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Effect of herbicides and their combination on weed management in onion (*Allium cepa* L.)

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Abstract
A field investigation entitled "Effect of Herbicides and their Combination on Weed Management in Onion (*Allium cepa* L.)" carried out during 2020-21 and 2021-22 at Horticultural Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) with an objective to study the weed dynamics and efficacy of different herbicide and their combination on weed management in onion. The experiment was laid out in Randomized Block Design with ten treatments replicated thrice. Five herbicides, namely Oxyfluorefen, Oxdiargyl, Pendimethalin, Fluazifop-p-butyl, and Quizalofop-p-ethyl combinations and hand weeding were compared with weedy check (untreated) plot. The herbicide treatment (T_7) Oxyfluorfen 23.5% @ 0.25 kg a.i./ha + Quizalofop-p-ethyl 5% EC @ 75 g a.i./ha + Pendimethalin 30% EC @ 1kg a.i./ha + hand weeding at 40 days after transplanting found significantly superior than control plot and recorded minimum weed density (6.47/m^2) at stages of crop growth, weed intensity (14.13%), weed dry biomass (16.40 g/m^2) and weed index (0.00%). Similarly, the same herbicide treatment registered the maximum weed control efficiency (88.86%), Herbicide efficiency index (3.99%), which were noticed in the same herbicide treatment. This clearly indicates that the application of Oxyfluorfen 23.5% @ 0.25 kg a.i./ha + Quizalofop-p-ethyl 5% EC @ 75 g a.i./ha + Pendimethalin 30% EC @ 1kg a.i./ha + hand weeding at 40 days after transplanting found effective herbicide to controlling weeds in onion cultivation.

Keywords: Herbicides, weed management, onion, *Allium cepa* L.

Introduction
Onion (*Allium cepa* L.) is an important vegetable and spice crop of India belongs to family Alliaceae and genus *Allium*. Onion is a bulbous, biennial herb which is consumed all over the world throughout the year. It promotes appetite and help to protect against high blood pressure, heart attack, and cancer due to the presence of phytochemicals and flavonoids such as quercetin, trisulfide, and vinyl dithiins. It is also used to cure a wide array of physiological disorders such as cough, obesity, insomnia, hemorrhoid, and constipation (Ibrahim *et al.*, 2011) [5].

Onion is one of the most commercial vegetable crops grown all over the world. India ranks first in the area and second in production with about 19.9% share after china in the world. India produces about 26.83 million tonnes of onion from an area of 1.63 million hectares with a productivity of 16.37 tonnes per hectare (Anon., 2021). Maharashtra is the leading onion-growing state; other important states are Karnataka, Gujarat, Bihar, Madhya Pradesh, Andhra Pradesh, Rajasthan, Haryana, Uttar Pradesh, and Tamil Nadu.

The management of weed is one of the most serious problems in onion which limits the crop yield and decreased profits. Weeds are a severe issue that drastically affects bulb production, by as much as 40–80% (Vishnu *et al.*, 2014) [14]. Due to the inherent qualities of onions, including their short stature, non-branching habitat, sparse foliage, near transplant planting, shallow root systems, and extremely slow initial development, regular irrigation creates an environment that is conducive to weed growth. It generally competes with crop for nutrients and depletes 30-40% of applied nutrients from the soil (Kour *et al.*, (2014) [6]. Therefore, it is essential to keep field weed free during critical periods of crop growth. However, been generally realized that forty days of hand weeding is a supplementary tool and substitute for the chemical weed control method. When applied at a suitable stage they kill the weed even before they appear on the surface and save the crop from weed competition during the critical growing period. Therefore, keeping in view the production of onions with judicial application of different herbicide combinations with hand weeding is the way to reduce weeds.

Herbicide not only controls the weeds timely and effectively but also offers great scope for minimizing the cost of weed control irrespective of the situation.

Research Methods

Field experiment was conducted at Horticultural Research cum instructional farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *Rabi*, 2020-21 and 2021-22. In Randomized Block Design with three replication having ten different treatments. T_1- Oxyfluorfen 23.5% EC @ 0.25 kg a.i./ha + hand weeding at 40 days after transplanting, T_2- Oxyfluorfen 23.5% @ 0.25 kg a.i./ha + Fluazifop-p-butyl 11.1% SL @ 0.25 kg a. i./ha, T_3- Oxyfluorfen 23.5% @ 0.25 kg a.i./ha + Fluazifop-p-butyl 11.1% SL @ 0.25 kg a. i./ha + hand weeding at 40 days after transplanting, T_4- Oxydiargyl 80% WP @ 0.09 kg a.i./ha + Fluazifop-p-butyl 11.1% SL @ 0.25 kg a.i./ha, T_5- Oxydiargyl 80% WP @ 0.09 kg a.i./ha + Fluazifop-p-butyl 11.1% SL @ 0.25 kg a.i./ha+ hand weeding at 40 days after transplanting, T_6- Oxyfluorfen 23.5% @ 0.25 kg a.i./ha + Quizalofop-p-ethyl 5% EC @ 75 g a.i./ha + Pendimethalin 30% EC @ 1kg a.i./ha, T_7- Oxyfluorfen 23.5% @ 0.25 kg a.i./ha + Quizalofop-p-ethyl 5% EC @ 75 g a.i./ha + Pendimethalin 30% EC @ 1kg a.i./ha + hand weeding at 40 days after transplanting, T_8- Oxydiargyl 80% WP @ 0.09 kg a.i./ha + Quizalofop-p-ethyl 5% EC @ 75 g a.i./ha + Pendimethalin 30% EC @ 1kg a.i./ha, T_9- Oxydiargyl 80% WP @ 0.09 kg a.i./ha + Quizalofop-p-ethyl 5% EC @ 75 g a.i./ha + Pendimethalin 30% EC @ 1kg a.i./ha + hand weeding at 40 days after transplanting, T_{10}- Weedy check. These herbicides were applied before transplanting as pre-emergent herbicides and post-emergent at proper moisture in the soil which is a prerequisite for spraying of herbicide. The herbicides were sprayed by use of 1000 litres of water per hectare. The quantity of water and the herbicides to be applied per plot were calculated on the area basis before spraying. The experimental field was brought to fine tilth by repeated ploughing and harrowing. Twenty tonnes of FYM and recommended dose of fertilizers (75:60:100 kg NPK / ha) were incorporated in the soil. The experimental plots of size 1.5 m x 1.5 m and the seedlings of variety N-53 were transplanted from nursery on 4th November 2020 and 19th November 2021 at the spacing 15 cm row to row and 10 cm plant to plant. Plant protection practices were undertaken as per the package of practice. The observations were recorded on weed density, weed intensity, weed control efficiency and weed index, herbicide efficiency index. The weed count in the net plot was calculated by quantitative method for this purpose two quadrants each having area of (0.56 m^2) were randomly prepared and the total weeds per (0.56 m^2) area were counted and recorded. Weed control efficiency (%) and Herbicide efficiency index (%) of each treatment was calculated by the following formula.

$$\text{Weed control efficiency (\%)} = \frac{\text{Weed dry weight (control plot)} - \text{Weed dry weight (treated plot)}}{\text{Weed dry weight (control plot)}} \times 100$$

$$\text{Herbicide efficiency index (\%)} = \frac{\frac{\text{Yield from treated plot} - \text{Yield from control plot}}{\text{Yield from control plot}} \times 100}{\frac{\text{Dry matter of weed in treated plot}}{\text{Dry matter of weed in control plot}} \times 100}$$

Weed index and Weed intensity was calculated by using the following formula.

$$\text{Weed index (\%)} = \frac{\text{Yield from the treated plot} - \text{Yield from the control plot}}{\text{Yield from the treated plot}} \times 100$$

$$\text{Weed intensity (\%)} = \frac{\text{Total number of weeds in a unit area}}{\text{Total number of weeds and crop plants in the same area}} \times 100$$

The collected data regarding experimental observations were subjected for statistical analysis.

Research Findings and Discussion

The results obtained from the present investigation are summarized below

Weed flora

In the present investigation, the major monocot weeds like *Cyprus rotundus* L., *Cynodon dactylon* L., *Echinocloa crusgalli* L., *Eleusine indica*, and dicot weeds like *Euphorbia hirta* L., *Enuphorbia geniculata* L., *Alternanathera triandra* L., *Phyllanthus niruri* L., *Portulaca oleracea* L., *Parthenium hesterophorus* L., *Commelina bengalensis* L., *Digera arvensis* L., were recorded.

Weed density (no. /m^2)

The weed density/m^2 at all growth stages was significantly differed by herbicidal treatment, Oxyfluorfen 23.5% @ 0.25 kg a.i./ha + Quizalofop-p-ethyl 5% EC @ 75 g a.i./ha + Pendimethalin 30% EC @ 1kg a.i./ha + hand weeding at 40 days after transplanting (T_7) recorded significantly least number of weeds (6.47/m^2), which was at par with treatment T_9 (6.94/m^2). This might be due to the control of weeds during the early stage by application of oxyfluorfen found to be more effective in controlling weeds, due to inhibition of protoporphyrinogen oxidase (PPO) which leads to accumulation of photodynamic toxicant or protoporphyrin in the cells/plant. The results conformity with those obtained by Bhutia *et al.* (2005) [2] and Sibel *et al*. (2010) [9].

Weed intensity (%)

Among the herbicidal treatments application of Oxyfluorfen 23.5% @ 0.25 kg a.i./ha + Quizalofop-p-ethyl 5% EC @ 75 g a.i./ha + Pendimethalin 30% EC @ 1kg a.i./ha + hand weeding at 40 days after transplanting (T_7) recorded lower weed intensity (4.13%), which was at par with treatment T_6 (5.01%). This might be due to application of pendimethalin showed better management of weed flora indicating the ability of pendimethalin to suppress the growth of all type of

weed flora through its higher persistency in soil. As result it reduced the weed intensity (Chattopadhyay *et al.*, 2016) [3].

Weed biomass (g/m^2)

In the herbicidal treatment Oxyfluorfen 23.5% @ 0.25 kg a.i./ha + Quizalofop-p-ethyl 5% EC @ 75 g a.i./ha + Pendimethalin 30% EC @ 1kg a.i./ha + hand weeding at 40 days after transplanting T_7 (16.40 g/m^2) was observed for the lowest weed biomass followed by T_6 (21.92 g/m^2), T_9 (27.19 g/m^2) and T_8 (27.19 g/m^2) this treatment are statistically at par with each others. However, the highest weed biomass was recorded under the control treatment T_{10} (147.83 g/m^2).

This might be due to the highest weed intensity and its dominance which utilized the sunlight, nutrients, moisture *etc*. over crop plants and resulted in higher growth and ultimately the higher weed biomass in weedy check. Similar results were reported by Mhite *et al.* (2015) [8] and Shinde *et al.* (2013) [11].

Weed index (%)

Weed index was significantly influenced by the different weed control treatments. Among the herbicidal treatments, application of Oxyfluorfen 23.5% @ 0.25 kg a.i./ha + Quizalofop-p-ethyl 5% EC @ 75 g a.i./ha + Pendimethalin 30% EC @ 1kg a.i./ha + hand weeding at 40 days after transplanting (T_7) recorded the lowest weed index (0.00%) due to least infestation of weed. The highest weed index T_{10} (30.67%) was recorded in weedy check due to prominent weed competition, suppression of crop plants by emerging weeds and more utilization of nutrients and moisture by weed canopy, hence giving highest weed index similarly recorded by Ghadge *et al.* (2012) [4] in garlic.

Weed control efficiency (%)

The treatment Oxyfluorfen 23.5% @ 0.25 kg a.i./ha + Quizalofop-p-ethyl 5% EC @ 75 g a.i./ha + Pendimethalin 30% EC @ 1kg a.i./ha + hand weeding at 40 days after transplanting (T_7) significantly recorded more weed control efficiency (88.86%), which was at par with treatment T_6 (84.86%), showed the better weed control efficiency might be due to higher efficiency of herbicides by way of their physiological actions, namely Oxyfluorfen which uncouple oxidative phosphorylation and prevent ATP production during respiration. The physiological action of Pendimethalin may be due to inhibition of cell division and other physiological functions (Shiddhu *et al.*, 2018). And Quizalofop ethyl functions systematically, get translocated into the plant system thus restricting weed growth and yielding significantly weed control efficiency after herbicidal treatment. Similar results were recorded by Ghadge *et al.* (2012) [4].

Herbicide efficiency index

Herbicide efficiency index was significantly influenced by the different weed control treatments. Among the herbicidal treatments application of Oxyfluorfen 23.5% @ 0.25 kg a.i./ha + Quizalofop-p-ethyl 5% EC @ 75 g a.i./ha+ Pendimethalin 30% EC @ 1kg a.i./ha + hand weeding at 40 days after transplanting (T_7) recorded the highest herbicide efficiency index (3.99%). This indicates weed killing potential and no phytotoxicity on crop and results in higher herbicide efficiency index of these treatments. These results are in accordance with Kumar *et al.* (2013) [7] while studying integrated weed management in garlic. Sharma *et al.* (2009) [10] reported similar findings in onion.

Table 1: Effect of herbicides on number of monocot weeds, dicot weeds (count per m^2) and weed intensity (%) in onion.

Treatments	Number of monocot weeds			Number of dicot weeds			Weed intensity (%)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	12.00	12.05	12.03	7.89	7.88	7.89	11.71	11.73	11.72
T_2	8.33	8.34	8.34	13.01	13.02	13.02	12.45	12.46	12.46
T_3	6.67	6.65	6.66	6.67	6.65	6.66	8.17	8.14	8.16
T_4	8.00	8.00	8.00	8.89	8.87	8.88	10.12	10.11	10.12
T_5	6.00	6.11	6.06	6.01	6.02	6.02	7.41	7.48	7.45
T_6	4.33	4.32	4.33	3.67	3.50	3.59	5.06	4.96	5.01
T_7	3.00	3.01	3.01	3.45	3.47	3.46	4.12	4.14	4.13
T_8	4.67	4.66	4.67	4.67	4.66	4.67	5.86	5.85	5.86
T_9	3.67	3.66	3.67	4.33	4.34	4.34	5.06	5.06	5.06
T_{10}	29.01	29.02	29.02	40.34	41.32	40.83	31.62	31.92	31.77
SEm (±)	0.81	0.80	0.80	1.14	1.11	1.12	0.91	0.89	0.90
CD (5%)	2.40	2.38	2.38	3.39	3.29	3.29	2.71	2.65	2.65

Table 2: Effect of herbicides on Weed biomass (g/m^2), Weed control efficiency (%), Weed index (%) and Herbicidal efficiency index (%)

Treatments	Weed biomass (g/m^2)			Weed control efficiency (%)			Weed index (%)			Herbicidal efficiency index (%)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	46.04	46.04	46.04	68.51	68.41	68.46	19.17	21.49	20.33	0.66	0.30	0.48
T_2	49.24	51.02	50.13	66.10	64.64	65.37	16.20	21.27	18.73	0.75	0.28	0.52
T_3	44.98	42.72	43.85	69.24	70.69	69.97	11.33	20.02	15.67	1.06	0.40	0.73
T_4	46.63	48.39	47.51	67.90	66.46	67.18	14.93	21.02	17.97	0.86	0.31	0.58
T_5	34.83	34.84	34.84	76.19	76.09	76.14	9.78	17.72	13.75	1.47	0.62	1.05
T_6	21.88	21.96	21.92	84.94	84.78	84.86	1.17	6.24	3.70	3.21	2.06	2.63
T_7	16.39	16.41	16.40	88.87	88.86	88.86	0.00	0.00	0.00	4.44	3.53	3.99
T_8	29.03	29.01	29.02	80.02	79.89	79.95	8.44	12.33	10.39	1.87	1.13	1.50
T_9	27.18	27.20	27.19	81.17	80.96	81.06	6.80	11.00	8.90	2.13	1.30	1.71
T_{10}	147.22	147.27	147.24	0.00	0.00	0.00	33.08	28.25	30.67	0.00	0.00	0.00
SEm (±)	4.12	5.18	4.68	1.39	1.80	1.61	1.02	1.09	1.05	0.15	0.11	0.13
CD (5%)	12.26	15.40	15.40	4.13	5.34	5.34	3.03	3.23	3.23	0.45	0.33	0.33

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