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Weed Management in Berseem (*Trifolium alexandrium* L.): A Review

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A B S T R A C T

Weeds are the part and partial of crop production since evolution of agriculture. Because of their superiority, efficiently harness favourable microclimate at the cost of crop. They mainly compete for mineral nutrients, soil moisture, space and light interception. In berseem field we can successfully achieve weed control below economic threshold level by adapting both precautionary and curative measures in an integrated manner. In recent days due to labour shortage chemical method of weed control is getting importance but it need to be supplemented with other weed control approaches, which helps in achieving agronomically superior, economically viable and ecologically safe weed control. One year seeding is remains equal to seven year weeding, in this regard integrated weed management is the key for sustainable fodder production in berseem.

Introduction

From the evolution of agriculture, weeds are the part and partial of the crops and causing considerable loss to the crop yield and quality because of their superior characteristics over crops like C_4-mechanism, prolific seed production, longer seed viability, dormancy mechanism, competing ability and higher temperature compensation point. They compete with crops for both natural as well as applied resources. Weeds causing annually 45 per cent loss to the Indian agriculture (2000 crores), which is nearly equal to the combined loss due to insects and diseases (Gupta, 2010). Weeds are invading almost all the crops with varied intensity. Fodder crops like berseem also affected by weeds, especially during early growth. Berseem (*Trifolium alexandrinum* L.) is a one of the most important winter season leguminous fodder crop in India known as king of the fodder crop. After Egypt and Pakistan, India is having the highest area under berseem cultivation (Muhammad *et al.*, 2014). In India, it is grown in approximately 2 million hectares area (Pandey and Roy, 2011). The crop cultivated under irrigated condition provides highly palatable, succulent and nutritious green fodder (800-850 q/ha) in 5-6 cuttings. Berseem fodder has 20% crude protein, 62% total digestible nutrients with

65% digestibility. It is well known that feeding of green fodder stimulates and enhances the milk production in dairy animals.

The per unit area productivity of green fodder and seed depends on various agronomical practices i.e. sowing, nutrient, irrigation and cutting management. In spite of this weed has greater impact on fodder and seed production of berseem. Weeds are considered as major biological constraints for limiting the crop productivity. In berseem during early stage of growth period weeds compete with main crops for nutrients, water, light and space thus to achieve the full yield potential of crop the initial 35 to 40 days after sowing crop growth period should be kept weed free (Wasnik *et al.,* 2017).

Due to slow growth of crop weeds adversely affects the crop growth and yield. In berseem, the infestation of weed flora reduces green fodder (23-28 %) and seed (38-44%) yield fodder (Wasnik *et al.,* 2017). Apart from thisweeds like *Cichorium intybus, Rumex dentatus and Sonchus asper* pose problems in harvesting of the berseem crop for seed. As, weed management is the major and important part of crop production. The problem of weeds in berseem is very much severe due to lack of appropriate weed control method. Therefore, It is utmost important to control the berseem weeds for enhancement of fodder and seed yield.

Associated weed flora of berseem crop

The weed flora in berseem field can be grouped into two categories *i.e*. crop-associated and non-crop associated. In crop-associated weeds *Cichorium intybus* and *Coronopus didymus* and in non-crop associated weeds, *Anagalis arvensis, Chenopodium album, Ecliptaalba, Medicago denticulata, Melilotus alba, Melilotus indica, Physalis minima, Rumex dentatus, Sonchus asper, Spergula arvensis,Trifolium resupinatum, Poa annua* and *Cyperus rotundus are* considered to be the most dominating weeds. The berseem field were infested with grassy weeds like *Cynodon dactylon, Chloris barbata, Digitaria longiflora, Dactyloctenium aegyptium.* Among broad leaved, *Amaranthus viridis, Euphorbia geniculata, Celosia argentia, Lantana camara, Trianthema portulacastrum, Commelina benghalensis, Corchorus aestuans, Parthenium hysterophorus, Tridax procumbens, Portulaca oleracea, Cichorium intybus* and among sedges, *Cyprus rotundus* (Pathan and Kamble, 2012). At Uttrakhand, the composition of weed flora observed in the berseem experimental plots were *Cichorium intybus, Trianthema portulacastrum, Poa annua, Coronopus didymus* and *Cyprus rotundus* (Joshi and Bhilare, 2006). The prominent weed flora observed on sandy loam soils of Ranchi were *Amaranthus viridis, Celosia argentia, Cichorium intybus, Chloris barbata, Commelina benghalensis, Corchorus aestuans, Cynodon dactylon, Cyperus rotundus, Dactyloctenium aegyptium, Digitaria longiflora, Euphorbia geniculata, Parthenium hysterophorus, Portulaca oleracea, Trianthema portulacastrum, Tridax procumbens* (Pathan *et al.,* 2013). Prajapati *et al.,* (2015) identified that the major weeds in the berseem field were *Polygonum* spp, *Medicago denticulata, Coronopus didymus, Cyperus rotundus, Cichorium intybus* and *Vicia* spp. under Tarai conditions of Uttarakhand. Gil *et al.,* (1991) reported that, Avena *fatua and Thlaspi arvense* as the predominant weed flora in berseem.

Singh *et al.,* (2010) noticed *Phalaris minor, Avena* spp and *Poa annua* among grasses, *Medicago denticulata, Coronopus didymus, Anagallis arvensis, Polygonum plebeium, Melilotus spp*. among broad-leaved and *Cyperus rotundus*, the only sedge as the major

weed in the berseem field. The major weed flora consisted of berseem were *Coronopus didymus, Anagallis arvensis, Melilotus indica, Lathyrus aphaca, Cirsium arvense, Cyperus rotundus, Chenopodium* album and *Rumex dentatus* (Priyanka *et al.,* 2017). Wasnik *et al.,* (2017) observed predominant weed species in berseem in Jhansi condition were *Anagalis arvensis*, *Chenopodium album, Cichorium intybus*, *Coronopus didymus*, *Eclipta alba, Medicago denticulata, Melilotus alba*, *Melilotus indica*, *Physalis minima, Rumex dentatus, Sonchus asper, Spergula arvensis, Trifolium resupinatum*. The dominant weed flora observed in the experimental field of berseem were *Cichorium intybus, Cyperus rotundus, Cynodon dactylon, Melilotus indica, Anagalis arvensis, Desmodium tortuosum, Spergula arvensis, Rumex hongifolius, Tridax procumbens and Chenopodium album* (Kumar and Dhar, 2008).

Losses caused due to weeds

However, it has been estimated that the fodder yield loss due to weeds in berseem was nearly 23 to 30 per cent (Joshi and Bhilare, 2006; Alfred, 2012) and seed yield loss was up to 50 % (Jain, 1998) and reported that at earlier stages of growth, berseem faces serious problem with fast growing different weeds. *Cichorium intybus* found associated with berseem and give more competitional stress by robbing the crop of essential nutrients, light, moisture and space (Thakur *et al.,* 1990). Kewat *et al.,* (2005) observed that among the different weeds, *Cichorium intybus*is one of the major obnoxious berseem crops associated weed which exert more nutrient and moisture stress.

Weeds in berseem causes substantial reduction (25-30%) in green fodder production, besides deteriorating the quality of seeds (Tiwana *et al.,* 2002).

Weed control methods

The weed management is one of the vital components of berseem cultivation particularly for seed production. They compete with crops for natural and applied resources besides being responsible for reducing quantity and quality of agricultural productivity (Rao and Nagamani 2010, 2013; Rao *et al.,* 2015). In order to reduce weed growth, many "weed control" strategies have been developed in order to control the growth and spreads of weeds.

Traditionally, weed control in India has been largely dependent on manual weeding. However, increased labour scarcity and costs are encouraging farmers to adopt labour and cost saving options. A much wider range and intensity of weeds occur in berseem. Weeds vary in their growth habit and life cycle. Therefore, no single weed control method may provide effective control of weed. Various weed management practices are in vogue and each has its own pros and cons. The choice of any weed control method depends on its effectiveness and economics. The various weed management practices can be grouped into three broad categories namely cultural and preventive; physical or mechanical and chemical weed control. These practices are discussed as under,

Preventive and cultural methods

Menace of weeds in berseem can be curbed effectively with the adoption of preventive methods. Deep summer ploughing with soil inversion plough after harvest of the crop is very effective way to reduce the weed count. Use of clean seeds and cultural practices such as time and method of sowing, crop rotation, dose, method and time of fertilizer application, time and method of irrigation have pronounced effect on weed crop interference.

Use clean seeds

In berseem, seeds contaminated with weed seeds is a major factor responsible for the spreading of weeds particularly chicory (*Chicorium intybus*). The intensity of this weed could be reduced by the use of weed free berseem seeds for sowing or making the berseem seed weed free by pre sowing treatment of berseem seeds with 10 % salt solution is most commonly used for eliminating the problem of Chicory including the other weed seeds in berseem crop (Joshi and Bhilare, 2006; Kumar and Dhar, 2008). The chicory seeds being lighter in weight then berseem seed float on the surface while berseem seeds settle down at the bottom of container. In this way chicory seeds may be drained off and berseem seed collected. ICAR-IGFRI, Jhansi in collaboration with ICAR-CIPHET, Ludhiana developed berseem-chicory seed separator for separating chicory seeds from berseem seeds. Slight differences in shape of seeds (the round shape and smooth texture of berseem and triangular shape and rough texture of chicory seeds), physical properties related to surface property and aero dynamics behaviour of both the seeds were used for separating chicory and berseem seeds (ICAR-IGFRI, 2011).

Crop rotation

Crop rotation is an important component of integrated weed management. Weeds with the same life cycle as the crop tend to increase under monoculture. Adopting proper crop rotation practices will help in overcoming the domination of certain weeds and reducing the weed competition in berseem based cropping systems. Inserting crop having different seeding and maturity time can break the life cycle of some economically important annual weeds. An important reason for rotating crops is to deplete the soil weed seed bank. Growing alternate crops in place of berseem for two or more years, soil weed seed banks decline to low levels where they can be more easily managed. Crop rotation has been found a very effective cultural practice in breaking the association of problematic weeds like chicory in berseem. Rotation of berseem fields with other crops like wheat, chickpea and mustard helps in reducing the population of chicory.

Sowing methods

Generally, berseem seeds are sown by broadcasting in 5-6 cm standing water. This helps in rapid germination and easy establishment of young seedlings. The use of seed drill is advantageous as line sowing helps in optimum seed placement resulting in uniform plant population. It also helps in easy inter-cultivation and recommended for seed production *per se*. Berseem seed drill was developed by IGFRI, Jhansi for line sowing of berseem in proper depth.

Physical and mechanical methods

Hand weeding in crops is as old as agriculture itself. It involves the removal of weeds by various tools and implements including hand weeding and uprooting. Manual weeding though effective but involves considerable amount of man-power and time. Due to costly and scarce labour, its feasibility is very less. Mechanical weeding is also difficult in broadcast sown wheat. However, mechanical control can be practiced effectively in line sowing seed crop of berseem. In a field trial on sandy clay loam soil of Jabalpur, Jha *et al.*, (2014) found that, *Cichorium intybus*, *Medicago denticulata* and *Cornopus didymus* as the dominant weeds. Hand-hoe was the most effective in controlling weeds which produced higher green fodder (612 q/ha) and seed yield (3.74 q/ha) compared to 266 and 1.57 q/ha in unweeded plots, respectively. Since the initial slow growth stage, two hands

weeding (3 and 5 weeks after sowing) should be done. At Pantnagar, Prajapati *et al.*, (2015) observed that manual weeding twice 3 and 5 weeks after sowing reduced weed dry weight from 85.8 to 45.9 g /0.25m^2 and increased the berseem seed yield from 3.50 to 4.10 q/ha as compared to unweeded control. Similarly, Pathan *et al.*, (2013) also found lower weed density with hand weeding at 3 and 5 week after sowing. The weed control efficiency was also higher under manual weeding than herbicide Pendimethalin/oxyflourfen at 0.1 kg/ha as pre emergence and imazethapyr at 0.1 kg ai /ha as post emergence.

Chemical method

Herbicides are effective tools in man's eternal struggle with weeds. When properly used, herbicides can safely and effectively accomplish their objective. Chemical weed control is preferred because of its better efficiency along with less cost and time involvement. Also, it causes no mechanical damage to the crop that happens during manual weeding. Moreover, the control is more effective as the weeds even within the rows are killed, which invariably escape, because of morphological similarity to crop, during mechanical control. Effective weed control depends on the proper selection of herbicides depending on the type of weed flora infesting the crop and further herbicide should be applied at optimum dose and time using proper application technology.

Traditionally, weed control in India has been largely dependent on manual weeding. However, increased labour scarcity and costs are encouraging farmers to adopt labour and cost saving options. In recent decades the predominant weed control method in many parts of the world is the use of effective and reliable chemical herbicides. Among the pesticides sold, herbicides occupy 16% share in India (Choudhury *et al.*, 2016).

Jha *et al.*, (2014) observed that menace of broad leaved weeds in berseem could be curbed selectively and economically with pre emergence application of oxyfluorfen @ 0.100 kg a.i./ha + imazethapyr @ 0.15 kg a.i./ha (immediate after harvest of 1st cut). Similarly, post emergence (3 WAS) application of imazethapyr at 0.10 kg a.i./ha and butachclor at 1.5 kg/ha as pre-emergence were effective in controlling weeds at Hisar (Priyanka *et al.*, 2017). In the clay soil of Rahuri, pre-emergence application of oxyflourfen at 0.1 kg/ha followed by imazethapyr as post-emergence at 0.10 kg/ha effectively controlled weeds and it was found at par with one hoeing at 3 week after sowing and one hand weeding at 5 week after sowing and imazethapyr as post-emergence at 0.10 kg/ha (Pathan *et al.*, 2013). In sandy loam soils of Jharkhand where water is limiting factor pre-emergence application of pendimethalin at 0.3 kg a.i/ ha + imazethapyr at 0.1 kg a.i/ ha (after the first and second cut) was found effective to control weeds in berseem. Higher dose of pendimethalin at 0.5 kg a.i/ ha along with Imazethapyr at 0.1 kg a.i/ ha after first cutting reduces the growth of berseem (Kumar *et al.*, 2018). Fifty per cent reduction in berseem population was also observed due to phytotoxic effect of pendimethalin when applied as pre-emergence or at 7 days after sowing. However, post emergence application at 14 days after sowing was safe and produced the maximum green fodder yields (Mishra, 2012). Pre-emergence application of oxyflourfen at 0.1 kg/ha + imazethapyr at 0.10 kg/ha after first cut of berseem found most productive and remunerative in Pune region of Maharashtra (Kauthale *et al.*, 2016). Pre-emergence application of imazethapyr at 0.1 kg a.i./ha reduced the population of weeds including *Cichorium intybus* in Jhansi (Kumar and Dhar, 2008). However, post emergence application of imazethapyr after first and second cut was found effective for control of

weeds and obtaining higher yield and remunerations at Rahuri (Sinare *et al.,* 2017). However, in clay loam soils of Gurdaspur Punjab, application of fluchloralin at 0.45 kg/ha or oxyfluorfen at 0.1 kg/ha followed by imazethapyr at 0.075 kg/ha appeared more useful for effective weed control in berseem which resulted in maximum green fodder and seed yield (Chopra and Saini, 2017).

Integrated weed management

Integrated weed management (IWM) is an approach which involves the utilization of all weed control techniques (cultural, physical, biological and chemical) in a series to keep the weed population below the level of economic injury to crop. Kantwa *et al.,* (2017) recorded the lowest weed dry weight at first (29.81 g/m^2) and second cut (66.30 g/m^2) and highest total green fodder yield (3.61 t/ha) from stale seed bed (10 days before sowing) + propaquizafop at 0.1 kg a.i./ha as post emergence.

Effect of weed control measures on

Weed density

Berseem is severely infested with weeds, many workers reported more than 100 weeds in one m^2 area (Pathan *et al.,* 2012; Jha *et al.,* 2014; Kumar and Dhar, 2008). Pathan *et al.,* (2012) found 114 weeds/m^2 in weedy check plot, out of this 76 were monocot and 38 were dicot. Application of Oxyflourfen at 0.100 kg a.i.ha^{-1} reduced monocot, dicot and total weed count to 21.7, 8.3 and 30.3 m-2, respectively. Imazethapyr at 0.1 kg a.i. ha^{-1} immediate after harvest of Ist cut was found at par. However, application of imazethapyr at 0.1 kg /ha after first and second cut reduced the weed density from 101 to 33 at Rahuri (Sinare *et al.,* 2017). In sandy loam soil of Hisar, Priyanka *et al.,* (2018) observed the highest population of *Coronopus didymus* 8, 12.8 and 14.7 plants/m^2, at 30, 60 and 120 days after sowing in weedy check plot, respectively. Application of Imazethapyr at 0.1 kg/ha as pre emergence completely controlled the population of swine cress (Jha *et al.,* 2014). At Jhansi, Kumar and Dhar (2008) observed that out of 127 of total weeds/m^2 48 plants were chicory in weedy check plot. Imazethapyr at 0.1 kg/ha was found better to control chicory population followed by common salt treatment. However, tank mix of oxyflourfen at 0.10 kg/ha + imazethapyr at 0.10 kg/ha (immediate after harvest of Ist cut) reduced weed density than sole application of either (Kauthale *et al.,* 2016).

Weed dry weight

Highest weed dry weight (40.22 g/m^2) of weeds were recorded in weedy check plot at Ranchi. It was significantly reduced due to application of pendimethalin at 1.0 kg/ha + imazethapyr at 0.15 kg/ha immediate after 1st cut (Kumar *et al.,* 2017). However, oxyflourfen at 0.10 kg/ha or imazethapyr at 0.10 kg/ha immediate after harvest of Ist cut registered the lowest (0.05 t/ha) dry weight of weed at harvest in Pune (Kauthale *et al.,* 2016; Sinare *et al.,* 2017). In silty clay loam Pantnagar Physical method like one hoeing at 3 weeks + one hand weeding 5 weeks after sowing was reduced weed dry matter at par with pendimethalin at 1.0 kg a.i./ha + imazethapyr at 0.15 kg a.i./ha (Prajapati *et al.,* 2015).

Brajkishor *et al.,* (2015) found that, significantly less weed dry weight in case of Pendimethalin at 1.0 kg a.i./ha + Imazethapyr at 0.15 kg a.i./ha applied immediately after 1st cut. Total weed dry matter in weedy check plot was 560 kg/ha out of which 190 kg was chicory. Application of imazethapyr reduced to 100 kg/ha at Jhansi (Kumar and Dhar, 2008). However, at Pantnagar total weed dry matter was 215 g/m^2 in weedy plot and

butachlor at 0.1 kg/ha as pre emergence reduced it to 149 g/m^2 (Joshi and Bhilare, 2006).

Weed control efficiency

It indicates the efficiency of the applied herbicide or other practices to control weeds. It is the percentage reduction in weed dry matter by any weed control treatment in comparison to weedy check plot. This index is used to compare the different weed control treatments. Higher the WCE of any treatment, better is the treatment, and vice versa. Jha *et al.,* (2014) stated that WCE of oxyfluorfen at 0.100 kg a.i./ha PE + imazethapyr at 0.150 kg a.i./ha (72.3%) was almost similar to oxyfluorfen at 0.10 kg a.i./ha + one hand weeding at 5 weeks after sowing (69.29%). May workers also reported similar results (Pathan *et al.,* 2013; Sinare *et al.,* 2017; Kauthale *et al.,* 2016 and Prajapati *et al.,* 2015) used pendimethlin at 1.0 kg /ha instead of oxyfluorfen to control weeds and got higher WCE. Higher weed control efficiency with 2 hand weeding has been reported earlier (Aggarwal *et al.,* 2014). Application of imazethapyr at 0.1 kg/ha at 3 weeks after sowing (WAS) is able to control weeds to considerable extent (65-75%) (Priyanka *et al.,* 2018). However, Kumar *et al.,* (2017) managed more than 80% weeds through application of pendimethalin at 0.3 kg a.i./ ha. Singh *et al.,* (2010) tested alachlor 2.0 kg/ha and Joshi and Bhilare, (2006) tested Butachlor at 1.0 kg ai/ha as PE and found higher weed control efficiency (70-83%).

Growth and yield components

It is well known fact that weeds adversely affects yield and quality of fodder. Application of herbicides not only improves fodder yield but also quality. Kumar *et al.,* (2017) recorded 479 q/ha green fodder yield with pendimethalin at 1.4 kg ai/ha as against 310 q/ha in weedy plot. However, Samunder (2012) reported highest green fodder yield with the application of trifluralin at 0.75 kg/ha which was statistically similar to weed free plot. Pre-emergence application of oxyflourfen at 0.10 kg/ha followed by post-emergence application of imazethapyr at 0.10 kg/ha immediate after harvest of Ist cut recorded significantly higher yield values of green fodder (Kauthale *et al.,* 2016). Agrawal *et al.,* (2001) also registered the highest green fodder yield with pre-emergence application of butachlor at 1. 5 kg ha^{-1} and it was comparable to hand weeding twice. Similarly, Tiwana *et al.,* (1985) obtained 29 and 31% higher green and dry matter yields of berseem with fluchloralin at 0.6 kg ha^{-1} over the weedy plot, respectively. Application of imazethapyr at 0.1 kg/ha improved green fodder yield by about 76% over weedy check at Jhansi (Kumar and Dhar, 2008). Pathan and Kamble (2012) observed that berseem plants in weedy plots were taller than herbicide treated. Higher weed density created more completion for the sunlight with the berseem crop resulted in more plant height in weedy check.

Economics

The application of imazethapyr at 0.1 kg a.i./ha found to be the most remunerative and effective herbicide for controlling the complex weed flora in berseem at Jhansi (Wasnik *et al.,* 2017; Kumar and Dhar, 2008; Priyanka *at el,* 2017). Similarly, Sinare *et al., (*2017) also recorded maximum mean gross returns (□ 96,520/ha), net returns of (□ 48,970/ha) and B-C ratio (2.09) were recorded due to application of imazethapyr at 0.1 kg/ha after 1st and 2nd cut. However, Kauthale *et al.,* (2016) tried combination of two herbicides at Pune, pre-emergence application of oxyflourfen at 0.10 kg/ha and post-emergence application of imazethapyr at 0.10 kg/ha immediately after Ist cut recorded maximum net monetary returns (□

1,34,048/ha) and B:C ratio (3.43). Pathan *et al.*, (2012) also obtained similar results in Rahuri, while, Kewat *et al.,* (2005) realised higher monetary returns with butachlor at 2 kg ai/ha as pre-emergence application.

Weeds deplete a large quantity of mineral nutrients, moisture, shade the crop (light interception) and occupy the space. Berseem field is most predominantly affected by Dicotyledonous weeds. The above stated review results reveals that, weeds should be controlled for successful crop production. The suitable weed control strategies like cultural control, mechanical methods, herbicide adoption and integrated approaches or individual will significantly decrease the weeds, which will lead to even greater yields. Chemical weed control is getting importance in areas, where labour is scarce and costly. Some of the herbicides either alone or their combinations at lower dose have been proved economically viable alternative to hand weeding in management of weeds in berseem field. However, integrated weedmanagement is the key to sustainable crop production throughout the world and will remain the mainstay for weed control for the foreseeable future.

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