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Efficacy of Herbicides for Weed Control in Garlic (*Allium sativum, L.*)

Nasir Ali[1], Muhammad Ashiq[2] , Hafeez Ameer[1]

[1]Department of Agronomy, Ghazi University, D.G. Khan, Pakistan
[2]Agronomic Research Institute, Faisalabad, Pakistan.

Edited by:
Nazim Hussain,
B.Z. University, Multan, Pakistan

Reviewed by:
Fahd Rasul,
University of Agriculture, Faisalabad, Pakistan
Muhammad Dawood,
Bahauddin Zakariya University, Multan, Pakistan

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Abstract: The study was conducted in 2016-17 at the Research Area of Plant Physiology Section, Directorate of Agronomy, Ayub Agricultural Research Institute Faisalabad to investigate the effects of several pre and post- emergent herbicides against hand weeding and control. Data were collected on the parameters like weed counts, stem girth, fresh biomass, dry biomass and bulb yield of garlic. The experiment was laid out in RCBD design with 3 replications with a net plot size of 2.8m×1.8m. Herbicidal treatments comprised Stomp 455 G/L CS @ 2000 ml , Dual Gold 960 EC 2000 ml, Hadaf 24EC @ 750 ml, Oxygen 24EC @ 750 ml, Calm 15EC @ 625ml, Hadaf 750 ml + Calm 625 ml ha^{-1} were tested against hand weeding (thrice) and a control treatment. Pre- emergence herbicides were applied 1 day after and post-emergence 35 days after planting. Dual Gold as pre-emergence and Hadaf + Calm as post-emergence were found as the best herbicides which gave 92.98 % and 90.83 % weed control respectively. Application of Stomp gave the highest stem girth of 2.1cm and yield of 19.773 ton/ha, while dual gold affected plant growth and gave stem girth of 1.53 cm and bulb yield of 16.867 ton/ha.

Keywords: Pre-emergence, Post-emergence, Herbicide resistance, Stomp, Dual Gold, Hadaf, Oxyegen, Hand weeding.

Corresponding author: Nasir Ali, E-mail: nasirali3938@gmail.com

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1 Introduction

Humanity is based on a numerous range of cultivated plant species; at the least 6000 species are used for different purposes. It's usually expressed that solely a couple of staple crops manufacture the bulk of food provide. This can be correct however the vital contribution of the many minor species shouldn't be underestimated (Hammer, 1993).

Garlic (*Allium sativum, Linn*.) belongs to the family Alliaceae is a perennial herb and in the world it is largely used as a spice or for seasoning in different dishes. It is cultivated all over the Pakistan and eaten up by most of the people due to its mordacious, piquant aroma that delicate and mulls greatly with cooking. Research shows that garlic could facilitate guard against heart diseases and cancer. Additionally, garlic reduces cholesteric and vital sign levels because of the presence of bound antioxidants. If the Islamic Republic of Pakistan will boost the cultivation of garlic, the country can even export it with different condiments and spices (Ahmad, 2010).

According to the United Nation's Food and Agricultural Organization (FAO) estimates world production of garlic is around 22.23 million tonnes (MMT). Asia is the largest garlic producing continent within the world and it contributes quite eightieth to the whole world garlic production. China is that the leading garlic producing country in 2010, that made 18.56 MMT of garlic accounting for over 77 of world output followed by India, Asian country, Egypt, Russia, Myanmar, Ethiopia, USA, Asian nation and land severally (FAO, 2010). According to commodity wise imports garlic is the nineteenth most critical import commodity of Pakistan after palm oil, rapeseed, sugar refined, cotton lint, cake of soybeans, chick peas, sunflower seed, dry onion, dry peas, jute, tea, wheat, arecanuts, flour of wheat, tomatoes, residuals of fatty subs, lentils and fatty acids (FAO, 2010). Pakistan ranked among the top 10 garlic importing countries of the world from 2001-2010 except for year 2001 and 2002 wherein Pakistan ranked as 13th and 14th biggest importer of garlic. From the 2001-2010 Islamic Republic of Pakistan hierarchical solely double among the highest 20 garlic

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commercialism countries of the world in the year 2003 and 2008. Within the year 2003 and 2008 Islamic Republic of Pakistan was web businessperson as well as web bourgeois of garlic (FAO, 2010).

Garlic crop is closely planted crop with terribly less cover and hand weeding thus, is a very important cultural observe for higher marketable bulb production. Manual weeding is tedious, high-priced and infrequently damages the crop (Mahmood, 2001). Application of weedicides is another method of weed control. Qasem (1996) claimed that post-emergence application of oxyfluorfen and oxadiazon at 3-4 leave stage gave higher crop yield as compared to weed-free crop. Madan et al. (1994) determined, a hundred weed management in hand weeding, 86.9 to 87.7% with weed killer + hand weeding and 66.7 to 88.2% weed management with weed killer alone. Field studies conducted in India during the rabi season regarding effect of herbicides (oxyfluorfen, oxadiazon) on growth, yield and yield attributes of garlic resulted in lowest weed population in weed-free control followed by oxyfluorfen + one hand hoeing and oxadiazon and fluchloralin application (Vora and Mehta, 1999). Vora and Mehta (1998) observed highest bulb yield of garlic in weed-free control while herbicide application alone did not control weeds effectively. Different reports have indicated the importance of many herbicides for effective and selective weed control in garlic including, linuron in pre-emergence or post-planting treatment (Oliver and Wilson, 1981; Rahman et al., 1985); methabenzthiazuron or its combination with bentazone or propyzamide as pre- emergence application (Trunkenboltz and Prin, 1977; Malavia et al,, 1985), trifluralin as pre-plant soil incorporated (Trunkenboltz and Prin, 1977); oxadiazon as pre- or post-emergence (Rahman et al., 1985); post-planting application of pendimethalin (Kulik and Goncharov, 1990;) and oxyfluorfen in pre- or post- emergence and post-planting treatments (Malavia et al., 1985).

Supply of this crop is still below the actual needs of the people due to its high demand and low production. To control the weeds is always a challenge which restricted the area under the cultivation of this crop. In most parts of the Asia, chemical weed management in garlic has received little attention and weeds are principally managed manually, which is pricey. Typically because of shortage of labour and unexpected rains, hand weeding or mechanical weed operations square measure delayed or left altogether. In such situations, herbicides provide the foremost sensible, effective, and economical method of weed management for increasing crop yield. It was speculated that screening of different herbicides against the hand weeding would provide evidence for the better control of weeds and achieve higher yields with maximum profit levels.

2. Materials and Methods

The experiment was carried out to study the comparative efficiency of different herbicides to control weeds in winter planted garlic *(Allium sativum, Linn.)* at Agronomic Research Institute, Faisalabad. The experiment was laid out in a randomized complete block design (RCBD) with 3 replications having a net plot size of 2.8 m × 1.8 m. The row to row and plant to plant distance was 20 cm and 10 cm respectively. The garlic cultivar (Gulabi Lehsan) was planted manually on October 6, 2016. Recommended seed of garlic was used @ 750 kg ha^{-1}.

Whole of the Phosphorus, potash and half of the nitrogen was broadcasted and incorporated into the soil at the time of seedbed preparation while remaining half of the nitrogen was top dressed at six leaf stage of the crop. All the per-emergence herbicides were applied after one and post emergence after 35 days of planting by “Knapsack” hand sprayer using “t-jet” and “hollow-con” nozzles respectively. Volume of spray was determined, using the standard calibration method. Hoeing was done once with the assistance of hand hoe in every treatment after seventy days whereas in hand weeding hoeing was done thrice after thirty five, seventy and one zero five days after planting when the soil was at field capacity after the irrigation. All the other agronomical practices were remained constant and uniform for all treatments, except those below study.

During the study eight treatments were assessed, three pre-emergence herbicides i.e. Stomp (Pendi) 455 G/L CS @ 2000 ml ha^{-1}, Dual Gold (S- metola) 960 EC @ 2000 ml ha^{-1}, Hadaf (Oxyfluorfen) 24EC @ 750ml ha^{-1} and three post-emergence herbicides i.e. Oxygen (Oxyfluor) 24EC @ 750 ml ha^{-1}, Calm (Quiza lofop) 15EC @ 625ml ha^{-1}, Hadaf (Oxyfluorfen) 750 ml + Calm (Quiza lofop) 625 ml ha^{-1} were used. Hand weeding (thrice) and control (untreated) were also included for comparison.

The data collected on weed and crop parameters were analysed statistically by using, STATISTIX 8.1 software. LSD test was applied at 5% probability level to compare treatment means.

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Table 1 Major weeds found in garlic crop.

Local Name	Botanical Name
Batho	*Chenopodium album*
Deela/Mork	*Cyperus rotundus*
It sit	*Trianthema portulacastrum*
Lehli	*Convolvulus arvensis*
Madhana	*Dactyloctenum aegyptium*
Swanki	*Echinochloa colona*

3. Results and Discussion

Major weeds found in garlic crops are listed in Table 1. Results discovered that weed population (30 DAS) was considerably significant among all the weed management treatments (Table 2). Maximum weed management proportion (over control) among pre-emergence herbicides was recorded 92.98% wherever Dual Gold (S-metolachlor) 960 EC @ 2000 ml ha^{-1} was applied. The lower weed density because of herbicides application over weedy check may need been because of the mortality of weeds in these treatments. Dual Gold has been reported as effective chemical in garlic *crop* (Habib et al, 2012). Among the post-emergence treatments, Hadaf (Oxyfluorfen) 750 ml + Calm (Quiza lofop) 625 ml ha^{-1} gave maximum weed control 54.97% (over control). A high weed control % was conjointly recorded within the manual hand weeding treatment as a result of uprooting and mechanical injury to the weeds by hand and hand hoe severally. The variation within the weed counts and weed control % among completely different weed management strategies may well be thanks to the variation within the mode of action of the herbicides to manage the weeds considerably. These results match with the results obtained by Johnson et al. (1997) and Varga et al. (2000), who represented that the variation within the weed management potency is because of herbicidal distinction scientifically.

3.1 Stem Girth (cm)

Stem girth at hundred and twenty days once the planting of garlic differed considerably between the treatments (Table 2). Application of Stomp (Pendimethaline) 455 G/L CS @ 2000 ml ha^{-1} and Hadaf (Oxyfluorfen) 24EC @ 750ml ha^{-1} recorded the most stem girth of 2.00 cm equally among the pre-emergence herbicidal treatments. Stomp 455 g/l CS @ 2000ml ha^{-1} was found safer on the germination and growth of garlic. That is why stem girth was also more in case of this safe herbicide. Whereas minimum stem girth of 1.53 cm was determined within the treatment wherever Dual Gold (S- metolachlor) 960 EC @ 2000 ml ha^{-1} was applied as a result of it's extremely phytotoxin and affected the garlic growth and development. Most stem girth of 2.10 cm was recorded within the hand weeding treatment producing less weed population that ultimately increase the expansion and development of the garlic by the availability of needed resources in needed proportion, whereas within the untreated (control) treatment minimum stem girth of 1.26 cm could be because of the severe weed infestation.

3.2 Fresh Biomass (kg $plot^{-1}$)

The highest value (Table 2) of the fresh biomass 20.66 kg $plot^{-1}$ of garlic was obtained from wherever Stomp (Pendimethaline) 455 G/L CS @ 2000 ml ha^{-1} was applied followed by hand weeding and Calm (Quiza lofop) 15EC @ 625ml ha^{-1} by recording 20.83 and 20.50 kg $plot^{-1}$ respectively. Among the pre-emergent herbicidal treatments Dual Gold (S-metolachlor) 960 EC @ 2000 ml ha^{-1} gave the minimum fresh biomass of 1.53 kg $plot^{-1}$ followed by the untreated (control) with 1.26 kg $plot^{-1}$, as like the results that were obtained by Lina et al. (2011) *and* Ankur et al., (2002).

Table 2. Effects of different weed management treatments on weed count, stem girth and other yield contributing parameters of garlic.

Treatment	Weed counts (m^{-2})	Weed control %	Stem Girth (cm)	Fresh Biomass (kg $plot^{-1}$)	Dry Biomass (kg $plot^{-1}$)	Bulb Yield (kg $plot^{-1}$)	Bulb Yield (t h^{-1})
Stomp	147.33ab	13.84	2.00ab	20.66a	13.33a	9.96a	19.77
Dual Gold	12.00d	92.98	1.53cd	17.66c	11.83e	8.50d	16.86
Hadaf	123.67b	27.67	2.00ab	20.00a	13.16ab	9.33bc	18.52
Oxygen	124.33b	27.29	1.86ab	18.66b	12.66bc	9.16bc	18.19
Calm	145.00ab	15.20	1.93ab	20.50a	12.50cd	9.00c	17.86
Hadaf+Calm	77.00c	54.97	1.76bc	20.00a	12.00de	9.00c	17.86
Hand Weeding	15.67d	90.83	2.10a	20.83a	13.50a	9.50b	18.85
Control	171.00a	-	1.26d	6.00d	2.73f	1.93e	3.83

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3.3 Dry Biomass (kg plot^{-1})

Subsequent to drying the garlic for 15 days after the collecting, dry biomass was recorded. The outcomes demonstrate critical distinction of dry biomass among the weed control treatments (Table 2). Most noteworthy biomass production of 13.33 kg plot^{-1} was noted among the herbicidal treatment where Stomp (Pendimethaline) 455 G/L CS @ 2000 ml ha^{-1} was applied. While most reduced dry biomass production of 11.83 kg plot^{-1} was noted in the treatment where use of Dual Gold (S-metolachlor) 960 EC @ 2000 ml ha^{-1} was done trailed by control (untreated) treatment having the quantity of 6.00 kg plot^{-1} dry biomass.

3.4 Bulb Yield (kg plot^{-1})

Results indicated an extensive difference of bulb yield plot^{-1} a few of the carried out treatments (Table 2). The maximum bulb yield of 9.96 kg plot^{-1} was executed from in which the application of Stomp (Pendimethaline) 455 G/L CS @ 2000 ml ha^{-1} become achieved, No doubt total number of weeds/m^2 is more in this treatment but higher number was due to *Cyperus rotundus* which is not as hazardous as those of monocot and dicot weeds that's why yield was not affected, followed hand weeding having the bulb yield of 9.50 kg plot^{-1}. The minimum bulb yield of 6.00 kg plot^{-1} turned into recorded from the control (untreated) treatment, while among herbicidal application remedies Dual Gold (S-Metolachlor) 960 EC @ 2000 ml ha^{-1} gave the low bulb yield of 11.83 kg plot^{-1}.

3.5 Bulb Yield (tons ha^{-1})

Analysis of variance (Table 2) indicated that bulb yield (tons ha^{-1}) become substantially (5% probability level) stricken by special weed management treatments. The results displayed that the very best yield of 19.77 and 18.85 tons ha^{-1} turned into recorded in treatments, in which utility of Stomp (Pendimethaline) 455 G/L CS @ 2000 ml ha^{-1} and hand weeding changed into completed respectively. In the control (untreated) treatment had been weeds have been allowed to grow freely, which affected the garlic growth and development ensuing decreased bulb yield of 3.83 tons ha^{-1}. Whilst the various herbicidal remedies Dual Gold (S- Metolachlor) 960 EC @ 2000 ml ha^{-1} recorded the minimal bulb yield of 16.86 tons ha^{-1}, at the same time application of Hadaf (Oxyfluorfen) 24EC @ 750ml ha^{-1} pre-emergence and Oxygen (Oxyfluor) 24EC @ 750 ml ha^{-1} post-emergence additionally gave satisfactory outcomes by means of recording the bulb yield of 18.52 and 18.19 tons ha^{-1} respectively. Similar results approximately the findings of Stomp (Pendimethaline) have been also proven with the aid of Jilani et al. (2003), Ghaffoor (2004) and Manisha et al (2005). They confirmed that the very best bulb yield changed into received from wherein Stomp (Pendimethaline) as sprayed.

3.6 Economics of weed management strategies

The determination of the economics for weed management in garlic was calculated from the method that was adopted by Hassanein et al. (2012). Farmers undertake most effective those progressed practices, which can be greater profitable. On the basis of modern-day market charges in herbicide products and the wholesale expenses of garlic, the control (untreated) treatment was of 192,500 PKR which was considered as the fixed cost (seedbed preparation, seed, sowing, fertilizer, irrigation, insect control, disease control, harvesting and transportation).

Table 3. Economics of different weed management strategies in garlic

Treatments	Total Variable Cost (PKR)	Total Cost (PKR)	Gross Income (PKR)	Net Income (PKR)	Benefit/ Cost
Stomp 455 G/L CS @ 2000 ml/ha + 1HW	6400	198900	1581840	1382940	7.95
Dual Gold 960 EC 2000 ml/ha + 1HW	6000	198500	1349360	1150860	6.80
Hadaf 24EC @ 750ml/ha + 1HW	5750	198250	1481600	1283350	7.47
Oxygen 24EC @ 750 ml/ha + 1HW	5750	198250	1455200	1256950	7.34
Calm 15EC @ 625ml/ha + 1HW	5875	198375	1428800	1230425	7.20
Hadaf 750 ml + Calm 625 ml/ha +1HW	7625	200125	1428800	1228675	7.14
Hand Weeding (thrice)	12000	204500	1508000	1303500	7.37
Control		192500	306960	114460	1.60

HW: hand weeding; PKR Pakistani Rupee (1USD= 104 PKR).

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Whereas cost of the different treatments were considered as total variable cost as shown by the data in (Table 3). Application of Stomp 455 G/L CS @ 2000 ml/ha + 1HW gave the highest values of gross income PKR 1581840, Net income PKR 1382940 and benefit/cost ratio of 7.95, followed by the application of Hadaf 24EC @ 750ml/ha + 1HW which gave gross income PKR 1481600, net income PKR 1283350 and benefit/cost ratio of 7.47 due to maximum yield production of garlic and significant weed control The lowest gross income 306960, net income 114460 and benefit/cost ratio of 1.60 was recorded in control (untreated) treatment due to large infestation of weeds which reduced the garlic yield to its minimum level.

4. Conclusion

Based on results described in this study it is concluded that one-of-a-kind herbicides that had been used to manipulate the weeds in garlic appreciably reduced the weed population, extended stem girth and garlic bulb yield. From the results based on weed control, stem girth, dry biomass, bulb yield and economics, the application of Stomp 455 G/L CS @ 2000 ml/ha + 1HW and of Hadaf 24EC @ 750ml/ha + 1HW were the best treatments and are also safe to use as they have no phytotoxic effects. So to control the weeds, for getting high bulb yield and high net income it is recommended to use Stomp 455 G/L CS @ 2000 ml/ha or Hadaf 24EC @ 750ml/ha as pre-emergence herbicide followed by a hand weeding after 70 days of planting in the irrigated areas of Punjab, Pakistan.

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