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Impact of Pre and Post Herbicides Treatments on Growth and Bulb Yield Parameters of Garlic (*Allium sativum* L.)

Deepesh Kumar Ahirwar[1]*, Dhanesh Kumar Raidas[2], Ghanshyam Bamaniya[3], S.A. Ali[4] and S.R. Ramgiry[5]

[1]M.Sc. Research Scholar, Department of Horticulture (Vegetable Science),
RAK College of Agriculture, Sehore-466001, (Madhya Pradesh), India.
[2]Assistant Professor, Department of Plant Physiology,
RAK College of Agriculture, Sehore-466001, (Madhya Pradesh), India.
[3]M.Sc. Research Scholar, Department of Genetics & Plant Breeding,
RAK College of Agriculture, Sehore-466001, (Madhya Pradesh), India.
[4]Professor, Department of Horticulture,
RAK College of Agriculture, Sehore-466001, (Madhya Pradesh), India.
[5]Principal Scientist, Department of Genetics & Plant Breeding,
RAK College of Agriculture, Sehore-466001, (Madhya Pradesh), India.

(Corresponding author: Deepesh Kumar Ahirwar)*
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ABSTRACT: Weeds are the most important biotic constraints to garlic production. Weed in garlic field are worldwide problem and losses due to weed were as high as 72.5%. The main problem for farmers in garlic cultivation is weed control, which occurs mainly during the vegetative growth stage of the crop. Since, labour availability to manual weeding and higher wages, it is necessary to have the strategy of conventional hand weeding and chemical control of weeds in appropriate time to attain target yield and economic benefit. In this view, field experiments were conducted at Fruit Research Station Intkhedi Bhopal, RAK College of Agriculture, Sehore (M.P.) during the *Rabi* season, 2017-18. The experiments were laid out in RBD and replicated thrice. The weed management options *viz*., pre and post emergence herbicide applications in different doses and time with conventional hand weeding. The trials were also compared with control plot (without hand weeding and without use of herbicides). Results indicated that the T_2 - Two hand weeding at 30 and 60 DAS recorded maximum value of plant height (cm), number of leaves plant^{-1} at 90 DAS and yield parameters viz. neck thickness (cm), clove diameter (cm), polar diameter (cm), equatorial diameter (cm), number of cloves bulb^{-1}, weight of 20 cloves (g), bulb yield (g plant^{-1}), bulb yield (86.45q ha^{-1}) at harvest and benefit cost ratio over the remaining various weed management practices followed by T_{10} Oxyfluorfen 23.5% EC 250g a.i. /ha + one hand weeding after 30 DAS and T_8 Oxadiargyl 80% WP 100g a.i. /ha +one hand weeding after 30 DAS as compare to control.

Keywords: plant height, number of leaves, weeds, neck thickness, clove diameter, bulb yield

INTRODUCTION

Garlic (*Allium sativum* L.) a herbaceous annual vegetable crop of family Alliaceae, is the second most valuable bulb crop after Onion crop. Garlic usable since ancient times and is believed to be native to Central Asia and Northeastern Iran. India ranks second in the cultivation and production of garlic in the world. It is cultivated in an area of 301.700 thousand hectares and production of 1717.900 thousand million tons with productivity of 5.69 tons ha^{-1}. Madhya Pradesh ranks second in garlic production grown in an area of 92.50 thousand hectares with production of 405.00 thousand MT and productivity of 4.38 tones hectare^{-1}. Indore, Ratlam, Neemuch, Shajapur, Ujjain and Sehore are the major garlic producing districts of Madhya Pradesh. Garlic is the most important as a spice crop which contains vitamin C (31 mg), calcium (181 mg), phosphorus (153 mg), calories (149 Kcal), sulphur (70 mg), manganese (1672 mg) and lysine (0.273 g) of edible portion (Mardomi, 2017). Further it is used in the treatment of many diseases like hypertension, diabetes, cancer, scabies and itching (Kilgori *et al*., 2007). Weed infestation in garlic is one of the major factors for loss in yield and bulb loss to the tune of 30-60%. Weed reduces the bulb yield to the extent of 40 to 80% (Verma and Singh, 1996). In garlic shallow root system make mechanical method of weed control difficult and sometimes causes damage to developing bulbs (Lawande *et al*., 2009). The main problem for farmers in garlic cultivation is weed control, which occurs mainly during the vegetative growth stage of the crop (Mohite *et al.*, 2015). Hence, weed control at their

growth stage is difficult for obtaining high yields and marketable products. Only hand weeding is not sufficient to control weed. So, it is necessary to use herbicides to control weed competition in garlic. Pendimethalin (Mohite *et al*., 2015), Oxyfluorfen (Sankar *et al*., 2015), were found effective for controlling weeds. Compared to single application of herbicides, many researchers find out the combination of herbicides together or with manual hand weeding as effective in managing weeds (Mohite *et al*., 2015, Sankar *et al*., 2015). The effectiveness of herbicide is depends on its behavior under a soil type, organic matter content, weather conditions, soil moisture etc. Hence, it is essential to screen several pre and post emergence herbicides and to choose optimum doses under particular environmental conditions for effective control of weed population in garlic field. Unavailability and higher cost of labor for manual hand weeding make the method uneconomical. In addition, being a long period crop, single hand weeding is not enough to control weeds. Thus, all these conditions make it obligatory to rely on herbicides for a timely and effective control of weed in garlic. Hence weed control through use of pre and post emergence herbicides on garlic cultivation was attempted in the present investigation.

MATERIALS AND METHODS

A field experiment was conducted at Fruit Research Station Intkhedi Bhopal, RAK College of Agriculture, Sehore (M.P.) during the Rabi season, 2017-18 on medium black (Vertisol) soil. The experiment was laid out using ten different treatments in randomized block design, viz**.,** $Treatment_1$ - Control plot (without hand weeding and without use of herbicides), $Treatment_2$ – Twice hand weeding at 30 and 60 days after sowing, $Treatment_3$ - Pendimethalin 30% EC 1.5 kg a.i.ha^{-1} (pre-emergence), $Treatment_4$ - Pendimethalin 30% EC 1.5 kg a.i. ha^{-1} + one hand weeding after 30 days after sowing, $Treatment_5$ - Quizalofop ethyl 5 % EC 40 g a.i. ha^{-1} 25 days after sowing (post- emergence), $Treatment_6$ - Quizalofop ethyl 5 % EC 40 g a.i. ha^{-1} + one hand weeding after 30 days after sowing, $Treatment_7$ - Oxadiargyl 80% WP 100 g a.i. ha^{-1} (pre-emergence), $Treatment_8$ - Oxadiargyl 80% WP 100 g a.i. ha^{-1} + one hand weeding after 30 days after sowing, $Treatment_9$ - Oxyfluorfen 23.5% EC 250 g a.i. ha^{-1} (pre-emergence), Treatmen t_{10} - Oxyfluorfen 23.5% EC 250 g a.i. ha^{-1} + one hand weeding after 30 days after sowing with three replications. All other crop production practices adopted during growing season. After complete development, the different plant growth parameter at successive crop stages viz., plant height, number of leaves $plant^{-1}$, observations were recorded on five randomly selected plants from every treatment and recorded yield attributing characteristics viz., neck thickness (cm), clove diameter (cm), polar diameter(cm), equatorial diameter (cm), number of cloves $bulb^{-1}$, weight of 20 cloves (g), bulb yield (g $plant^{-1}$) and bulb Yield (q ha^{-1}) at the harvest. Finally mean data of the all characters were computed for statistical analysis as per standard procedure given by Panse and Sukhtme (1989).

RESULTS AND DISCUSSION

A. Impact of pre and post herbicides treatments on growth parameters

Plant height $plant^{-1}$: The plant height $plant^{-1}$ at 90 DAS and at harvest of the crop is presented in (Table 1 and Fig. 1). The impact of different treatments with pre and post herbicides treatments on plant height $plant^{-1}$ was found significant of the crop at 90 DAS and at harvest.

The significantly maximum plant height was recorded in treatment, T_2 – (two hand weeding 30 and 60 days after sowing) at 90 DAS (64.60) and at harvest (68.50) followed by treatments T_{10} – (Oxyfluorfen 23.5% EC 250 g a.i. /ha + one hand weeding after 30 DAS) at 90 DAS (62.25) and at harvest (66.40) and treatments T_9 - Oxyfluorfen 23.5% EC 250 g a.i./ha (PE) at 90 DAS (58.73) and at harvest (64.75).While it recorded it minimum value for control at 90 DAS and harvest (42.73, 47.23) in crop of Garlic. This increase in growth of plant height could be due to no weed competition and lower in case of treatment T_2 – two hand weeding 30 and 60 days after sowing. The improvement in the above results is due to the direct effects of these treatments led to a decrease in the number of weeds. Due to reduced competition between weeds and crops, vegetative growth of crop plants was encouraged. The similar results were also reported by Vora and Mehta (1999), Nandal *et al.,* (2001) in Garlic and Santosh *et al*., (2004) in Onion.

Number of Leaves $plant^{-1}$: The number of leaves $plant^{-1}$ at 90 DAS and at harvest of the crop is presented in (Table 1 and Fig. 2). Two hands weeding at 30 and 60 days after sowing was found maximum numbers of leaves $plant^{-1}$ at 90 days after sowing and at harvest stages (10.87, 12.67) and was found significantly superior over the remaining treatments investigated by T_{10}– (Oxyfluorfen 23.5% EC 250 g a.i. /ha + one hand weeding after 30 DAS) at 90 DAS and at harvest (10.03, 11.83) and treatmentsT_9 - Oxyfluorfen 23.5% EC 250 g a.i. /ha (PE) at 90 DAS and at harvest (9.77, 11.37). However, minimum number of leaves $plant^{-1}$ was recorded in control (7.80, 7.80). This increase in number of leaves $plant^{-1}$ could be due to no weed competition and created suitable environments for growth and development of crop. The present results are in conformity with those of Santosh *et al*., (2004) in Onion and Naresh and Mourya (2006) in Garlic.

Table 1: Impact of pre and post herbicides treatments on growth parameters of Garlic at successive crop stages of garlic (*Allium sativum* L.).

Treatments	Plant height plant^{-1} (cm)		No. of leaves plant^{-1}	
	At 90 DAS	At harvest	At 90 DAS	At harvest
T_1	42.73	47.23	7.80	7.80
T_2	64.60	68.50	10.87	12.67
T_3	52.60	62.25	8.33	9.57
T_4	53.75	63.85	9.20	10.13
T_5	50.95	60.55	8.00	9.30
T_6	52.27	62.45	8.27	9.93
T_7	56.53	63.60	9.33	10.62
T_8	58.47	64.10	9.40	11.35
T_9	58.73	64.75	9.77	11.37
T_{10}	62.25	66.40	10.03	11.83
SEm±	**1.1**	**1.4**	**0.05**	**0.03**
CD 5%	**3.24**	**3.54**	**0.70**	**0.56**

T_1– Control plot (without hand weeding and without use of herbicides); **T_2** – Two hand weeding at 30 and 60 days after sowing; **T_3** – Pendimethalin 30% EC 1.5 kg a.i. /ha (PE); **T_4**– Pendimethalin 30% EC 1.5 kg a.i. /ha + one hand weeding after 30 DAS; **T_5**– Quizalofop ethyl 5 % EC 40 g a.i. /ha 25 DAS (PoE); **T_6**– Quizalofop ethyl 5 % EC 40 g a.i. /ha + one hand weeding after 30 DAS; **T_7**– Oxadiargyl 80% WP 100 g a.i. /ha (PE); **T_8**– Oxadiargyl 80% WP 100 g a.i. /ha + one hand weeding after 30 DAS; **T_9**– Oxyfluorfen 23.5% EC 250 g a.i. /ha (PE); **T_{10}**– Oxyfluorfen 23.5% EC 250 g a.i. /ha + one hand weeding after 30 DAS.

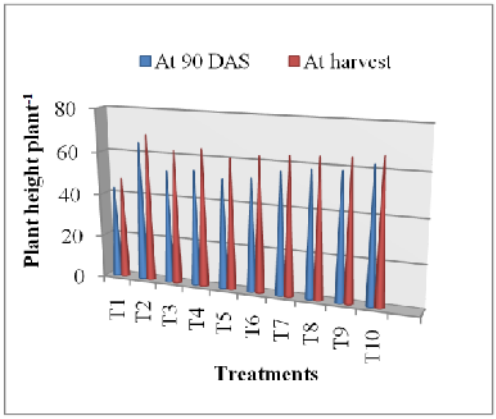

Fig. 1. Impact of pre & post herbicides treatments on plant height plant^{-1} (cm).

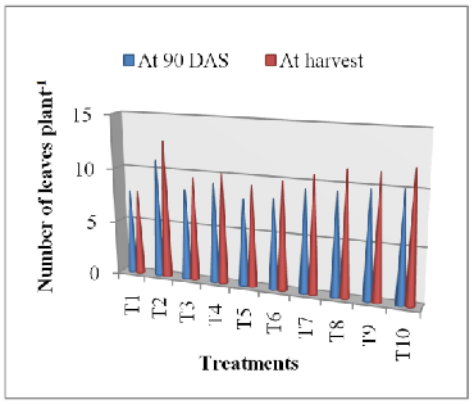

Fig. 2. Impact of pre & post herbicides treatments on number of leaves plant^{-1}.

B. Impact of pre and post herbicides treatments on bulb yield parameters of Garlic

Neck thickness and Clove Diameter of garlic bulb (cm): The neck thickness and clove diameter of garlic bulb (cm) at harvest is presented in (Table 2 and Fig. 3). Result revealed that selected pre and post emergence herbicides with one hand weeding treatments had significant effect on neck thickness (cm) and clove diameter (cm). The maximum neck thickness and clove diameter (cm) (0.90, 0.97 cm) was recorded with the treatment of two hands weeding at 30 and 60 DAS and it was followed by Oxyfluorfen 23.5% EC 250 g a.i.

ha^{-1} + one hand weeding after 30 DAS applied as pre emergence (0.82, 0.93 cm) thereafter results were received from treatment Oxadiargyl 80% WP 100 g a.i. /ha + one hand weeding after 30 DAS (0.78, 0.89 cm). While the minimum neck thickness and clove diameter (0.41, 0.70 cm) was recorded under control plot. Similar results were reported by Ushakumari *et al.*, (2001) in Onion and Chopra *et al*. (2007) in Garlic (*Allium sativum* L.).

Table 2: Impact of pre and post herbicides treatments on yield parameters of Garlic (*Allium sativum* L.)

Treatments	Neck thickness (cm)	Clove diameter (cm)	Polar diameter (cm)	Equatorial diameter (cm)	No. of cloves $bulb^{-1}$	Weight of 20 cloves (g)	Bulb yield (g $plant^{-1}$)	Bulb yield (q ha^{-1})
T_1	0.41	0.70	2.25	2.64	13.35	18.25	28.10	25.62
T_2	0.90	0.97	3.39	4.30	39.45	35.50	45.78	86.45
T_3	0.68	0.71	2.53	3.25	24.25	24.30	33.20	40.62
T_4	0.70	0.76	2.61	3.32	26.45	26.45	35.55	53.54
T_5	0.61	0.64	2.48	3.10	23.75	23.60	30.25	31.25
T_6	0.65	0.69	2.57	3.21	25.10	25.54	35.40	46.87
T_7	0.71	0.83	2.87	3.94	26.97	26.54	31.78	53.12
T_8	0.78	0.89	3.16	4.10	32.35	31.10	39.51	73.95
T_9	0.76	0.87	3.05	4.05	29.54	29.15	36.70	68.75
T_{10}	0.82	0.93	3.25	4.14	36.20	33.65	45.40	84.33
SEm±	**0.002**	**0.001**	**0.011**	**0.018**	**0.51**	**3.28**	**2.70**	**2.72**
CD 5%	**0.14**	**0.12**	**0.32**	**0.40**	**2.13**	**5.38**	**6.14**	**4.90**

Polar diameter and equatorial diameter (cm): The Polar diameter and equatorial diameter (cm) at harvest of the crop is presented in (Table 2 and Fig. 3). The impact of pre and post herbicides was found significant for polar diameter and equatorial diameter (cm). The maximum polar diameter and equatorial diameter (cm) (3.39, 4.30 cm) was observed under the treatment two hand weeding at 30 and 60 days after sowing and it was at par with (3.25, 4.15 cm) polar diameter and equatorial diameter of bulb with treatment Oxyfluorfen 23.5% EC 250 g a.i. ha^{-1} + one hand weeding after 30 days after sowing followed by the Oxadiargyl 80% WP 100 g a.i. /ha + one hand weeding after 30 DAS (3.16, 4.10 cm) While, the minimum polar diameter and equatorial diameter (cm) of bulb i.e. (2.25, 2.64 cm) was recorded under the control plot treatment. The finding obtained in the experiment match the results by Adekpe *et al*., (2007)

Number of cloves $bulb^{-1}$: The number of cloves $bulb^{-1}$ at harvest is presented in (Table 2 and Fig. 4). All treatments resulted significant effect on number of cloves $bulb^{-1}$. The maximum number of cloves (39.45) was recorded under the treatment two hand weeding at 30 and 60 DAS and it was at par with the treatment Oxyfluorfen 23.5% EC 250 g a.i. ha^{-1} + one hand weeding after 30 DAS. (36.20) followed by the Oxadiargyl 80% WP 100 g a.i. /ha + one hand weeding after 30 DAS (32.35 cm). While minimum number of cloves $bulb^{-1}$ (13.35) was found under treatment of Control plot. Similar results were reported by Ahmad and Kandeel (1991) and Nandal *et al*., (2002) in Onion.

Weight of 20 cloves (g) - The weight of 20 cloves (g) at harvest is presented in (Table 2 and Fig. 4). All treatments were significantly affected on weight of 20 cloves (g) of garlic. The maximum weight of 20 cloves was recorded under the treatment of two hand weeding at 30 and 60 DAS (35.50 g) thereafter results were received from (33.65 g) treatment Oxyfluorfen 23.5% EC 250 g a.i. ha^{-1} + one hand weeding after 30 days after sowing. However the minimum weight of 20 cloves (18.25 g) was recorded with the control plot treatment. Similar finding have been reported by Patil, *et al.*, (2016) in Garlic.

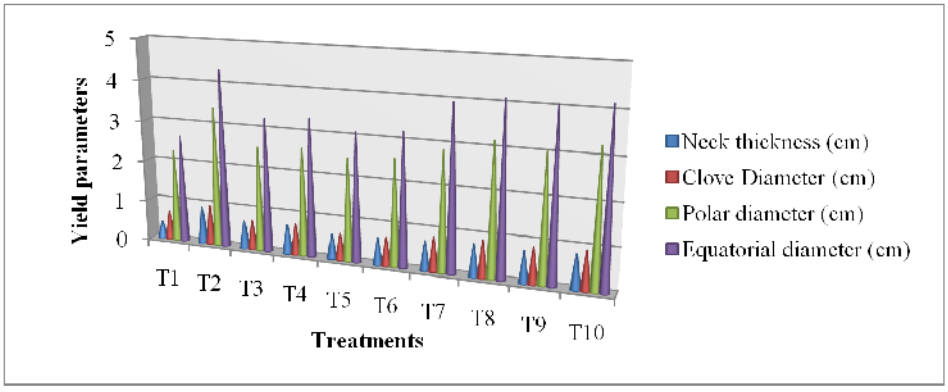

Fig. 3. Impact of pre and post herbicides treatments on yield parameters

Bulb yield (g plant^{-1}) and Bulb Yield (q ha^{-1}): The bulb yield (g plant^{-1}) and bulb yield (q ha^{-1}) at harvest of the crop is presented in (Table 2 and Fig. 4). Harvested bulb yield (g plant^{-1}) and bulb yield (q ha^{-1}) of garlic was significantly affected by treatments. The treatment two hand weeding at 30 and 60 DAS found maximum bulb yield (g plant^{-1}) and bulb yield (q ha^{-1}) (45.78, 86.45) and thereafter it were received from Oxyfluorfen 23.5% EC 250 g a.i. ha^{-1} + one hand weeding after 30 days after sowing (45.40, 84.33). The lowest bulb yield (g plant^{-1}) and bulb yield (q ha^{-1}) (28.10, 25.62) was found in control plot treatment. Similar finding have been reported by Sandhu *et al.* (1997), Warade *et al.* (2007), Rahman *et al.*, (2011); Mallik *et al.*, (2016) in Garlic (*Allium sativum* L.) .

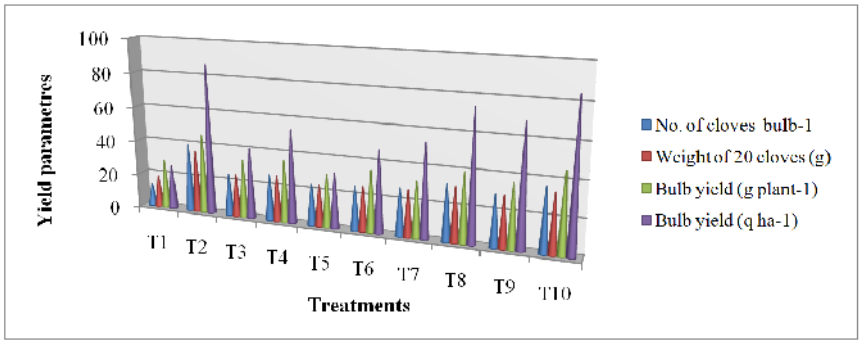

Fig. 4. Impact of pre and post herbicides treatments on yield parameters.

(a) Spray of pre emergence herbicides.

(b) Plant growth.

(c) Bulb yield.

Plate 1.

CONCLUSION

As a result, in this study it has been found that to achieve good bulb yield and yield quality, it is best to apply two hand weeding 30 and 60 DAS and in addition to treatment oxyfluorfen 23.5% EC 250 g a.i. hectare^{-1} (pre-emergence) + one hand weeding after 30 DAS and Oxadiargyl 80% WP 100 g a.i. hectare^{-1} (pre-emergence) + one hand weeding after 30 DAS can also achieve good bulb yield and yield quality as compared to other treatments. Intercultural activities in the soil make the soil brittle, allowing sufficient moisture and air to flow through it to aid plant growth. The crop also benefited from two hand weeding done at 30 and 60 days after sowing in the experiment. Therefore higher bulb yield and lesser weed infestation as well as maximum gross and net return were recorded by cultural practices and pre-emergence herbicides treatments. Thus appropriate choice for weed control in garlic would be an integration of cultural and herbicidal control combination for boosting the Garlic production.

FUTURE SCOPE

Garlic is the most important bulb crop for its nutritive value as a spice crop of India grown in *Rabi* season. It has been recognized all over the world as valuable spices for seasoning and flavouring food and a popular remedy by various aliments and physiological

disorders. Carbohydrates, proteins, phosphorus, ascorbic acid and sulphur are the principle ingredients of garlic. The weeds compete for the nutrients, moisture, space and light and affect growth and development. Weed reduces the bulb yield to the extent of 40-80% therefore, it is essential to keep the field weed free during the critical period of crop growth. As garlic is commercial crop, farmers invest more money through costly inputs like seed material, fertilizers, plant protection schedule and irrigation for achieving higher yield. But over reliance on herbicide use sometimes may cause residual toxicity to succeeding crops and ground water contamination. Massive pollution pressures on the environment from different sources including herbicide use necessitate sustained efforts of exploring non-chemical weed control. In order to minimize their ill effects, several crop husbandry techniques like stale seed bed technique, tillage practices (conservational/conventional), soil solarization (mulching) planting techniques (raised furrows) could be combined in an integrated way to make weed control strategy effective and economical.

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Conflict of Interest. The author declares that there is no conflict of interests concerning the publication of this paper.

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