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Weed management in Allium: A review

BT Patil, CB Bachkar and BB Handal

Abstract
Among the spice crop onion and garlic are most important and widely cultivated crop in India. Allium crops are highly vulnerable to weed infestation due to its slow emergence and slow initial growth, non-branching habit, sparse foliage, shallow root system. Weeds compete for nutrients, soil, moisture, space and light considerably reducing the yield, quality and value through increased production and harvesting costs. Weed infestation in onion and garlic is one of the major factors for loss in yield and bulb loss to the tune of 30-60 per cent. Manual hand weeding is a very tedious and labour expensive method of weed control. Sometimes due to shortage of labour and unexpected rains, hand weeding or mechanical weed operations are delayed or left altogether. The chemical weed control in onion and garlic has received little attention and weeds are mostly managed manually. In such situation, herbicides offer the most practical, more effective and economical method of weed control for increasing bulb yield of allium crops. The herbicide like Oyxfluorfen +Quizalofop ethyl, Pendimethalin, alone or combination are effective for controlling weed flora in Allium crops.

Keywords: Allium, weed, Herbicide, weed control, yield, weed intensity

Introduction
Among various spices grown Allium crops (Onion and Garlic), are the second most widely cultivated crop in the family Alliaceae and is a diploid species (2n = 2x = 16). It is considered as a valuable nutritive, medicinal and condimental crop produce used throughout the world. There is a great demand for its powder as a condiment by the food processing industries. It is also a good foreign exchange earner crop of India as large quantity of garlic is exported every year. It's cultivated commercially throughout tropical and sub-tropical belt of the world. It is an important cash crop of Himachal Pradesh. India is the second largest producer in world next to China. Madhya Pradesh is front runner in its production followed by Gujarat. India ranks second in the world in the total area and production under onion and garlic. In India area under these crops is more than 15.0lakh ha and production is 22835 thousand MT/ha.(Anon., 2017) [2]. The main onion and garlic growing states are Madhya Pradesh, Gujarat, Orissa, Maharashtra, Uttar Pradesh, Bihar, Rajasthan and Andhra Pradesh. In Maharashtra the major onion and garlic growing districts are Nasik, Jalgaon, Ahmednagar, Pune, Solapur, Satara and Sangli. Allium crops are highly vulnerable to weed infestation due to its slow emergence and slow initial growth, non-branching habit, sparse foliage, shallow root system (Rahman *et al.*,2012, Lawande *et al.*, 2009) [26, 13], frequent irrigation and high fertilizer application. Weeds compete for nutrients, soil, moisture, space and light considerably reducing the yield, quality and value through increased production and harvesting costs (Hussain 1983) [8]. Allium are closely planted crop with very small canopy. Due to smaller leaf size it cannot compete with the weeds. Their competition with the plants starts at very early growth stage. The weed emergence occurs that competes with the tender seedlings. Weeds also harbor insect pests and disease-causing organisms. The losses caused by weeds have been estimated to be much higher than those caused by insect pest and diseases.

Weed infestation in onion and garlic is one of the major factors for loss in yield and bulb loss to the tune of 30-60 per cent (Lawande *et al.*, 2009) [13]. Weed reduces the bulb yield to the extent of 40 to 80 per cent (Verma and Singh, 1996) [48]. In onion and garlic shallow root system make mechanical method of weed control difficult and sometimes causes damage to developing bulbs (Lawande *et al.*, 2009) [13]. The predominant weed flora that hampers the growth and yield of crop vary with soil type, moisture, and other climatic factors.

The weeds compete for moisture, space, nutrients and light which affects growth and development of crop. Therefore, it is essential to keep field weed free during critical period of crop growth. However, manual hand weeding is a very tedious and labour expensive method of weed control. Sometimes due to shortage of labour and unexpected rains, hand weeding or mechanical weed operations are delayed or left altogether. The chemical weed control in onion and garlic has received little attention and weeds are mostly managed manually. In such situation, herbicides offer the most practical, more effective and economical method of weed control for increasing bulb yield of allium crops. In this paper, the published information on weed management in Allium crops (onion and garlic); related more to the present investigation, is reviewed. The information has been broadly categorised under the following headings.

1. Weeds associated with Allium crops
2. Crop-weed competition
3. Losses caused by weeds
4. Effect of herbicides on crop growth and development
5. Effect on yield and weed control
6. Economics of weed control

1 Weeds associated with Allium crops

The type and intensity of weeds observed in garlic vary from region to region and season to season. Different weed species can be observed in a locality even in the same season. In addition to the type and intensity of weeds, the time of occurrence of weeds is also most important.

The important weed species observed in the Allium grown field were; *Cyandon dactylon* L., *Erigeron mucronatus* L.(among monocots) and *Parthenium hysterophrous* L., *Protulaca oleracela* L., *Digera arvensis* L., *Amaranthus viridis* L., *Argemone mexicana* L., *Amarnthus polygamous* L., *Euphorbia hirta* L.(among dicots) and *Cyperus rotundus* L.(among sedges).

Sandhu and Randhawa (1978) [31] observed that weeds *viz*., *Chenopodium album* L., *Cyperus rotundus* L., *Asphodeus fistulosis* L., *Medicago denticulate* L., *Trigonella polycerata* L. and only limited number of Medicago denticulate L., *Trigonella polycerata* L., *Cyperus rotundus* L. appeared later in onion crop. Patel *et al*. (1983) [19] and Singh and Singh (1993) [36] reported that predominant weeds observed in onion crop were *Panicum colonum* L., *Brachiaria eruciformis* L., *Echinochola colonum* L., *Cyperus rotundus* L. (among monocot), *Portulaca oleracea* L., Trianthema portulacastrum L., *Eclipta alba* Hassk., *Physalis minima* L. and *Amaranthus viridis* L. (among dicots). Kumar *et al*. (1992) [12] studied the effect of different weed control treatments in kharif onion and observed weed species like Trainthema portulacastrum L., *Convovulus arvensis* L., *Chenopodium murale* L. among the dicot and *Echinochloa crusgalli* L. and other grass in monocots. Challa (1997) [5] reported the infestation of weed flora *viz*., *Cyperus rotundus* L., *Chenopodium album* L., *Chenopodium murale* L., *Digera arvensis* L., *Cynodon dactylon* L., *Anagallis arvensis* L. in the experimental plot of onion at Gurgaon (Haryana) during rabi season.

Mehmood *et al*. (2007) [17] reported that the most dominant weed species were *Phalaris minor* L., *Cronopus didymus* L., *Medicago denticulate* L., and *Rumex dentatus* L. observed in garlic crop.

2 Crop-weed competition

Bhan *et al*. (1976) [4] reported that onion crop face weed competition during the early stages of crop growth and maintaining fields weed free for initial 45 days is sufficient to avoid the losses in yields. Further increase in the period of weed free maintenance did increase the bulb yield. Bhalla (1978) [3] reviewed weed competition, crop losses and chemical weed control in onion and reported that if crop is kept weed free for the first 6-8 weeks, weeds do not affect yield. Singh *et al*. (1986) [37] reported that early period of 40 days after transplanting in onion was found to be the most critical period for weed competition. Chopra and Chopra (2006) [6] revealed that the higher bulb yield was obtained when crop was free for initial 60 DAT and Critical period of crop weed competition was found to be 20-60 DAT. Tewari *et al*. (2003) [44] reported that in onion weed competition throughout crop period, on an average, causes 82 per cent reduction in bulb yield. Weed infestation prevailed up to 15, 30, 45 and 60 days after transplanting registering 1.2, 39.8, 56.1 and 69.3 per cent reduction in bulb yield over weed free-check. However there was no significant difference in bulb yield due to weedy situation upto 60 days and weedy condition throughout crop period. Challa (1997) [5] observed that the critical weed free period of 60 days is essential to get economically sound yields in onion

3. Losses caused by weeds

Bhalla (1978) [3] reported that the loss of onion yield is mainly the result of decrease in bulb size owing to the weed competition. The yield reduced by 48-85 per cent depending upon duration of weed competition and intensity of weed. Singh *et al*. (1985) [35] reported that uncontrolled weed causes 74.9 per cent reduction in yield of onion. unweeded treatment gives 6.1 t/ha yield which was the lowest among the all treatments. While 47.9% and 82.2% onion bulb yield reduction due to uncontrolled weeding throughout crop period was mentioned by Phogat *et al*. (1989) [23] and Tewari *et al*. (2003) [44] respectively. Weed infestation prevailed up to 15, 30, 45 and 60 days after transplanting in onion registering 1.2, 39.8, 56.1 and 69.3 per cent reduction in bulb yield respectively over weed free check. Reported by Tewari *et al*. (2003) [44]. It is, thus, recapitulated from foregoing review that the losses occurred due to the weeds vary from location to location, season to season, nature and intensity of weed infestation, type of weed species and growing condition of crop.

4. Effect of herbicides on crop growth and development

Singh *et al*. (1982) [34] studied the effects of weedicides on weed control and yield in onion and observed that application of Oxadiazon 1.0 kg/ha gives maximum plant height i.e. 66.7 cm in 1979-80 due to less crop weed completion and in 1980-81 highest plant height in weed check plot i.e. 60.8 cm and highest number of leaves were noted in repeated weeding and Nitrofen 2.0 kg/ha + one hand weeding. Malik *et al*. (1982) [15] reported after studying chemical weed control in onion that growth characters were significantly highest under weed free treatment and among chemical treatments Oxadiazon 1.5 kg a.i./ha.

Patel *et al*. (1983) [19] studied integrated weed management in onion bulb crop and revealed that two hand weedings at 20 and 40 days after transplanting recorded the highest bulb size and the lowest bulb size was noticed in unweeded control. Among the herbicide treatments application of Fluchloralin 1.35 kg/ha showed highest (3.95 cm) bulb size. Manjunath *et al*. (1989) [16] carried out studies on growth yield and yield

component of onion as influenced by herbicide and weeds and observed that Fluchloralin at 2.0 kg a.i./ha was phytotoxic to onion crop. Plant height was less than half of the control in unweeded treatment. Warade *et al*. (1995) [49] reported that the Fluchloralin @ 0.5 kg/ha was effective for getting maximum polar and equatorial diameter of onion bulb. While two hand weedings gave highest bulb diameter and bulb weight reported by Shah *et al*. (1996).Verma and Singh (1996) [48] observed that maximum plant height as well as number of marketable bulbs/ha were obtained under weed free plot followed by Pendimethalin1.5 kg/ha.

Mahmood *et al*. (2002) [14] studied weed control in garlic in relation to weedicides and mentioned that there was no significant difference in average bulb weight and average bulb size due to different weedicide treatments. However, minimum bulb size was observed in weed control treatment. Further he reported that average clove weight was significantly higher in weed free treatment. Turk and Tawaha (2002) [45] observed that number of cloves and plant height of garlic were greatest in clean weeded treatment and least in unweeded treatment. Mehmood *et al*. (2007) [17] carried out studies on integrated weed management practices in garlic crop in Pakistan and observed that in all weed control treatments, higher bulb weight was recorded as compared to weedy control for both years

Ved *et al*. (2002) [47] reported that maximum growth and onion yield given by Alachlor 2.0 kg/ha + HW 45 DAT and Pendimethalin 1.5 kg/ha + HW 45 DAT. Ramani and Khanpara (2010) [27] studied efficacy of various herbicide in garlic (*Allium sativum*) and reported that all herbicide treatments showed significantly higher values of plant height, bulb diameter, number of cloves/ bulb and 100 cloves weight over unweeded check in garlic. While Pendimethalin @ 2.5 L /ha was effective for getting maximum growth than the control treatments reported by Rahman *et al*. (2012) [26]. Sable *et al*. (2013) [29] observed maximum plant growth with Oxyfluorfen 0.26 kg a.i./ha + hand weeding at 30 DAT However, Oxyfluorfen @ 0.088 kg a.i./ha + Quizalofop ethyl 5% EC 0.025 kg a.i. /ha + HW 45 DAT was effective for getting maximum growth of onion reported by Anarase (2014) [1]. Pre-emergence application of oxadiargyl and post-emergence application of Quizalofop ethyl, found more effective for growth and yield of garlic bulb (Sampat *et al*., 2014) [30].

Hajebi *et al*. (2015) [7] reported that Pendimethalin 0.75 kg ha^{-1} + Imazethapyr 0.075 kg ha^{-1} resulted in higher garlic plant height among herbicide treatments Mohite *et al*. (2015) found that maximum bulb size of garlic was noticed in Pendimethalin @ 1.0 kg a.i./ha + Quizalofop ethyl @ 0.050 kg a.i./ha at 30 DAP. Patil *et al*. (2017) [22] reported that application of Oxyfluorfen @0.150 kg a.i.+ Quizalofop ethyl @ 0.050 kg a.i./ha as post emergence herbicide found better for controlling weeds and increasing growth and yield of garlic.

5. Effect on yield and weed control

Bhalla (1978) [3] reported that the Tenoran application at 2.5 kg/ha after 3 or 5 weeks of transplanting onion seedling control many kind of weeds and gives significantly higher yield than control. Singh *et al*. (1982) [34] indicated that, Oxadiazon (0.5 kg/ha) + one hand weeding gave maximum onion bulb yield and was followed by Pendimethalin 1.0 kg/ha + one hand weeding. While Oxadiazon 1 to 1.5 kg a.i./ha and Pendimethalin 2.0 kg/ha (post planting, 10 days after transplanting) proved to be the best herbicides for onion giving good weed control and enhanced yield observed by Malik *et al*. (1982) [34]. Sonone *et al*. (1982) [41] observed that Nitrofen at 2.0 kg a.i./ha + one hand weeding at 45 days after transplanting in onion has given significantly higher yield. Fluchloralin 1.35 kg a.i./ha and Alachlor 1.5 kg/ha + hand weeding at 40 DAT were quite effective in checking weed growth and increasing onion bulb bulb yield reported by Patel *et al*. (1983) [19] and Singh *et al*. (1985) [35]. The application of Fluchloralin (1.0 kg/ha) resulted in maximum size of bulb and control the weeds effectively reported by Mishra *et al*. (1986) [18]. Patel *et al*. (1986a) [20] proved that application of Fluchloralin at 0.9 kg a.i./ha + hand weeding 40 DAT recorded lowest dry weight of weeds, highest WCE, bulb yield of onion. Patel *et al*. (1987) reported that Fluchloralin at 0.90 kg a.i./ha as pre-planting + Nitrofen 1.25 kg a.i./ha as post emergence 15 DAT effective for weed control and gives maximum onion bulb yield. Fluchloralin 0.5 kg/ha produced maximum yield with controlling weeds in kharif onion (Warade *et al*. 1995) [49]. Challa (1997) [5] reported that Fluchloralin at 1.5 kg a.i./ha was found to be the most effective pre-emergence herbicide for weed control during critical period and which gives maximum bulb yield. Sukhadia *et al*. (2002) [42] reported that application of Fluchloralin or Pendimethalin at 0.9 kg/ha with one hand weeding at 40 DAT gives highest bulb yield. Warade *et al*. (2006) observed that pre-emergence application of Fluchloralin at 1.0 kg/ha supplemented with two hand weeding at 30 and 60 DAT showed least weed count and dry matter production favoring highest yield of onion bulb.

Sandhu *et al*. (1987) [32] observed that, application of Methabenzthiazuron 0.875 kg a.i./ha along with hand weeding highest bulb yield. Prasad and Singh (1988) [24] obtained highest bulb yield with Alachlor 1 kg a.i./ha + one hand weeding 45 DAT. Application of Oxadiazon (0.75 and 1.0 kg/ha), Pendimethalin (1.0 and 1.5 kg/ha) and Fluchloralin (1.0 and 1.5 kg/ha) separately gives yield at par with weed free (Phogat *et al*. (1989) [23]. Jayakumar *et al*. (1991) [9] reported that application of Oxadiazon 1.0 kg/ha or Pendimethalin 1.0 kg/ha reduced the weed population weed dry weight and onion bulb yield followed by two hand weeding on 15 and 35 DAT. Post emergence application of Oxyfluorfen 0.250 kg/ha gave highest bulb yield reported by Singh *et al*. (1992) [40]. While Qasem (1996) [25] reported that Pre-plant application and post-emergence application of Oxyfluorfen and Oxadiazon were effective in weed control and increased garlic yield over the other herbicide treatments. Tewari *et al*. (1999) [43] revealed that application of Pendimethalin (0.75 kg a.i./ha) or Oxyfluorfen (0.07 kg a.i./ha) followed by one hand weeding at 40 DAT checks weed competition and recorded the maximum onion bulb yield.

Singh and Nandal (2002) [38] revealed that herbicidal treatments applied at 1.0 kg/ha + HW at 65 DAP gave best results for maximum weed control (except Fluchloralin) and highest garlic bulb yield was recorded in Pendimethalin applied at 1.0 kg/ha + HW at 65 DAP. Mehmood *et al*. (2007) [17] conducted an experiment on integrated weed management practices in garlic crop in Pakistan and reported that all herbicide treatments followed by hoeing except Metribuzin gave bulb yield at par with weed free treatment. Metribuzin resulted in minimum bulb yield (0.59 t/ha) because of its extreme phytotoxicity to garlic crop, which resulted in the survival of a few plants. Pendimethalin in combination with

manual hoeing gave the highest bulb yield and monetary returns. Kathepuri *et al*. (2007) [11] reported that application of Pendimethalin 1.0 kg/ha PPI + hand weeding at 40 DAT were most effective in reducing weed density and also increase yield as compared to weedy check.Ramani and Khanpara (2010) [27] studied efficacy of various herbicide and observed that all the herbicide treatments reduced the density and dry weight of weeds and increased yield and yield attributes significantly over unweeded check in garlic.

Uygur *et al*. (2010) [46] reported that among the herbicidal treatments, Oxadiazon and Oxyfluorfen provided a better control than Pendimethalin and Tepraloxydim on weed coverage and density in onion crop. Ghadge *et al*. (2012) reported that the treatment of Pendimethalin (PE) @ 0.5 kg/ha + two hand weedings was found superior in reducing the weed population of monocot as well as dicot weeds garlic. However, application of Oxyfluorfen (PE) @ 1 kg/ha was found next best treatment.Rahman *et al*. (2012) [26] studied the influence of different weed management practices on yield of garlic crop (Alliumsativum) reported that for controlling weeds, Pendimethalin @ 2.5 L ha-1 was found to be the best herbicide as compared to control and other herbicides. Kumar *et al*. (2013) found that the Pendimethalin 0.75 kg/ha + HW was best herbicide for controlling weeds in garlic crop.Sable *et al*. (2013) [29] observed that Oxyfluorfen 0.26 kg a.i./ha + hand weeding at 30 DAT gave the higher onion bulb yield (291.94 q/ha). Shashidhar *et al*. (2013) [33] reported that highest yield of garlic bulb recorded by treatment Oxyflurofen @ 0.10 g a.i./ha and at par with Pendimethalin 1.0 kg a.i./ha. Shinde *et al*. (2013) mentioned that Pendimethalin 38.7% CS @ 1.75 l/ha (422.58 q/ha) followed by Oxyfluorfen 23.5% EC @ 1.0 l/ha highest bulb yield in rabi onion with minimum weed population as compared to unweeded plot.Anarase (2014) [1] reported that highest bulb yield was recorded by chemical weed control treatment Oxyfluorfen @ 0.088 kg a.i./ha + Quizalofop ethyl 5% EC 0.025 kg a.i. /ha + HW 45 DAT in rabi onion. Hajebi *et al*. (2015) [7] reported that pre-emergence tank-mix application of Pendimethalin @ 0.75 kg ha^{-1} + Imazethapyr @ 0.075 kg ha^{-1} proved superior to all the other herbicide treatments in reducing weed competition (density and dry weight) in garlic crop.

6. Economics of weed control

Singh *et al*. (1992) [40] reported that application of Oxyfluorfen pre-planting @ 0.250 kg/ha gave the maximum net return and highest the B:C ratio. Similar findings were reported by Kalhapure and Shete (2013) [10]. while, Sable *et al*. (2013) [29] revealed that Oxyfluorfen 0.26 kg a.i./ha + hand weeding at 30 DAT showed maximum B:C ratio in onion. Likewise Anarase (2014) [1] observed that the highest B:C ratio was recorded by treatment Oxyfluorfen @ 0.088 kg a.i./ha + Quizalofop ethyl 5% EC 0.025 kg a.i. /ha + HW 45 DAT. However, Singh *et al*. (1998) obtained highest B:C ratio from Pendimethalin application @ 1.00 kg/ha along with hand weeding at 40 DAT (1:4.75) followed by Oxyflurofen @ 0.25 kg a.i./ha + hand weeding 40 DAT (1:4.45) as compared to weedy check.Similar findings was also reported by Rameshwar *et al*. (2002) [28], Kathepuri *et al*. (2007) [11] in onion. and Singh *et al*. (2002) [38] in garlic crop. Sampat *et al*. (2014) [30] reported that combination of Oxadiargyl 90 g/ha pre-emergence plus Quizalofop-ethyl as post-emergence 50 g/ha applied at 2-3 leaf stage of weeds gave highest a B: C ratio in large segmented garlic variety.

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