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WEED MANAGEMENT IN CULTIVATED FODDER CROPS – A REVIEW

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SUMMARY

Fodder crops are essential to agriculture because they are grown mainly for animal feed. These crops, which include legumes and grasses, are essential to keeping animals' diets steady and wholesome. One of the main causes of the cattle population's low productivity is the lack of enough feed and fodder resources. In India green fodder, dry fodder, and feed concentrate are currently in low supply to the tune of 11.23, 23.40 and 28.90%, respectively. A major problem in agriculture, weeds lower crop productivity and quality, including fodder crops, and result in large financial losses. They are one of the major biotic constraints in agricultural production. Fodder crops, such as alfalfa, clover, and various grasses, are integral to livestock farming as they provide essential nutrition for animals. However, weed infestation significantly hampers fodder yield and quality by competing for nutrients, water, light, and space. Effective weed management is vital to ensure optimal fodder crop productivity. This review presents an overview of weed problems in cultivated fodder crops, evaluates various weed management strategies including cultural, mechanical, chemical, and integrated approaches and outlines future research priorities.

Key words: Berseem, fodder, maize, sorghum, weed management

In agriculture, fodder crops are essential since they are grown mainly for animal feed. These crops are vital for giving animals a balanced diet since they are high in vital nutrients such vitamins, minerals, proteins, and carbs. The numerous advantages of fodder crops make them essential in contemporary agriculture. But, India is now experiencing shortages of green fodder, dry fodder, and feed concentrate to the tune of 11.23%, 23.40%, and 28.90%, respectively (Roy *et al.*, 2019). Livestock plays a vital role in agriculture and directly contributes 4.1% of the nation's GDP in the country. Even though India only makes up 2.29% of the world's land area, it leads the world in maintaining the greatest livestock population, according to the 20th livestock census. 8.4 million hectares, or 5.23% of India's total land area, are used for the production of green fodder. Over the previous 20 years, this crop area has hardly changed (Koli and Bhardwaj, 2018). One of the main causes of the cattle population's low productivity is the lack of enough feed and fodder resources. For these animals' nutritional demands, fodder crops like sorghum, maize, bajra, and other legumes are grown. Livestock productivity, milk yield and quality, meat production, and general animal health are all intimately correlated with the availability of fodder. Berseem, cowpea, and lucerne are examples of legumeous fodder crops that are essential for nitrogen fixation, improving soil fertility and lowering the demand for synthetic fertilizers.

Weed infestation in fodder crops causes a significant decline in biomass production and compromises fodder quality. Since fodder crops are grown for quick vegetative growth and high biomass, timely weed management is crucial to optimize productivity. The study explores prevalent weeds, their impact, and management strategies in key cultivated fodder species. Crop yield and nutrient uptake are considerably diminished due to increased crop-weed interference. As per available estimates, the weeds cause up to one-third of the total loss in crop yield, in addition to impairing produce quality and posing various health and environmental hazards. Weeds account for about one-third of the total losses caused by agricultural pests (DWR, 2015). Similar to grain crops, weeds are also considered a major constraint in fodder crop production. Weeds possess several characteristics that

give them advantages over fodder crops. Weeds with high dry matter accumulation capacity offer strong competition to fodder crops for growth factors from the emergence of seedlings. Maximum crop-weed competition occurs up to 4-5 weeks in most seasonal forage. The losses caused by weeds vary with the season, crop, and variety. An estimated 8,000 plant species are believed to behave as weeds in agriculture, with about 250 species considered potentially dangerous (Westbrooks, 1998). Early-stage weed control in fodder crops is crucial for better establishment.

Weed management is a critical aspect of ensuring the efficient use of resources, optimal growth, yield of fodder and maintaining the quality of fodder crops. Effective weed management strategies include mechanical, chemical, and biological control methods. Mechanical methods, such as tillage and mowing, physically remove weeds from the crop field. Chemical control involves the use of herbicides to target specific weed species without harming the fodder crops. Biological control methods employ natural predators or pathogens to reduce weed populations (Swanton & Weise, 1991). By implementing these strategies, farmers can enhance the productivity and profitability of fodder crops, contributing to the overall success of their farming operations. Since, very limited information is available about weed flora and their management in fodder crops, and considering that weeds are the major constraints in fodder crop cultivation, generating data on weed flora and weed management in fodder crops is essential.

Losses due to weeds

Weeds are a significant challenge in agriculture, causing substantial economic losses and reducing the productivity and quality of crops, including fodder crops. Furthermore, the costs associated with managing herbicide-resistant weeds can be substantial, adding to the financial burden on farmers (Heap, 2014). Although, fodder crops are less affected by weed menace than grain crops as they are grown more densely. Even than in *kharif* season, major fodder crop like sorghum bear 33% loss in fodder productivity in the absence of weed control (Satpal *et al*., 2021). In pearl millet, loss in yield of 27.6% was reported from 72 trials at farmer's fields (Ghard*eet al*., 2018). Weeds not only deteriorate fodder quality but also decrease fresh fodder yield of berseem by 23-30 per cent and its seed yield up to 50 per cent in silty loam soils (Alfred, 2012 & Joshi and Bhilare, 2006).

Fodder yield: In fodder cultivation, weeds compete with the main crop for essential resources such as nutrients, water, light, and space, leading to reduced fodder yield and quality. Weeds also act as hosts for pests and insect that affect fodder crop, and indirectly lower the quality and market value of harvested fodder crop. Studies have shown that season long weed infestations and competition with crop can considerably reduce fodder crop yields, depending on the type of weed and the level of infestation (Dalley *et al*., 2006). The losses caused by the weeds vary with the season, crop and variety. It is estimated that a 1% reduction in the market value of forage crops occurs if there is a 1% weed population in the field or if weed seed is combined with harvested crop (Colbach *et al*., 2019). Generally, there is a 20-25% value reduction in marketed feed if forage plants are combined with 1/4 weeds. In fodder maize, weeds are thought to be responsible for 37% yield reduction, globally (Oerke and Dehne, 2004). The loss in fodder yields due to weed competition has been reported to the extent of 11.7% in lucerne and 8.3% in oat. In crop like sorghum, magnitude of yield loss was as high as 54%. In berseem, the extent of yield reduction due to weed flora has been estimated to the extent of 23 to 28% in case of green fodder yield and 38 to 44% in case of seed yield (Wasnik *et al*., 2017).

Fodder quality: Weeds not only reduce the quantity of fodder but also adversely affect its quality. The presence of weeds in fodder crops can lower the nutritional value of the harvested fodder (Arif *et al*., 2006), making it less palatable and nutritious for livestock (DiTomaso, 2000). Weeds such as nutgrass (*Cyperus rotundus*) and wild mustard (*Sinapis arvensis*) have lower digestibility and nutritional content compared to high-quality fodder crops like alfalfa and clover. They can also alter the taste of milk when they are ingested by dairy cows, or they can decrease the quality of wool when they get caught in sheep's fleece. *Celosia argentea* enabled the weed to compete successfully with fodder sorghum and the weed also attained the height higher than fodder sorghum. The *Celosia argentea* interfered in harvesting operation and reduced the quality of green fodder sorghum as the weed got mixed with the harvested fodder sorghum. Weeds result in a considerable reduction in the efficiency of input used and quality (Yaduraju and Mishra, 2018).

Indirect effects on livestock and human health: Some of them can cause allergic reactions in humans or animals, such as skin rashes or respiratory problems. Others can be poisonous if ingested or

Fig. 1. Weeds infestation in fodder crops

touched. For example, plants like ragwort (*Senecio jacobaea*) and bracken fern (*Pteridium aquilinum*) contain toxins that can lead to liver damage and other health issues in livestock. The presence of such toxic weeds in fodder crops can result in increased veterinary costs and loss of livestock.

Therefore, in order to obtain a good sale value and yield, weeds in feed are a significant limiting factor that must be managed (Kumar *et al*., 2012). Proper weed control also minimizes the spread of invasive species, contributing to sustainable agricultural practices (Singh *et al*., 2019). But before choosing a control strategy, understanding the weed life cycle is crucial. There are three main categories of weeds: biennial, annual, and perennial

A biennial weed germinates in the first year and sheds seeds in the second year, completing its life cycle in two years (Farmwest, 2020). In forage crops, they cause less of an issue than annual weeds. Annual weeds complete growing in a single year e.g. *Trianthema*. Summer annual weeds prefer warm, humid climates. They are typically found in the C_4 group and are tolerant of dryness. In contrast, winter annual weeds can withstand high humidity and cold temperatures. They are dormant during the winter after germinating in the winter, growing vegetative in the spring, and flowering and seeding in the summer. Perennial weed continues their life cycle for several years. They possess storage structures like onion, stolons, tubers, and rhizomes.

3. Weed flora in *rabi* and *kharif* fodder crops

The dominant and associated weed flora with different *rabi* and *kharif* fodder crops are listed in Table 1.

Methods of weed management

Preventive Measures

Prevention is an initial step of weed management. In this method all-curative measures are taken to prevent the introduction/entry of weeds to crop field (entirely new locality) by stopping multiplication and movement. preventive measures like use weed free crop seeds, application of well decomposed FYM and compost, Restricting use of weed seeds containing field soil, separation of weed seed by salt solution and use clean machinery should be adopted in the field.

Eradication

Eradication is the complete removal of weeds/ vegetative parts from the field. It is one of the most expensive methods of the weed management. Complete eradication of weeds is not feasible in the field conditions because of presence of huge seed bank in the soil. This practice is generally adopted in the areas of high value such as green houses, ornamental plant beds etc.

Control

It includes methods that lessen but do not always completely eradicate weed infestations. When using control measures, the crop produces a regular yield even if the weeds are rarely killed and their growth is severely inhibited. The characteristics of the weeds involved and the efficiency of the applied control strategy, in general, determine the level of weed control that is achieved. It can be achieved by various ways such as physical, mechanical, cultural, chemical and biological ways.

Cultural Methods

In the cultural method of weed control, the competitive ability of crops is increased against the weeds. Cultural methods do not provide complete weed control but it helps in weed suppression by furnishing a competitive advantage to crops by utilizing light, moisture, nutrients and space. Timely adoption of appropriate cultural methods can reduce weed density and weed competition. Some cultural practices which can be easily adopted in farmers' fields such as use of Optimum seed rate and maintain proper crop stand, choose suitable method of sowing (prefer line sowing

TABLE 1
Dominant and associated weed flora with different fodder crops

Associated fodder crops	Weed flora
***Kharif* season**	
Maize	*Coccinia grandis, Cleome viscosa*
Sorghum	*Celosia argentea, Coccinia grandis, Cleome viscosa*
All the fodder crop (during pre-*kharif* and *kharif* season): Sorghum, Maize, Pearl millet, Guar, Cowpea	*Trianthema spp: Trianthema portulacastrum, Trianthema monogyna* ***Grasses*: *Brachiaria ramose, Eleusine indica, Echinochloa colona, Digitaria sanguinalis*** **Sedges:** *Cyperus esculentus, Cyperus iria, Cyperus rotundus* **Broadleaved:** *Trianthema portulacastrum, Trianthema monogyne, Amaranthus viridis*
Rabi season	
Berseem (*Trifolium alexandrinum*)	**Grass:** *Poa annua*
Oat (*Avena sativa*)	**Broadleaved weeds:** *Coronopus didymus, Rumex dentatus, Cichorium intybus* **Grass:** *Poa annua* **Broadleaved:** *Rumex dentatus*

of crops rather than broadcasting for easy management of weeds), crop rotation, mixed/intercropping etc.

Continuous growing the same crop in same field may increase the population of crop associated and crop bound weeds, therefore the crop should be rotated with another suitable alternate crop. Repeated sowing of berseem in the same field increases the population of the crop-associated and crop-bound weeds. Bringing the berseem seed production fields to oat seed production fields helps in breaking the crop-associated (Chicory, lesser swinecress, toothed dock, persian clover, bur clover, annual yellow sweet clover, white sweet clover and fields purry) and crop bound (dodder) weeds life cycle. According to crop, crop rotation not only changes the crop in field but also changes the tillage, soil preparation practices and weed management techniques. Fodder sorghum can also be replaced with fodder cowpea for the control of *Celosia argentea*. Almost 86% reduction in seed production of *C. argentea* due to turning the land to cowpea was recorded (Mukherjee *et al*., 2019).

Intercropping cereals with legumes for forage production is a common practice worldwide. This approach improves the quality of green fodder and suppresses weed growth due to the smothering effect of leguminous plants, resulting in a yield advantage (Poggio, 2005). Intercropping is a cultural practice that enhances competition between crops and weeds by increasing light interception through a less competitive crop, resulting in effective weed suppression (Baumann *et al*., 2001). Results revealed that mixed cropping of maize (Variety 'African Tall') + cowpea (Variety 'Bundel Lobia 2') (50% seed rate of both the crops) reduced infestation of *Trianthema* sp. considerably. According to Bilalis *et al*, (2010), the lowest weed density was observed in in maize–bean and maize–cowpea intercrops as compared to sole crops. Prasad and Brook (2005) reported that during the early growth period of maize, its canopy is not able to intercept all incoming solar radiations, and the remaining radiation is captured by the intercrop growing under the maize. Growing of maize and cowpea simultaneously in intercropping systems suppressed the weed growth more than monocultures (Mishra, 2019). Less weed density by intercropping maize and legumes compared with the mono-cropped maize by blocking the availability of light for weeds was also reported by Bilalis *et al*., (2010). Verma *et al*., (2015), reported higher weed control efficiency more than 80% and a weed index between 17.60 to 11.37% in maize and cowpea intercropping systems grown for quality fodder. Growing berseem + gobhi sarson/ rye (at the seed rate of 600 g/ha) as mixed cropping offered strong competition to *C. didymus* and prevented its growth and spread within berseem (Mukherjee *et al*., 2019).

Mechanical/Physical Methods

Mechanical or physical methods of weed control are being used since man started growing crops. Under mechanical weed control weeds are killed using farm implements or by physical force. The practices generally adopted are stale seedbed (light irrigation allows weeds to germinate followed by physical manipulation of soil to destroy the weeds), chemical seedbed (after the emergence of weeds chemical method of weed control is used to control the weeds), hand weeding, cutting etc. Cutting is an essential practice for green fodder harvesting. The fodder crop is left for seed production after taking two or three cuttings for green fodder. In each cutting

10-12% reduction in most of the small and annual weeds population has been observed which do not have regeneration capacity. The highest fodder sorghum yield was obtained with two hand weeding at 20 and 30 days after sowing, although the results was at par with chemical weed management, where, atrazine (0.375 kg *a.i.*/ha) and pendimethalin (0.750 *a.i.* kg/ha) were applied as pre-emergence. But maximum yield of multi cut-fodder was obtained with two hand weedings (Singh *et al.*, 2019). In cluster bean also two hand weeding at 20 and 35 DAS proved to be most effective method to control weeds infestation (Dhaker *et al.*, 2009).

Chemical Methods

In the present scenario among all the other weed control methods chemical method is a very effective method of weed control. Chemicals are cheap, readily available and provide broad spectrum weed control. The chemicals used for weed control are known as herbicides. Weeds can be managed in different fodder crops as under.

Berseem: Weed infestation can be minimized by treating the crop seeds with 10% common salt solution followed by cleaning the seeds with fresh water resulted in good management of chicory in berseem. Cultural practices like summer deep ploughing also found effective for the management of weeds in Berseem. Imazethapyr as PRE and PoE found effective for the management of weeds in berseem among various studies. Wasnik *et al.* (2020) reported that imazethapyr @ 100 g/ha (20 DAS) resulted in lowest weed density and highest weed control efficiency in berseem. Shrivastava *et al.* (2022) reported that butachlor, trifluralin, fluchloralin, imazethapyr, oxyflourfen, and pendimethalin can be used for the management of weed flora in the berseem crop. The persistence of these herbicide varies in the soil based on various factors like chemistry of the chemical, soil fauna, environmental factor etc. Butachlor persists up to 100, fluchloralin 243, imazethapyr 90-240, oxyflourfen 60-80, and pendimethalin 60-200 days in soil. Butachlor has 5-24, fluchloralin 12-46, imazethapyr 57-71, oxyflourfen 12-29 and pendimethalin 55-77 days' half-life. The application of herbicides influences soil environment by affecting soil flora and fauna. However, the chemical weed control is widely accepted method due to its cost-effectiveness and timely control of weed flora. It also cut down the yield losses.

Fodder maize: Mukherjee *et al.*, (2019), reported that PRE application of atrazine at 0.75 kg ha^{-1} showed crop selectivity and found effective for the management of weeds in fodder maize. However, atrazine residues were found from 0.008 to 0.531ìg g^{-1} in the green fodder maize at 60 days after application. Kaur *et al.*, (2016), reported that directed spray of non-selective herbicides, paraquat 500 g/ha and glyphosate at 900 g/ha and 1800 g/ha at 2-4 leaf stage resulted in good control of grassy and broad-leaf weeds in maize. Baldaniya *et al.*, 2018, recorded the lowest weed index and highest weed control efficiency (76.5%) under two hand weeding (at 20 and 40 DAS) followed by atrazine 0.5 kg/ha + topramezone 0.025 kg/ha (TM) at 20 DAS (73.9%). Significantly higher green and dry fodder yield was (785 q/ha and 269 q/ha, respectively) was recorded under two hand weeding's (at 20 and 40 DAS) which was found statistically at par with application of atrazine 0.5 kg/ha + topramezone 0.025 kg/ha (TM) at 20 DAS (748 q ha^{-1} and 249 q/ha, respectively).

Pearl millet: Pre emergence application of atrazine @ 0.5 kg *a.i.*/ha in 450 L of water was found effective for the management of broadleaf weeds and some annual grasses, resulting in reducing crop-weed competition during the early growth stages (Bhuva and Detroja, 2018; Samota *et al.*, 2022). Kumar *et al.*, (2024) reported that one hoeing through weed-cum mulcher at 3-4 weeks crop stage resulted in significant reduction in weed biomass, improves crop yields by 20-40% as compared to unweeded controls. Munny *et al.*, (2023) recorded at among chemical weed management practices, PRE application of atrazine 0.75 kg/ha followed by 2,4-D 0.75 kg/ha (PoE) was the most effective sequential application for the management of mixed flora in pearl millet resulted in 77.5% WCE.

Sorghum: Singh *et al.*, 2019, reported that PRE application of atrazine @ 0.375 kg a.i./ha + pendimethalin @ 0.750 kg a.i./ha (TM) resulted in significantly reduction in total weed density and dry weight of weeds. This combination was found effective for the management of weeds in sorghum for longer duration. Kumar *et al.*, in 2008 reported that sequential application of atrazine @ 0.5 kg/ha (PRE) followed atrazine @ 0.5 kg/ha at 10 days after sowing resulted in highest weed control in fodder sorghum and found effective for the management of *Cyperus* species and *Echinochloa colona.* Priya and Kubsad (2013) achieved maximum benefit to cost ratio with integrated weed management practices which includes pre-emergence application of atrazine @ 0.5 kg/ha followed by 2,4-D application @ 0.75 kg/ha as post-emergence (20 days after sowing) and inter-cultivation at 30 days after sowing.

Cluster bean: Dhaker *et al.*, (2009), reported that IWM practices were found effective for the management of weeds in cluster bean. PoE application of imazethapyr at 100 g/ha (20 DAS) followed by one hand weeding at 35 DAS resulted in higher weed control efficiency and lower weed index. Weeds can be managed on later stages with weeder cum mulcher at 3-4 week crop stage (Science Direct, 2005). Application of imazethapyr + imazamox (RM) 70 g/ha at 21 DAS produced highest seed yield of cluster bean which was at par with imazethapyr 70 g/ha as PRE (Kumar *et al*., 2024).

Cowpea: Weeds can be easily managed in cowpea with the application of herbicides. Application of pendimethalin as pre-emergence @ 0.75 kg/ha, followed by hand weeding at 20-25 days after sowing is effective against major weed flora of cowpea (Hanumanthappa., 2012). Oluwafemi and Abiodun, (2016) reported that application of pendimethalin three days before planting were effectively controlled weeds and help in attaining highest cowpea yield.

Oat: Weeding with weeder cum mulcher at 4-week crop stage followed by application of 2,4-D @ 0.50 kg *a.i*/ha at 30-35 DAS resulted in better management of weeds in fodder oat. ICAR-IIPR (2023) recommends mechanical weeding at 3-4 weeks after sowing for row crops like pulses, applicable to oats, using weeders to control early weed growth and conserve soil moisture.

Lucerne: Use pre-emergence herbicides like trifluralin (a dinitroaniline herbicide, e.g., Treflan, Tristar; inhibits microtubule formation, preventing weed seed germination and root growth) to control grassy weeds. Crop rotation with non-leguminous crops can also be adopted to control weeds. UC IPM (2023) also recommends trifluralin at 0.56–0.75 kg a.i./ha as a pre-plant incorporated herbicide for controlling grassy weeds in lucerne, with guidelines for soil incorporation and crop safety.

CONCLUSION

Weeds pose a significant threat to fodder crop production, leading to substantial losses in yield, quality, and farm profitability. Weed management is crucial for the successful cultivation of fodder crops. Effective weed management strategies, such as cultural practices, mechanical control, chemical control, biological control, and integrated weed management, can help mitigate these issues. Ensuring the health and productivity of fodder crops allows farmers to provide high-quality feed for livestock, contributing to sustainable and profitable agricultural practices.

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