fig 1) were also observed in T_7 & T_6 respectively as in the table- 3 and fig.- 2.

Oxyflurofen is a nitrodiphenyl ether herbicide applied to control pre emergent and post emergent grassy and broadleaf weeds as reported by Sean May *et al.* (2015). Alister *et al.* (2009); Shaner (2014) reported, oxyflurofen strongly adsorbs to soil particles and remain stable inside the soil profile. It affects terrestrial plants when directly applied as pre emergence to the soil or spray over the plants as post emergence. It causes general foliar necrosis within two days of exposure when applied as post emergence. Further, Hess (2000) reported, the leaf appears to be soaked with water and the leaf tissue turns dark green color which aggravates the necrosis and desiccation of the affected tissue. Anastoasov (2010) reported the other sign of phytotoxicity including week chlorosis, deformation of leaf and vegetation tips and inhibition of plant growth due to reduced and ineffective functioning leaf stomata. Systematically, the application of oxyflurofen inhibits the emergence of weedy plants, provides an encouraging ecological condition for better crop growth at the initial vegetative stage leading to enhanced bulb development and crop yield with effective weed management practice.

Likewise, Akobudu (1987) reported, pendimethalin is a dinitroaniline herbicide applied to control the weeds. It is primarily active on grass weeds and also effectively controls broad leaves as reported by *Das* (2011). Pendimethalin also strongly adsorbs to soil organic matter and clay particles and not easily leaches through the soil. It prevents plant cell division and elongation in some specifically vulnerable type weed and controls the weed population by preventing the weeds from the very emerging stage, particularly during the crucial development phase of the crop.

The present study exhibits that application of oxyflurofen 23.5% EC before planting and one hand weeding at 40-60 days after planting or combined spray of pendimethalin 30%EC and quizalofop ethyl 5% EC at the time of planting and second application at 30 days after planting not only reduces the weed infestations effectively but also increases bulb yield with higher B:C in onion crop.

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