Indian Journal of Weed Science (2023) **55**(2): 141–148
http://dx.doi.org/10.5958/0974-8164.2023.00025.4

REVIEW ARTICLE

A review on weed management in millets

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Received: 1 June 2023 | Revised: 19 June 2023 | Accepted: 21 June 2023

ABSTRACT

In recent years, millets have been recognized as nutri-cereals and given much needed impetus for their cultivation by national and international policies. Millets are cultivated mostly under rainfed conditions and under-nourished soils which makes them more susceptible to weed competition losses. Grasses, sedges and broad-leaved including parasitic weed *Striga* infest millet crops. Weeds cause millets yield reduction of 15-97%. It is essential to control weeds during the critical period of crop-weed competition which may be 15-42 days after sowing. Weed management in millets mostly relies on the cultural and mechanical methods due to lack of selective herbicides for usage in these crops, especially the minor millets. Integration of several methods is required to obtain optimum weed management and millet crops yield. Weed competitive crop varieties, reduced spacing, optimum fertilizer dose and placement, mulching with crop residues, inter-cropping, cultural and mechanical methods and use of selective herbicides is the appropriate strategy for weed management in millets. *Striga* management through resistant varieties, crop rotation, catch crops, herbicide use and herbicide resistant varieties may be opted based on the suitability of the methods.

Keywords: Millets, Sorghum, Pearl millet, Finger millet, Kodo millet, Barnyard millet, Foxtail millet, *Striga*, Weed management

INTRODUCTION

Millets are a group of small seeded cereal crops cultivated for grain and fodder purposes. They are considered to be the earliest domesticated crops in human civilization. The earliest domestication of common millet (*Panicum miliaceum*) in East Asia extended to 10,000 years ago (Lu 2009). Mostly, millets are cultivated in parts of tropical and semi-arid regions of the world. These crops are an important source of food and fodder for millions of resource-poor farmers in the world. There are several types of millets, categorized as major, minor and pseudo-millets (**Table 1**). In India, during the past 50-60 years their cultivation and consumption has reduced due to availability of high yielding varieties of rice and wheat and changes in food habit. However, in recent years, owing to their high nutritional values, low glycemic index, awareness to millets as nutri-cereals has increased and they are in high demand again. Millets are climate-resilient crops highly tolerant to drought stress and high temperature, also they need less inputs and management. Therefore, under the changing climate scenario, these crops are more suited to arid and semi-arid regions. India is the leading millet producing country with a share of around 80% of Asia's and 20% of the global production (FAO 2021). Among millets, pearl millet has the highest area of cultivation followed by sorghum and finger millet (**Table 2**). There is ample scope to enhance the area of millet cultivation under different agro-ecological zones based on suitability to climate.

In spite of high yield potential of some of the small/minor millets like finger millet, kodo millet and barnyard millet, the productivity is still quite low, which needs to be increased through development and adoption of better genotypes and improved management practices. Cultivation of millets is beset with many biotic constraints; weeds are the major

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Table 1. Diversity in millets

Scientific name	Common name	Local name
Major millets		
Sorghum bicolor (L.) Moench	Sorghum/Great millet	Jowar
Pennisetum glaucum L.	Pearl millet	Bajra
Minor millets		
Eleusine coracana L. Gaertn.	Finger millet	Ragi, Mandua
Paslpalum scrobiculatum L.	Kodo millet	Kodon
Echinochloa frumentacea L.	Barnyard millet	Sanwa
Panicum sumatrense Roth ex. Roem. and Schult.	Little millet	Kutki
Setaria italica L.	Foxtail millet	Kakun
Panicum miliaceum L.	Proso millet	Chena, Barri
Panicum ramosa L.	Brown-top millet	Korale
Pseudo-millets		
Fagopyrum esculentum L.	Buckwheat	Kuttu
Amaranthus viridis L.	Amaranthus	Chaulai

Table 2. Area, production and productivity of millets in India (2020-21)

Crop	Area (mha)	Production (mt)	Yield (kg/ha)
Pearl millet	7.65	10.86	1420
Sorghum	4.38	4.81	1099
Finger millet	1.16	1.99	1724
Other minor millets	0.44	0.35	781
Total	13.63	18.01	

(Source: https://apeda.gov.in/apedawebsite/index.html)

ones. Therefore, an understanding of the nature of weed problems and their possible management options is very important. In this paper, the recent information on various aspects of weed management in millets has been reviewed.

Weed flora infesting millets

Millets are generally grown in rainy season which favours abundant growth of weeds. All types of weeds, *viz*. grasses, sedges and broad-leaved infest the millet crops during their early phase of growth (**Table 3**). The weed flora infestation, their intensity of competition with the crop varies with the geographic regions, soil and weather conditions and also the field and crop management practices (Stahlman and Wicks 2000; Mashingaidze *et al*. 2012). *Echinochloa colona* (L.) Link. (jungle rice), *Echinochloa crus-galli* (L.) Beauv. (barnyard grass), *Eleusine indica* (L.) Gaertn. (goose grass), *Digitaria sanguinalis* (L.) Scop. (crab grass) and *Sorghum halepense* L. Pers. (johnson grass) among grasses; *Amaranthus palmeri* S. Wats (Palmer amaranth), *A. retroflexus* L. (Redroot pigweed), *Celosia argentea* L. (white cock's comb), *Trianthema portulacastrum* L. (horse weed), *Tribulus terrestris* L. (puncture vine), *Boerhaavia diffusa* L. (hog weed), *Acanthospermum hispidum* DC (Bristly starbur) among broad-leaved; *Cyperus rotundus* L. among sedges, and *Striga asiatica* (L.) Kuntze. and *S. hermonthica* (Del.) Benth. (Witch weed) are the most common weeds of millets worldwide. In sorghum, grasses i.e., *Echinochloa*, *Panicum*, *Digitaria*, and *Sorghum halepense* are considered to be the most common and troublesome weeds (Limon-Ortega *et al.* 1998; Peerzada *et al.* 2017). Carpetweed (*Trianthema portulacastrum*) was also reported to be the dominant (more than 28%) weed in pearl millet crop (Deshveer and Deshveer 2005). Girase *et al.* (2017) recorded grassy weeds like *Cynodon dactylon, Brachiaria eruciformis*; broad-leaved weeds like *Parthenium hysterophorus, Commelina benghalensis, Celosia*

Table 3. Major weeds in millet crops

Crop	Major weeds	References
Sorghum	*Sorghum halepense* (L.) Pers., *Ipomoea purpurea* (L.) Roth., *Amaranthus* spp., *Digitaria sanguinalis* (L.) Scop., *Echinochloa crus-galli* (L.) P. Beauv., *Sida spinosa* (L.), *Urochloa platyphylla* (Nash.), and *Senna obtusifolia* (L.) Irwin and Barne	Smith and Scott 2010
	Echinochloa crus-galli, Cynodon dactylon, Sorghum halepense, Digitaria sanguinalis, Amaranthus viridis, Alternanthera pungens, Digera arvensis, Convolvulus arvensis, Vernonia cinerea, Eclipta alba, Trianthema portulacastrum, Euphorbia hirta, Physalis minima and *Cyperus rotundus*	Verma *et al.* 2018
Pearl millet	*Trianthema portulacastrum, Tribulus terrestris, Cyperus rotundus, Amaranthus viridis, Amaranthus spinosus, Cyperus compressus, Euphorbia* spp., *Echinochloa colona* and *Cynodon dactylon*	Deshveer and Deshveer 2005
	Cynodon dactylon, Echinochloa crus-galli, Brachiaria ramosa, Eluropus villosus, Amaranthus viridis, Digera arvensis, Euphorbia hirta, Boerhaavia diffusa, Acanthospermum hispidum, Commelina benghalensis, Portulaca oleracea and *Cyperus rotundus*	Mathukia *et al.* 2015
	Cynodon dactylon, Brachiaria eruciformis, Parthenium hysterophorus, Commelina benghalensis, Celosia argentea, Panicum isachne, Amaranthus viridis, Euphorbia microphylla, Phyllanthus niruri, Alteranthera triandra and *Cyperus rotundus*	Girase *et al.* 2017
Finger millet	*Cyperus rotundus* L. *Cynodon dactylon* (L.) Pers. *Commelina benghalensis* L. *Ageratum conyzoides* L. *Dactyloctenium aegyptium* (L.) Willd. *Echinochloa colona* (L.) Link, *Digitaria marginata* Stapf, *E. indica. Acanthospermum hispidum* DC. *Spilanthes acmella* (L.) Murray, *Eragrostis pilosa* (L.) *P. Beauv. Parthenium hysterophorus* L. *Amaranthus viridis* L. *Alternanthera sessilis* (L.) R. Br. ex DC. *Celosia argentea* L. *Euphorbia hirta* L. and *Leucas aspera* (Wild.) Link, *Ocimum canum* Sims	Rao 2021
Kodo millet	*Brachiaria reptans, Acrachne racemosa, Dactyloctenium aegyptium, Panicum repens* under grasses, *Cyperus rotundus* under sedge and broad-leaved like *Trianthema portulacastrum, Boerhaavia diffusa, Parthenium hysterophorus, Digera arvensis* and *Tribulus terrestris*	Vinothini and Arthanari 2017
	Cyperus rotundus, Cynodon dactylon, Brachiaria ramosa, Chloris barbata, Dactyloctenium aegyptium, Digitaria marginata, Eleusine indica, Echinochloa colona, Ageratum conyzoides, Alternanthera sessilis, Commelina benghalensis, Cinebra didema, Euphorbia hirta and *Syndrella nodiflora*	Lekhana *et al.* 2021
Little millet	*Echinochloa colona, Enhinochloa crus-gulli, Dactyloctenium aegyptium, Eleusine indica, Setaria glauca, Cynodon dactylon, Cyperus rotundus, Celosia argentea, Commelina benghalensis, Phyllanthus niruri, Solanum nigrum* and *Amaranthus viridis*	Chapke *et al.* 2020
Barnyard millet	*Echinochloa colona, Echinochloa crus-galli, Dactyloctenium aegyptium, Eleusine indica, Setaria glauca, Cynodon dactylon, Phragmites karka, Cyperus rotundus, Sorghum halepanse, Celosia argentea, Commelina benghalensis, Phyllanthus niruri, Solanum nigrum* and *Amaranthus viridis*	Chapke *et al.* 2020
Foxtail millet	*Echinochloa colona, Cynodon dactylon, Echinochloa crus-galli, Eleusine indica, Dactyloctenium aegyptium, Sorghum halepense, Amaranthus viridis, Commelina benghalensis, Celosia argentea, Phyllanthus niruri, Solanum nigrum* and *Cyperus rotundus*	Prabhakar *et al.* 2017

argentea, Panicum isachne, Amaranthus viridis, Euphorbia microphylla, Phyllanthus niruri, Alternanthera triandra; and sedge *Cyperus rotundus* in pearl millet. In the U.S. central Great Plains, Reddy *et al.* (2014) reported Canada thistle [*Cirsium arvense* (L.) Scop.], kochia [*Kochia scoparia* (L.) Schrad.], redroot pigweed (*Amaranthus retroflexus* L.), green foxtail [*Setaria viridis* (L.) Beauv.], and palmer amaranth (*Amaranthus palmeri* S. Watson) as the most common troublesome weeds interfering with millet crops. *Striga* is a major biotic constraint that causes considerable crop damage in millets in the semi-arid tropics. *Striga hermonthica* is a serious weed in the dry savannas of sub-Saharan Africa. Striga infestation in sorghum is reported to be higher in Nigeria than in other West African countries with about 80% of land cropped to sorghum infested by this weed (Mamudu *et al.* 2019).

Losses due to weeds

Weeds successfully compete with the crop, harbour insect pests, and create problems at harvest (Zimdahl 1999, Ottman and Olsen 2009). They compete with crop plants for nutrients, water, sunlight and space, thereby inflict huge loss in soil nutrients and crop yields. The extent of yield loss depends upon the weed flora, time of infestation, soil type, rainfall and management practices followed. In pearl millet, loss in yield of 27.6% was reported from 72 trials at farmer's fields, in sorghum, 23.5–27.4% actual yield losses were observed in the farmers' fields whereas, 35–50% potential yield losses were recorded in weedy condition (Gharde *et al.* 2018). Sharma and Jain (2003) reported up to 40% loss in grain yield due to weed competition in pearl millet. Weeds are a major constraint decreasing the yield and quality of sorghum (Geier *et al.* 2009). In the early development stages, sorghum plants are relatively small, fragile and has slow growth (Silva *et al.* 2014). Competition with weed at this stage is quite critical, and if control measures are not taken in the first few weeks after the emergence of sorghum plants, grain yield can be reduced by around 35-70% (Rodrigues *et al.* 2010). Losses in grain yield from 15 to 97% in sorghum under different climatic conditions were reported by Peerzada *et al.* 2017. In finger millet, loss in yield could be in the range of 5-70% (Prasad *et al.* 1991, Kumara *et al.* 2007, Rao and Chauhan 2015, Mishra *et al.* 2016, Rama Devi *et al.* 2021). In central India, the yield loss due to weeds in finger millet was estimated to be 46.6 to 68.1%, in kodo millet 56.6 to 67.3%, in little millet 59.6% and in barnyard millet it was 63.5% (ICAR-DWR 2021).

Weeds may remove 29.94–51.05, 5.03–11.58 and 48.74–74.34 kg/ ha nitrogen, phosphorus and potassium, respectively from the soil in sorghum crop (Satao and Nalamwar 1993). The nutrient depletion by weeds in pearl millet was up to 61.8 kg N, 5.6 kg P and 57.6 kg K/ha (Ram *et al.* 2004).

Weeds also act as alternate host of pest and diseases of millets. The rust, smut, ergot and downy mildew pathogens of various millets infect weed species like *Cynodon dactylon, Sorghum halepense, Oxalis corniculate, Digitaria marginata, Pennisetum* sp. and *Eragrostis tenuifolia* and help them overwinter (Frederiksen 1984; Marley 1995; Reed *et al.* 2000). Sorghum shoot fly (*Atherigona soccata*) and gall midge (*Stenodiplosis sorghicola*) infest weeds like *Brachiaria distachya, Panicum repens, Setaria intermedia, Cyperus rotundus* and *Sorghum halepense* and survive therein until new crops come (Nwilene *et al.* 1998, Bilbro 2008).

Crop-weed competition

The type of weed, crop varieties, row spacing, placement of fertilizer, soil moisture availability decides the nature of crop-weed competition. Critical period of crop-weed competition defines the maximum period weeds can be tolerated without affecting final crop yields (Zimdahl 1980). Weeds must be removed within this period to reduce the crop losses. This critical period in millets is usually 15-42 days after sowing (**Table 4**). Variations in temperature and carbon dioxide levels are likely to have significant influence on weed biology and crop-weed interactions. Ziska (2001) observed that the vegetative growth, competition and potential yield of sorghum (C_4) could be reduced by co-occurring of common cocklebur (*Xanthium strumarium*), a C_3 weed, as the atmospheric CO_2 increases. Ziska (2003) observed that in a weed-free environment, increased CO_2 significantly increased the leaf weight and leaf area of sorghum but no significant effect on seed yield or total above-ground biomass relative to the ambient CO_2 concentration. An increase in velvet leaf biomass in response to an increasing CO_2, reduced the yield and biomass of sorghum. Watling and Press (1997) studied the effects of CO_2 concentrations (350 and 700 μmol/mol) in sorghum

Table 4. Critical period of crop-weed competition in millets

Crops	Critical periods (days after sowing)	References
Sorghum	28–42	Sundari and Kumar 2002
Pearl millet	15-30	Labarada *et al.* 1994
Finger millet	25–42	Sundraesh *et al.* 1975

with and without *Striga* infestation. They observed that a high CO_2 concentration resulted in taller sorghum plants, and greater biomass, photosynthetic rates, water-use efficiencies and leaf areas; and lower *Striga* biomass/host plant.

Weed management methods

Cultural methods: Cultural practices like tillage, crop rotation, competitive crop varieties, reducing row spacing, increasing seed rate, mulching, timing of fertilizer application and placement techniques, all these helps to reduce the crop-weed competition. The cultural techniques, like reduced row spacing, increase the crop ability to compete for incoming light more efficiently (Grichar *et al.* 2004). Narrow row spacing (<30cm) was found beneficial in reducing weed competition and increasing yield of foxtail and proso millets (Nelson 1977, Agdag 1995). Varietal differences exist for weed competitiveness within a crop. Integration of competitive crop cultivar can be good strategy to suppress weed growth. In sorghum, cultivars 'CSH 16', 'CSV 20' and 'SPV 462' have been identified as weed suppressive (Mishra *et al.* 2014). Intercropping of compatible crops not only helps in suppression of weeds but also gives additional yield. Intercropping of blackgram and greengram in pearl millet significantly reduced the density as well as biomass of weeds and also realized higher net returns, B:C and income equivalent ratio in comparison to sole crop of pearl millet (Mathukia *et al.* 2015). Crop residue mulching in millets is an effective method to control the annual weeds.

Mechanical methods: Mechanical weed management is one of the effective weed management practices followed in cultivation of millet crops. The mechanical weeding involves handheld tools to the most advanced vision-guided hoes (Hussain *et al.* 2018). However, the hand weeding or inter-row cultivation are the most widely practiced methods for millet cultivation. Among the different operations used for cultivating the millet crops, the weeding and inter-cultivation operations are most energy expensive and involve more drudgery (Gowda *et al.* 1999). Usually the inter-cultivation operation performed two to three times at 10 to 15 days interval depending up on the weed pressure and field condition. However, the inter-cultivation operation followed by hand weeding was found to be effective in controlling the weeds (Gowda and Dhananjaya 2000).

Hand hoeing and blade harrowing are the most effectively followed method for weeding in pearl millet. First weeding should be done at 20-25 DAS and should be repeated every two weeks up to 45 DAS for effective weed control (Yadav 2012). Cuerrier *et al.* (2009) used mechanical harrowing to control the weeds in grain pearl millet and forage pearl millet, when weeds are at 3 to 5 leaf stage. The weeding was done by cutting the soil 3 to 4 cm deep using Tine harrow (Hatzenbichler, Austria). The harrow had adjustable flexible tines with working width of 1.5 m. The operational speed was adjusted according to the weed pressure and strength of the tines. In barnyard millet (*Echinochloa frumentacea*) the weeds could be effectively controlled by using a mechanical weeder integrated with hand weeding under rain-fed conditions (Shamina *et al*. 2019). Gowda and Dhananjaya (2000) conducted a comparison study between the improved tools with traditional hoe for weeding in finger millet. Improved blade hoe and improved bent type sweep hoe performed better, controlled the weeds effectively conserved the soil moisture at flowering and grain filling stages; yielded highest grain yield compared to traditional hoe. A blade type engine operated mechanical weeder was developed to perform weeding in finger millet; it could cover 2-4 rows at a time and had very good weeding efficiency. The developed weeder was able to perform weeding operation in crop having a plant height up to 30 cm. The weeding efficiency varied from 85 to 88%, plant damage varied from 2.5 to 3.6%, field capacity varied from 0.11 to 0.14 ha/h and weeding cost in developed weeder varied from Rs. 447.42 to 572 per hectare (Shrinivasa *et al.* 2017).

Herbicide use in millets

Herbicides are an important component of weed management strategy in crops. While proper seedbed preparation and cultivation before planting can help to control early-season weeds, selective pre-emergence soil residual herbicides are often necessary (Vanderlip *et al.* 1998). Due to scarcity of herbicides registered for millets, options for chemical control of weeds in this group of crops are not many (**Table 5**). Herbicides have been most effective in millets when supplemented with one hand weeding. The five best herbicide treatments in terms of weed control and grain sorghum yield were quinclorac, atrazine + dimethenamid-p, S-metolachlor followed by (*fb*) atrazine + dicamba, dimethenamid-p *fb* atrazine, and the standard treatment of S-metolachlor + atrazine *fb* atrazine (Bararpour *et al.* 2019). Pimentel *et al.* (2019) verified that post-emergence application (PoE) of atrazine (2.0 kg/ha) was efficient in the weed control and selective to the sorghum crop, not affecting productivity in Brazil. Oxyfluorfen 0.2 kg/ha *fb* hand weeding at 25 days after seeding (DAS) recorded 92.3 and 95% less population and biomass of *Trianthema portulacastrum* and 86.1 and 91% less population and biomass, respectively, of all other weeds, and thus gave 24.96% more pearl millet yield and highest net return (Deshveer and Deshveer 2005). In pearl millet, pre-emergence application (PE) of atrazine 0.5 kg/ha *fb* hand weeding at 35 DAS and atrazine 0.4 kg/ha PoE at 20 DAS followed by hand weeding at 35 DAS appeared to be the best integrated weed management practice (Girase *et al.* 2017). In kodo millet, isoproturon 500 g/ha PE followed by hand weeding at 40 DAS found to be effective in reducing the density of weed species in irrigated kodo millet (Vinothini and Arthanari 2017). In another study, Lekhana *et al.* (2021) reported that bensulfuron-methyl 0.06 + pretilachlor 0.330 kg/ha at 3 DAS recorded lower total weed density and weed dry biomass with weed control efficiency (59.21%) without any phytotoxic effect on kodo millet and produced higher grain, net returns and BC ratio (2.74). In barnyard millet, bensulfuron-methyl 60 + pretilachlor 495 g/ha (RM) PE on 3 DAS was found effective (Thambi *et al.* 2021).

Integration of nutrient-use efficient and weed suppressive cultivars like 'CSH 16', 'CSV 20' and 'SPV 462' with atrazine at 0.50 kg/ha PE *fb* need-based manual weeding was found necessary to increase the nutrient-use efficiency and productivity of sorghum in semi-arid tropical areas in India (Mishra *et al.* 2014).

Millet breeders in different ecological areas effectively accelerated the breeding process, thereby 30 novel herbicide-resistant millet varieties/hybrid varieties were registered for further breeding programme at the national or local level in China (Darmency *et al.* 2017).

Management of *Striga* in millets

Striga is a root parasite which parasitizes millets like sorghum, pearl millet and finger millet. It is also known as witchweed and can destroy a crop with up to a 100% yield loss (Ejeta 2007). *Striga* spp. parasitism is considered as one of the most devastating agriculture problems across sub-Sharan Africa (SSA) countries. Over 50% of the arable land under cereals in these countries is infested by *Striga* spp. (Gressel *et al.* 2004; Rodenburg *et al.* 2016). Integrated use of weed control and crop management practices could enhance productivity of sorghum and suppress *Striga* (Fasil *et al.* 1997). A treatment consisting of row planting, mineral fertilizer (42 kg N/ha) and 2,4-D herbicide led to 40% increase in cereal yield and appreciable reduction in *Striga* infestation, compared to the control (broadcast planting, no fertilizer and early weeding; farmer's practice).

Table 5. Effective herbicides in millets

Millets	Herbicide	Dose (kg/ha)	Time of application	Weeds controlled	References
Sorghum	Atrazine	0.5–1.0	PE	BL, GR and to some extent *Striga*	Walia *et al.* 2007; Mishra *et al.* 2014
	Pendimethalin	0.75–1.0	PE	GR and BL	-
	2,4-D	0.50–0.75	PoE	BL	-
Pearl millet	Atrazine	0.50	PE	BL, GR and to some extent *Striga*	Banga *et al.* 2000 Girase *et al.* 2017
	Oxyfluorfen	0.20	PE	GR and BL	Deshveer and Deshveer 2005
	2,4-D	0.50–0.75	PoE	BL	-
	Pendimethalin	1.0	PE	GR and BL	Ram *et al.* 2004
Finger millet	Butachlor	0.75	PE	GR and BL	Prasad *et al.* 2010
Finger millet, kodo millet, little millet, barnyard millet (transplanted)	Atrazine	0.50	PE	GR and BL	Dubey and Mishra 2022
	Oxyfluorfen	0.10	PE	GR and BL	
	Pyrazosulfuron	0.02	PE	BL, SG & some GR	
	Metsulfuron	0.004	PoE	BL	
	2, 4-D	0.50	PoE	BL	
Kodo millet	Isoproturon	0.50	PE	GR and BL	Prajapati *et al.* 2007
	Isoproturon	0.50	PE	GR and BL	Vinothini and Arthanari 2017
	Bensulfuron-methyl + pretilachlor	0.06 + 0.330	PE	BL and GR	Lekhana *et al.* 2021
Barnyard millet	Bensulfuron-methyl + pretilachlor	0.06 + 0.495	PE	BL and GR	Thambi *et al.* 2021
Buck wheat	Alachlor	1.00	PE	GR	Rana *et al.* 2003
	Pretilachlor	1.00	PE	GR	
	Oxyfluorfen	0.25	PE	BL and GR	
	Metolachlor	1.00	PE	GR	

BL: broad-leaved weeds; GR: grasses; PE: pre-emergence; PoE: post-emergence

Catch cropping with Sudan grass was found useful to reduce *Striga* infestation in sorghum at Harbu (Parker 1988). It was shown that catch cropping with some varieties of cowpea, groundnut and soybean can cause suicidal germination of *S. hermonthica* (Carsky *et al.* 2000; Schulz *et al.* 2003)

In maize and sorghum, seed treatment with imazapyr showed promise in controlling *Striga* (Dembele *et al.* 2005). 2,4-D PoE effectively controls *Striga*. *Striga* in sorghum could be controlled between 62-92% by the combined application of urea and dicamba, while chlorsulfuron in combination with dicamba achieved 77-100% control of *Striga* (Babiker *et al.* 1996). Rotation of infested land into non-susceptible crops or into fallow is theoretically one of the simplest solutions for parasitic weed control, but it is also one that is neither simple nor acceptable (Parker and Riches 1993).

Wild sorghum accessions are an important reservoir for *Striga* resistance that could be used to expand the genetic basis of cultivated sorghum for resistance to the parasite (Mbuvi *et al.* 2017). Host plant resistance can be a promising method for controlling parasitic weeds. Genetic resistance to *Striga* in sorghum has been reported by Haussmann *et al.* 2004 and Rich *et al.* 2004. The genetic engineering technologies and use of gene-editing and CRISP/Cas9 could help in developing new *Striga* resistant genotypes and exploring further the molecular and genetic mechanisms involved in the resistance to *Striga* (Makaza *et al.* 2023).

Way forward

Millet cultivation is gaining momentum with their projection as the nutri-cereals, particularly in sub-tropical regions. Being climate resilient crops, they appropriately fit into crop diversification under conventional or organic/natural farming systems. Productivity of millets is quite low, which needs to be increased through development and adoption of better genotypes and improved management practices. Weeds offer serious competition for resources thus are the major biotic constraint in millet cultivation. Weed management in millets is a challenging task in the early growth phases. Also, there is lack of pre- and post-emergence selective herbicides, especially in minor millets. In this scenario, an integrated weed management approach comprising weed competitive varieties, agronomic manipulation of cultivation practices to give an edge over weeds, cultural and mechanical interventions along with herbicides would be ideal approach. New AI based weeding tools are also in developmental stage which will helpful in the chemical free farming. Development of herbicide resistant, *Striga* resistant varieties may altogether change the traditional weed management practices. However, the cultivation of herbicide resistant varieties has to be monitored for avoiding development of resistance in weeds.

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