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A Review on Efficacy of Weed Management Methods in Onion

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A B S T R A C T

Onion *Allium cepa* L. (2n=16) is the most important bulbous vegetable. It forms an indispensable part of many diets, both vegetarian and non-vegetarian. Onion is regarded as an important export oriented crop and fetches a handsome foreign exchange. Onion among vegetables has very poor competitive ability with weeds due to its inherent characteristics such as shallow root system, narrow leaf and less area. The reduction in crop yield has direct correlation with weed competition. The effective weed control involves identification of weed flora and their management through suitable methods. Hand weeding in onion is a common practice in India, but due to less availability of labourers during critical period of crop makes hand weeding difficult leading to heavy yield losses. Hence a brief review was presented to find out suitable weed management method in onion.

Introduction

Among many causes of low productivity of onion, it shows more susceptibility to weed competition as compared to other crops due to its inherent characteristics such as slow germination, extremely slow growing and can suffer from successive flush of weed. They have narrow upright leaves which do not shade out weeds that emerge in the row. The degree of damage caused by weeds is related to the type, species and density of weeds growing in a crop community. Weed species are known to vary with season and type of cultivation. Persistence of weeds in a location is largely influenced by climatic, edaphic (soil) and biotic factors which affect their occurrence, abundance, range and distribution. The reduction in bulb yield varies to the extent of 48 to 80 per cent depending upon the duration, intensity of weed growth and weed competition (Patel *et al.*, 1983).

So, early season weed control is essential for successful crop production. Manual weeding is very tedious, time consuming, cumbersome, expensive and it is under many situations become uneconomical method of weed control, even often damages the crop as well. Numerous herbicides with high potency and environmental safety are becoming available for effective control of weeds in field crops in present days. Hence, a brief review is presented on the efficacy of weed

management methods on growth and yield of onion crop.

Various weed management methods/techniques

Weeds can be controlled by various methods such as manual and cultural, chemical, mechanical, biological and use of stale seed bed. The weeds infestation is problematic especially at early stage of crop growth. Usually farmers do not remove weeds early enough to prevent major damage due to this weed competition.

Manual and cultural methods of weed management

Hand weeding is better in increasing the bulb diameter, bulb weight and bulb yield when compared with the control. Hand weeding on 45 DAP gave more yield due to minimum crop weed competition for resources (Saraf *et al.,* 1994). Calamai and Martini (1994) reported that 86 per cent weed control efficiency was with hoeing alone in onion. Shah *et al.,* (1996) found that hand weeding was significantly better in increasing the bulb diameter, bulb weight, bulb yield and loss of bulb weight than unweeded control. Higher onion bulb yield and weed control efficiency were observed in treatment combination of one HW at 30 DAT + mulching (Singh *et al.,* 1997). Melander and Hartvig (1997) reported that hoeing close to the row leaving 5 cm untilled strip has the potential of saving labour cost for hand weeding in non herbicidal growing system of onion. The higher bulb and weed control efficiency were recorded in the weed free treatment followed by three HW on 20, 40 and 60 days after transplanting (Amrutkar *et al.,* 1998). Bhutia *et al.,* (2005) reported significantly higher bulb yield with twice hand weeding at 25 & 45 DAT. Jilani *et al.,* (2007) studied that three hand hoeing practice showed the best results in onion bulb diameter, bulb weight and bulb yield ha^{-1}. Three hand hoeings proved to be the best weed control practice. Maximum bulb size and yield of onion were recorded in hand weeded plots as compared to weedy check as noticed by Hussain *et al.,* (2008). Higher weed control was obtained with manual weeding throughout the crop season (Zubiar *et al.,* 2009). Kathepuri *et al.,* (2011) reported that the application of two HW at 20 and 40 DAT was significantly superior for weed control in rabi onion. Hand weeding throughout the growing season controlled all weeds and resulted in higher onion bulb yield (Rahman *et al.,* 2011). Kalhapure and Shete (2012) reported that three HW at 20, 40 and 60 DAS recorded significantly lowest weed density, dry weight of weed and higher weed control efficiency. All the growth attributes of onion *viz.*, plant height, neck thickness, bulb weight and bulb diameter were recorded maximum in weed free plots. This treatment also recorded highest bulb yield. Khatam *et al.,* (2012) found onion bulb yield was highest in the manual weed control followed by pendimethalin @ 2 litre ha^{-1}. Rahman *et al.,* (2012) studied the relationship between manual weeds removal timings (or manual weeding intervals) and onion yield. Onion yield and yield components (bulb diameter, height and weight) increased significantly with increasing frequency of manual weeding; whereas, weed density, fresh and dry weed biomass decreased significantly with increase in frequency of manual weeding. Moreover, a negative linear relationship between bulb yield and weed density was found.

Mechanical method of weed management

Mechanical weed control is comparatively faster and less labour intensive than hand weeding (Chivinge, 1990). Most mechanical weed control methods, such as hoeing, tillage, harrowing, torsion weeding, finger weeding

and brush weeding, are used at very early weed growth stages (Singh, 2014). Many mechanical control methods become difficult after the cotyledon stage and their selectivity decreases with increasing crop and weed age. Thus, if the weeds have become too large, an intensive and aggressive adjustment of the implements is necessary to control the weeds, and by doing this one increases the risk of damaging the crop severely (Carter and Ivany, 2006). Power weeder was found useful for weeding in between standing rows of cash crops like cotton, tapioca and grape. The weeder could cover an average of one ha per day of eight hours. The cost of weeding by this machine came to only one-third of the weeding cost by manual labourers (Tajuddin, 2006).

Mechanical weed control uproot the weeds between the crop rows and keep the soil surface loose to ensure better water intake capacity and soil aeration (Yadav and Pond, 2007). Rajakumar (2008) reported that stage of weed growth and their morphology would influence the selection and efficiency of weeding implement. The physical damage to weed plants by burial to one cm depth followed by cutting at the soil surface are effective for controlling weeds. The use of 'Cycle Hoe Weeder' was found to be effective in controlling grass as well as broad leaved weeds (69 and 44per cent) and (63 and 67per cent) at 30 and 60 DAS, respectively and produced significantly higher grain yield in soybean as noticed by Gore *et al.,* (2010). Gowsalya *et al.,* (2010) found that pre-emergence application of pendimethalin at 0.75 kg ha^{-1} on 3 DAS followed by one weeding with oleo weeder on 45 DAS or pre-emergence application of pendimethalin at 0.75 kg ha^{-1} on 3 DAS followed by one weeding with wheel hoe weeder on 45 DAS was effective and economical weed management method in rainfed pigeonpea. Sathya Priya *et al.,* (2013) recorded lower gross and net returns with pre-emergence application of pendimethalin at 0.75 kg ha^{-1} followed by rotary weeding on 45 DAS.

Chemical method of weed management

At present there is lot of scope for use of herbicide due to shortage of labourers and increases in wages of farm labourers. The earlier attempt in India to control weeds by herbicides was made in 1937 Punjab for controlling *Carthamus oxycantha* by using sodium arsenite. 2, 4-D was first tested in India in 1946. Since then a number of herbicides have been imported and tested for their effectiveness in controlling many weed species. The formulations of oxadiargyl have the major market in Andhra Pradesh, Gujarat and Rajasthan for the weed management in onion, garlic and rice. But on onion and garlic in Maharastra, oxyfluorfen is more popular than oxadiargyl. Being a broad spectrum herbicide, pendimethalin is very popular amongst farmers for weed management in several crops (Choudhary *et al.,* 2016). In many advanced countries, the average annual consumption of herbicides is 675 to 1350 g/ha. It is as high as 5000 g/ha in Japan. Against these high figures, in India at present the average annual herbicide use is hardly 40 g/ha (www.agriinfo.in). In India however the herbicide consumption is only 16 per cent of total pesticide consumption. During 1995, herbicide use in India was quantified as 6040 t (technical grade) whereas in 2010 it was more than 7000 t (Choudhary *et al.,* 2016). The selection of herbicides will depend on the crop type, its potential use, the variety, crop growth stage, condition of the foliage, soil type and weeds present in the field (Davies and Welsh, 2002).

Application of herbicides

Considerable yield increase in onion could be obtained by effective control of weeds longer

duration with use of herbicides (Pandita *et al.*, 1978). Chemical herbicides have been found very promising in controlling weeds in onion (Singh *et al.*, 1986). Singh *et al.*, (1997) indicated that oxyfluorfen at 0.37 kg ha^{-1} was the most effective treatment for reducing populations of *Poa annua*, *Coronopus didymus* and *Medicago denticulata* in sandy soils of Himachal Pradesh. Balraj Singh *et al.*, (1998) stated that oxyfluorfen at lower dose of 0.15 kg ha^{-1} alone or with one hand weeding found to be superior in controlling weeds when compared to other herbicidal treatments. Shimi and Maillet (1998) stated that the best weed control in onion was achieved with oxyfluorfen (2 l ha^{-1}) and ioxynil + sethoxynil + sethoxydim which resulted in better control of broad leaved weeds. Ramachandra Prasad (2000) reported that pendimethalin and oxyfluorfen were most effective in lowering dry weight of grassy weeds as compared to alachlor and metalachlor. Bulb yield was higher under pre-emergence application of pendimethalin at 1.5 kg ha^{-1}, oxyfluorfen at 0.15 kg ha^{-1} and pendimethalin at 1.0 kg ha^{-1} with one hand weeding on 50 days after transplanting (Yadav *et al.*, 2000). Ranpise and Patil (2001) observed that pre-emergence application of oxyfluorfen at 0.4 kg ha^{-1} in onion recorded maximum yield (242.2 q ha^{-1}) followed by oxyfluorfen 0.2 kg ha^{-1} (233.3 q ha^{-1}) as compared to the lower yield under control (50 q ha^{-1}) due to maximum weed intensity. Kolhe (2001) indicated that dry matter of weeds was significantly reduced due to application of pendimethalin, metalachlor, oxyfluorfen either alone or in combination with hand weeding at 35 DAP compared to weedy check in onion. Presently herbicides are widely applied for weed destruction and oxyfluorfen is a very effective herbicide suitable for weed destruction in onion and cabbage (Stall and Gilreath, 2002). Oxyfluorfen, pendimethalin and metribuzin significantly reduced the weed population and increased onion yield to levels comparable to yields of weeded control in a relay cabbage-onion cropping system (Sanjeev *et al.*, 2003). Oxyfluorfen and oxadiazon were used as pre and post emergence and visual ratings estimated 65 days after crop emergence indicated that weed control was adequate in oxyfluorfen and oxadiazon treatments but onion plants were damaged, particularly in oxyfluorfen treated plots (Ghoshen, 2004). Priyadharshini and Anburani (2004) recorded lesser weed population of 67.90 m^{-2} with the application of pendimethalin at 1.0 kg ha^{-1} with mulching in onion. An increase in the bulb yield of onion by 62.69 per cent with pendimethalin at 2.5 l ha^{-1} than the unweeded plots was recorded by Zubiar *et al.*, (2009). In onion, pendimethalin at 1.0 kg ha^{-1} + hand weeding and oxyfluorfen at 0.24 kg ha^{-1} recorded higher weed control efficiency of 80.6 and 73.4 per cent (Patel *et al.*, 2011). Chaitanya *et al.*, (2012) stated that pre-emergence application of pendimethalin at 1.0 kg *a.i.*ha^{-1} along with post emergence application of quizalofop ethyl at 50 g *a.i.*ha^{-1} on 25 DAS recorded lower weed growth. Sathya Priya and Chinnusamy (2013) reported that pre-emergence application of oxyfluorfen at 200 g ha^{-1} recorded higher bulb yield due to better control of weeds at critical stages thus providing favourable environmental condition for better growth and development leading to enhance bulb yield. Ramalingam *et al.*, (2013) found that pre-emergence application of oxyfluorfen (23.5% EC) at 400 g ha^{-1} gave significantly lower total weed density, weed dry weight and higher weed control efficiency at all the intervals. Shinde *et al.*, (2013) indicated that pendimethalin 38.7% CS at 1.75 litre/ha exhibited the greatest grass weed control efficiency (90.19 %), whereas oxyfluorfen 23.5% EC at 1.0 litre/ha showed the greatest broadleaved weed control efficacy (82.95 %) in onion. Chaitanya *et al.*, (2014) reported that the total number and total dry weight of weeds were lowest with

pendimethalin at 1.5 kg *a.i.*/ha. Kalhapure *et al.*, (2014) reported that the pre-plant application of pendimethalin 0.750 kg/ha followed by post-emergence application of oxyfluorfen 0.250 kg/ha mixed with quizalofop-ethyl 0.050 kg/ha resulted in effective control of various broad-leaf and grassy-weeds and recorded lower weed density, weed biomass, weed index and higher weed control efficiency in onion. Kumar (2014) revealed that effective weed control was recorded under application of oxyflurofen 23.5 EC before planting +one hand weeding at 40 days after transplanting or combined spray of Pendimethalin 30EC + quizalofop ethyl 5 EC at the time of planting and second application at 30 days after transplanting in onion. Kumar *et al.*, (2014) reported that significantly highest weed population (104.68/m^2) was recorded in weedy check plot while minimum weed population was recorded in the treatment with the application of oxyflurofen 23.5EC @ 2 ml/L before planting and Quizalofop ethyl 5EC @ 3.5 ml/L at 30 DAT (46.01). Panse *et al.*, (2014) observed that application of Oxyfluorfen 23.5% EC before planting + Quizalofop ethyl 5 % EC at 30 days after transplanting recorded highest weed control efficiency and higher marketable bulb yield with cost benefit ratio. Sable *et al.*, (2014) reported that effective weed control was attained under oxyfluorfen 0.26 kg *a.i.*/ha with hand weeding (30 DAT), followed by oxyfluorfen 0.26 kg *a.i.*/ha + oxyfluorfen 0.26 kg *a.i.*/ha (30 DAT). Gandolkar *et al.*, (2015) studied that application of pre emergence herbicides, either pendimethalin @ 1.0 kg ha^{-1}, butachlor @ 1.0 kg ha^{-1} or oxyfluorfen @ 0.08 kg ha^{-1} with post emergence herbicides either fenoxaprop-p-ethyl @ 75g ha^{-1} or propaquizafop @ 100 g ha^{-1} reduced the grass density (0.88 0.5m^{-2}) at harvest. Among the herbicide treatments, application of oxyfluorfen @ 0.08 kg ha^{-1}followed by oxyfluorfen @ 0.25 kg ha^{-1} showed significant reduction in broad leaved and total weed density. Vishnu *et al.*, (2015) evaluated that combined spray of oxyfluorfen @ 0.240 kg ha^{-1} and propaquizafop @ 0.090 kg ha^{-1} as PE followed by second spray as POE at 45 DAT was equally effective with this treatment. Sankar *et al.*, (2015) assessment that application of Oxyflurofen 23.5 % EC @ 1.5ml/L before planting and one hand weeding at 40-60 days after onion seedlings transplanting recorded the maximum weed control efficiency of 78.4 per cent in onion. Mallik *et al.*, (2017) reported that application of pendimethalin 30 EC + one hand weeding at 45 DAT controlled most of weeds alongwith maximum weed control efficiency in garlic crop. Siddhu *et al.*, (2018) noted that oxyflourfen 0.150 kg/ha + quizalofop ethyl 0.05 kg/ha found significantly superior and recorded minimum weed density and dry weight of weeds and maximum weed control efficiency and weed management index in garlic.

Weed management by mulching technique

Lament (1993) has documented the advantages of using plastic mulch as one component of a complete "intensive" vegetable production system. The crops have shown significant increases in earliness, total yield and quality. Anisuzzaman *et al.*, (2009) reported that among various mulches, black polythene mulch gave the higher growth and seed yield of onion. Waiganjo *et al.*, (2009) reported that black polythene mulch or grass mulch gave the best weed control, the highest plant weight and onion bulb yield providing the highest net returns in the first and second seasons. Lalitha *et al.*, (2010) observed that plant growth and yield are also positively influenced by the plastic mulch due to the modification of soil microclimate. Although plastic mulch has many advantages, but high initial cost, removal and disposal of plastic materials are some of the limitations

experienced by the farmers. Coolong (2012) when combined with tillage techniques and herbicides, plastic mulches allow vegetable growers to maintain nearly weed-free fields. The ability of plastic mulches to alter crop microclimate can also lead to improved earliness, quality and yield. Rajablariani *et al.,* (2012) concluded that the plastic mulches reduced weed dry weight by 98, 95, 89, 85 and 84 per cent for silver/black, black, blue, clear and red, respectively relating to weedy plots. The black plastic mulch resulted in an 80 per cent reduction in weed biomass. The marketable yield was greater with the use of plastic mulches (up to 24 to 65%) compared to bare soil. Job *et al.,* (2016) concluded from the studies that overall black polymulching have a positive impact on yield and growth parameters in onion production.

Weed management by stale seedbed technique (SSB)

In general, weed density is very high at early growth stage to critical period of crop weed competition. Therefore, new approaches are needed to reduce weed problems before sowing or crop emergence (Sathappan *et al.,* 2012). In stale seedbed technique, after seedbed preparation, the field is irrigated and left unsown to allow weeds to germinate and which are killed either by a non-selective herbicide or by carrying out tillage prior to the sowing (Singh, 2014). The success of stale seedbed depends on several factors like method of seedbed preparation, method of killing emerged weeds, weed species, duration of the stale seedbed, environmental condition (Singh, 2014). Stale seedbed is based on the principle of flushing out germinable weed seeds prior to the planting of the crop, depleting the seed bank in the surface layer of soil and reduction of subsequent weed seedling emergence (Johnson and Mullinix, 2000). The stale seed bed with cultural operation was the second best treatment next to stale seed bed with glyphosate in comparison to conventional method. Stale seed bed is one of the weed management options that have the potential to reduce labour and weed management cost. Stale seed bed formation is successful when most of the non-dormant weed seeds in the top 6 cm of the soil profile (Sanbagavalli, 2001). The optimum timing for stale seed bed preparation was 20 to 30 days before planting which provided adequate weed control and resulted in optimal yield (Lonsbary *et al.,* 2003). Through stale seedbed method, weed population could be eliminated by pre-plant shallow tillage or by post emergence herbicide spray (Gnanavel and Kathiresan, 2014).

Adoption of stale seed-bed practice caused reduction in weed count (18.8-34.1 %) and dry weight (21.3 %) as compared with that of conventional tillage - flat bed (Ranjit, 2007). Stale seed bed technique followed by inter cultivation twice at 20 and 35 DAP significantly lowered the total weed density and weed dry weight (23.9 No./m^2 and 10.3 g/m^2) and was at par with hand weeding twice at 20 and 30 DAP (22.6 No./m2 and 9.4 g/m2, respectively) (Basavaraj *et al.,* 2013).

Biological method of weed management

In general weeds are managed either manually or by using herbicides but for the former is costly, time consuming and regenerates soon and thus not feasible and later on creates soil and water pollution, health hazards, forces heavy financial burden and needs technical know-how for its application. To overcome these problems, biological control appears pollution free and economic option for weeds control. Insects, mites, nematodes, plant pathogens, animals, fish, birds and their toxic products are major weed controlling biotic agents and among these insects are one of the important groups

(Tiwari *et al.*, 2013). Pioneering works on biological control of weeds was carried in India for control of *Parthenium hysterophorus* (Kumar and Ray, 2011). 'BIOMAL' a dry formulation of *Colletotrichum gloeosporioides* f.sp. malvae, was used in Canada for the control of *Malva pusilla* in flax and lentils and *Colletotrichum gloeosporioides* f.sp. Cuscutae, for the control of *Cuscuta sp*. in soybean (Das, 2008). *Lantana camara* (Ghaneri) was controlled by using *Crocidosema lantana* Busck, a moth as most promising bio-agent in Haweli. This bio-agent feeds on flowers and seeds (Singh, 2014).

Solarization method of weed management

It is an effective method for the control of soil-borne diseases and pests as well as many weeds. The method has been previously described by Labrada (1996). The soil must be clean, surface-levelled and wet, previously to being covered with a thin (01-02 mm) transparent plastic and very well sealed. The soil must be kept covered during the warmer and sunnier months (30-45 days). Soil temperatures must reach above 40° C to exert a good effect on various soil-borne pests, including weed seeds. Soil solarization is a broad-spectrum control method, simple, economically feasible and environmentally friendly. It does not affect soil properties and usually produces higher yields (Campiglia *et al.*, 2000). After solarization the plastic must be recovered, and the use of deep or mouldboard tillage must be avoided. This system is more suitable for small areas of vegetables, but it has been mechanized for extensive areas of tomatoes, onion and other vegetable crops. Soil solarization is widely used under plastic greenhouse conditions in southern Spain. Biofumigation consists in the incorporation of fresh manure into the soil in plots to be solarized. The breakdown of the organic matter produces toxic gases under the plastic and enhances the biocide effects. Normally the soil should be removed after solarization or biofumigation to enable the gases to escape from the soil before planting takes place (Monserrat, 2001).

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