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Weed Management in Millets- A Holistic Approach

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ABSTRACT

Millets are the traditional staple food of dry land regions and have the potential to contribute substantially for food, fodder and the nutritional security. The millets are relatively poor competitors against weeds especially during the early growth stages due to their slow initial growth and wider spacing. Yield loss due to weeds in millets varies from 5 to 94 per cent depending on climatic, edaphic and biotic factors. Weeds compete with crops for nutrients, soil moisture, sunlight and space when they are limiting, resulting in reduction in yield, quality and increased cost of production. The objective of this paper is to review the research that have been conducted pertaining to various aspects of weed management in millets. The literature suggests that instead of relying on any single method of weed control, all the feasible methods are to be integrated for the effective and sustainable management of weeds in millets. Integrated weed management can effectively overcome the problems of weed shift and development of resistance in weeds and reduce the weed seed bank and manage the weeds below the economic threshold level to avoid any economic loss.

Key words: Crop-weed competition, Integrated weed management, Millets.

Weeds are not strangers to man. They have been there when the farmers started to cultivate crops. In the world there are 30,000 weed species, out of these 18,000 species cause damage to the crops. Any plant growing at a place and time where it is not desired is called weeds. In India, the loss caused by weeds, insects, diseases and others accounts for 37, 29, 22 and 12 per cent, respectively (Yaduraju, 2006). Weeds caused an economic loss of $ 11 billion in India. In pearl millet, economic loss due to weeds was reported to be $ 17 million (Gharde *et al.,* 2018). Weeds also affect the crop production indirectly by harboring pests and diseases, increasing the cost of production and reducing the quality of produce.

Millets are the traditional staple food of the dry land regions of the world and have the potential to contribute substantially for food, fodder and the nutritional security of these regions. They are highly nutritious and climate compliant crops. Because of drought tolerance, millets can be cultivated in areas that are often too hot and dry. Millets are nutri-cereals and are highly nutritious. Millet grains contain protein, essential fatty acids, dietary fibre, Vitamin B and minerals such as calcium, iron, zinc, potassium and magnesium (Rao *et al*., 2017). They have low glycemic index and hence good for diabetic patients. Millets are considered as climate smart crops, since they are photo-insensitive, hardy and survive in high temperatures and resilient to climate change. They are resilient crops because of low carbon and water foot print. India is the world's leading producer of millet with an area of 24.02 million hectares with a production of 47.48 million tonnes (GOI, 2020). The major millet producing states in India are Rajasthan, Maharashtra, Karnataka and Uttar Pradesh (Adekunle *et al.,* 2018).

Importance of weed management in millets

The millets are relatively poor competitors against weeds especially during the early growth stages. During the initial growth phase, millets grow very slowly. Only when the crop reaches the mid growth phase, millets attain canopy cover enough to shade the weeds and suppress its growth (Mishra, 2015). Planting in wider rows to facilitate interrow cultivation and/or ditch furrow irrigation worsens the problems. Manual method is the most commonly adopted method for weed control in millet. But the non-availability of labour and ever-increasing labour wages have made the farmers to seek alternate method of weed management. Chemical method is the most viable method of weed control in crops. However, rely on chemicals alone for weed management is not advisable due to its ill effects on environment and development of herbicide resistance in weeds. Therefore, a system that combines herbicides with cultivation and other crop husbandry practices can be adopted.

Crop weed competition

Weeds compete with crops for nutrients, soil moisture, sunlight and space when they are limiting, resulting in reduced yield and quality and increased cost of production. Allelochemicals from allelopathic weeds adversely affect the growth of emerging crop seedlings and also cause several other damages. Fateh *et al*. (2012) reported that whole plant extract of bindweed (*Convolvulus arvensis* L.) had inhibitory

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effect on the germination of millets and growth characters. The magnitude of losses depends on crop cultivars, nature and intensity of weeds, spacing, duration of weed infestation, edaphic and climatic factors and management practices followed. Weeds that emerge with or before the crop are the most competitive and result in the greatest yield loss (Swanton *et al*., 2015). Weeds that emerge later than the crop are less competitive in terms of crop yield loss but still may be considered problematic if they affect the harvesting of crop or reduce the quality of economic produce. The yield reduction in millets due to crop weed competition is presented in Table 1.

An unhindered growth of weeds during the initial growth stage of the millets enabled the weeds to draw nutrients at a faster rate than the crop. Mishra *et al.* (2012) observed that weeds removed about 31.59, 6.56 and 30.38 kg ha^{-1} of N, P and K from unweeded plot and also observed that adoption of weed management practices significantly increased the nutrient uptake in sorghum. Ramesh *et al*. (2019) also reported that weeds depleted 47.73 kg N, 31.19 kg P and 39.89 kg K ha^{-1} in pearl millet. There was considerable difference among the weed species in nutrient uptake. For the production of unit quantity of dry matter, broad leaved weeds removed more amount of nutrients than the sorghum crop (Stahlman and Wicks, 2000).

Millets are mostly grown in the dryland, where availability of water is scanty and uncertain. Under moisture stress condition, weeds alone can cause 50 per cent reduction in yield due to competition for moisture (Abouziena *et al*., 2014). Depletion of soil-water by weeds, however, may create severe moisture stress conditions for the millets to grow.

Strategies for weed management in millets

Gaining knowledge in various fields, such as growth and life cycle of weeds, methods of reproduction and distribution, seed dormancy, critical period of crop weed competition in crops *etc*. would help us to identify appropriate methods for sustainable weed management.

Critical period of crop weed competition

For every crop there is a critical period of crop weed competition. It is the shortest span of time during the crop growth weeding results in maximum economic returns. It can also be defined as, the period during crop cycle, weed must be controlled to avoid economic loss. Knowledge of critical period of weed control would help us to decide the time of weed control. Once the crop reaches about 50 cm in height, weed control no longer affects the yield in millets. Weeds emerged after the critical weed-free period would not affect the yield, but control measures taken after the critical weed free period would make harvest more efficient, reduce the weed seed bank and reduce weed problems in subsequent years. Critical period of weed competition of millet crops are given in Table 2.

Weed flora in millets

Several species of grasses, broad-leaved weeds and sedges were found in association with millets. Major grass weeds found in association with millets were *Digitaria sanguinalis* (L) Scop., *Eleusine indica* (L.) *Gaertn, Cynodon dactylon* Pers., *Echinochloa colona* Link., *Sorghum halepense* (L.) Pers., *Setaria glauca* Beauv., *Setaria viridis* L. and *Panicum repens* L. *Ageratum conyzoides* L, *Convolvulus arvensis* L., *Achyranthes aspera* L, *Commelina benghalensis* L., *Amaranthus viridis* L, *Boerhaavia diffusa* L, *Cleome viscose* L. and *Euphorbia hirta* L. are the major broad-leaved weeds and *Cyperus rotundus* L. and *Cyperus iria* were the major sedges found along with millets. Parasitic weed, *Striga spp*. was also found in association with millets (Mishra, 2015). Striga is a root hemi parasitic plant which mainly infect millets such as sorghum, pearl millet, finger millet, foxtail millet, little millet, proso millet, fonio, teff and barnyard millet (Atera *et al*., 2012; Parker, 2012). Infestation of striga resulted in 15-75 per cent yield loss and under severe infestation complete crop failure may also occurs (Walia, 2006).

Integrated weed management

Integrated weed management is system approach for sustainable weed control with an objective to reduce the selection pressure for the development of resistance in weeds (Shaner, 2014; Chauhan *et al.,* 2017). Lamichhane *et al*. (2017) reported that integrated weed management was more effective than any single method in controlling weeds. The common strategies in IWM are cultural methods, physical, biological, allelopathy, chemical and biotechnological methods.

Cultural methods of weed management

Weeds can be effectively controlled by adopting cultural

Table 1: Yield loss due to weeds in different millets.

Crops	Reduction in grain yield (%)	References
Sorghum	15-83	Mishra (1997)
Pearl millet	55	Banga *et al.* (2000)
	16-94	Balyan *et al.* (1993)
Finger millet	72	Kujur *et al.* (2019)
	40	Sharma and Jain (2003)
	34-61	Shubhashree and Sowmyalatha (2019)
Kodo millet	55-61	Lekehana *et al.* (2021)
Barnyard millet	50	Shamina *et al.* (2019)

Table 2: Critical period of crop-weed competition in millets.

Crops	Critical periods (DAS)	References
Sorghum	28-42	Sundari and Kumar (2002)
Pearl millet	Up to 35	Thanmai *et al.* (2018)
Finger millet	20-30	Pradhan and Patil (2010)
Barnyard millet	25-30	TNAU (2021)
Foxtail millet	20-35	TNAU (2016)
Proso millet	Up to 35	TNAU (2021)

methods. Cultural methods are cost effective and easy to practice, acceptable and accessible to small and large farmers, non-chemical and ecologically sound.

Different cultural methods are:

Optimum time of sowing

Initial flush of weeds can be avoided through manipulation of time of sowing of a crop, a little earlier or later than its normal time of sowing. According to Mathukia *et al.* (2015) timely weed control and timely sowing reduced the crop-weed competition and enabled the crop to utilize the resources efficiently and ultimately resulted in better growth. Das (2016) reported that striga infestation was reduced, due to very late planting of sorghum.

Proper row spacing and method of planting

Narrow row spacing suppresses weed growth more efficiently than crops grown in wide row spacing. Narrowing the crop row improves the crop yield and allows the crop to utilize light, nutrients and moisture more efficiently (Hozayn *et al*., 2012). Locke *et al*. (2002) observed that, faster canopy closure of the crop, reduced weed seed germination due to shading. Hand weeding twice with narrow spacing was the best weed management practice for WCE, higher productivity and profitability in line sown rainfed barnyard millet (Shamina *et al*., 2019). Weed density and dry weight were higher in paired row planting compared to regular planting in pearl millet. Higher weed density recorded in paired row planting might be due to more space between two rows which resulted in better environment for germination and growth of weeds (Kaur and Singh, 2006). Transplanting 15-20 days old seedlings recorded higher WCE and lower weed density in pearl millet compared to line sowing, ridge and furrow sowing and broadcasting (Kasana *et al.,* 2018).

Plant population

Planting sorghum crop at higher densities of 7.5 plants m^{-2} suppressed the growth and biomass of *Echinochloa esculenta* by 22 and 27 per cent as compared to lower densities (4.5 plants m^{-2}) (Wu *et al*., 2010).

Direction of planting

Light is an important resource for crop-weed competition and enhancing light interception by the crop can be used as a method to suppress weed population in cereal crops (Borger *et al*., 2015).

Manipulating the crop row orientation may reduce the light interception by weeds and increased the light interception by the crop, depending on the location of the crop (latitude), crop species and height of the weed (Holt, 1995).

Weed competitive cultivar

The competitive potential of a crop usually depends upon its ability to access and utilize resources like light, moisture, nutrients and space. Specific characteristics that enhance the crop competitive potential may include rapid emergence, rapid biomass accumulation, leaf characteristics, canopy structure, tillering capacity and height (Buhler, 2002). Selection of competitive and allelopathic sorghum cultivars, affected the weed seedling emergence by decreasing the light interception and releasing numerous allelochemicals (Peerzada *et al*., 2017). Mishra *et al.* (2015) reported that sorghum hybrid CSH-16 performed better and was very effective in suppressing the weed growth among the other 11 cultivars tested. Competitive cultivars restrict light penetration to weeds by absorbing the light in the canopy, resulting into reduced weed dry matter production. ICRISAT had developed striga resistant varieties/lines S1561, S1477, S1511 for Africa and Asia. Other striga resistant varieties include IS 6961, IS 7777, IS 7739, IS 14825, IS 14928, Framida and P 967083. The resistance to striga was offered mainly by creating barriers for attachment of striga and by reducing stimulant production.

Intercropping

Intercropping increases the use of natural resources, compared to sole crops. Pearl millet + black gram (1:1) intercropping recorded higher weed control efficiency (65.8%) and weed smothering efficiency (52.0%) and lower weed dry weight over sole cropping (Mathukia *et al.,* 2015). Finger millet intercropped with small onion drastically reduced the weed biomass and recorded higher weed control efficiency and yield (Vishalini *et al.,* 2020). In push and pull strategy, sorghum, desmodium and napier grass were grown together. Desmodium was deterrent in insect (stem borer) attack and an inhibitor of striga. Stalk borers get reflected from demodium and feed on napier grass raised in the border. Hence both stalk borer and striga can be managed.

Crop rotation

Crop rotation is the repetitive cultivation of an ordered succession of crops and crop and fallow on a given piece of land. Different crops obviously brought about different cultural practices and disrupted the growth cycle of weeds and prevented the selection of flora towards increased abundance of problem species (Barberi and Lo Cascio, 2001). In contrast, continuous cropping selects the weed flora by favoring those species that are more similar to the crop and tolerant to weed control methods adopted (*e.g.*, herbicides). Inclusion of leguminous crops in finger millet rotation, trigger the germination of striga but prevent its continued growth. Most of the annual weeds get strangled, if sweet potato or cowpea were grown after finger millet.

Soil solarization

Soil solarization is a simple and effective technique of controlling soil-borne pests, including weeds. It involves covering the moist soil surface with 25 to 50 mm polyethene sheet (LDPE film) to trap solar radiation during the summer months. This would raise the soil temperature by 8 to 10°C as compared to non-solarized soils and would kill soil born pests as well as weeds. As heavy soil retains more water and produces sufficient steam everyday, this technique works well on heavy soil compared to light soil. Soil solarization of 4-6 weeks is needed for sufficient control of weeds. The other advantages include, improving the soil structure, increasing the availability of nutrients especially N and controlling soil-borne fungi. Patel *et al*. (2005) reported that weeds such as *Cynodon dactylon*, *Cyperus rotundus* and *Melilotus* spp. cannot be controlled by soil solarization. Soil solarization was found to be the best non chemical and agronomical weed management practice to reduce weed seed bank, since it reduced the density of grasses, sedges and broad-leaved weeds to a great extent (Arora and Tomar, 2012).

Mulching

Covering the soil with a thick layer of mulch, deprive weed seeds from sunlight necessary for germination, photosynthesis and growth. Weed suppression due to mulching was directly related to the amount of mulch applied, which influences the light extinction through the mulch and consequently reduced the weed seed germination (Teasdale and Mohler, 2000). Kaur and Singh (2006) reported that application of organic mulches @ 4 t ha^{-1} decreased the weed density significantly as compared to no mulch. Small-seeded weed species appear to be more sensitive than large-seeded species due to physical effects of mulch. Mulching is effective against most of annual weeds and some perennial weeds like *Cynadon dactylon, Sorghum halepense.* Vishalini *et al.* (2020) reported that mulching with rice straw or shredded coconut waste significantly reduced the weed density and weed dry weight in finger millet. In addition to the favourable influence of mulching in weed suppression, mulching also reduces evaporation from the soil surface, improves the soil tilth and reduces the erosion.

Stale seedbed

Stale seedbed technique is a cultural-cum-preventive measure. Stale seedbed (SSB) is based on the principle that weed seeds are flushed out before the crop is planted, so that the weed seed bank in the top layer of the soil is depleted and the occurrence of weeds are reduced (Johnson and Mullinix, 2000). It involves, creating a seedbed one or two weeks before the seed is sown in order to stimulate the emergence of weeds prior to seeding. Emerged weeds are then destroyed by cultivation or application of a non-selective herbicide. Weed species that need light to germinate, have low initial dormancy and are present on the top layer (3-5 cm) of the soil are more vulnerable to seedbed technique (Chauhan *et al*., 2010). *Cyperus iria, Echinochloa colonum, Eleusine indica* are sensitive to stale seedbed technique. Patil *et al*. (2013) reported that stale seedbed technique followed by inter cultivation twice at 20 and 35 DAP significantly reduced the weed density and weed dry weight in finger millet.

Application of natural or synthetic stimulants

Striga requires chemical signals exuded by the host roots for germination and haustoria formation. Natural stimulants for striga germination were first detected and extracted from cotton roots and were identified as "strigol and strigol acetate". Ethylene and other synthetic analogue of strigol like GR 45, GR 7 can also stimulate striga germination. Application of strigol's synthetic analogue well in advance of the sowing of crop induces the germination of striga, but seedling will degenerate in the absence of suitable host (suicidal germination). Striga plants those survived can be controlled by manual weeding or by the application of contact herbicides. Das (2016) reported that application of GR 45, GR 7 @ 0.1-1.0 kg ha^{-1} as pre-plant incorporation reduced 50 per cent striga population in sorghum. It was also reported that ethylene treatment resulted in 90 per cent reduction in striga seed bank in the plough layer soil.

Fertilization

Scientific manipulation of the crop weed environment in favour of crop plants by the application of fertilizers will lead to selective stimulation of crop growth, which itself may serve as a weed smothering measure. Chavan *et al.* (2017) reported that total dry weight of weeds at harvest was significantly higher due to application of 100 kg N ha^{-1} followed by 80 kg N ha^{-1} and 60 kg N ha^{-1} and lowest level of nitrogen recorded higher weed control efficiency. It was also observed that application of N in four splits significantly lowered the density and dry weight of weeds. Tadesse *et al*. (2018) reported that application of N up to 46 kg ha^{-1} significantly reduced the density of striga, 49.8 per cent over control.

Trap cropping

Any plant which stimulates the weed parasite to germinate, without getting parasitized is called as trap crop. Thus, trap crops are false hosts which lead to suicidal germination. Crops such as cotton, soybean, sunflower, cowpea, jute, pigeon pea, chickpea, kenaf, groundnut and castor will act as trap crop. Tadesse *et al.* (2018) observed that among the trap crops, cowpea had more profound effect on suppressing the germination of striga. Cotton crop as trap crop led to a suicidal germination of 13-50 per cent striga seed (Barberi, 2019).

Catch cropping

Crops which stimulate the weed parasite to germinate and themselves get parasitized are called catch crops. Striga plants should be ploughed and buried along with the crop in to soil, well before they come to flowering and set seed. Growing sudan grass [*Sorghum sudanense* (Piper) Stapf] just for 5 weeks and incorporated into the soil and sowing sorghum in the stubbles reduced the infestation of *Striga helmonthica* in East Africa (Das, 2016).

Allelopathic weed management

Allelopathy refers to any positive or negative effects of a living organism on another living organism through direct or indirect release of allelochemicals into the environment. In allelopathic weed control, allelopathic potential of crops are manipulated in such a way that allelochemical from these crops reduce crop weed competition. The allelochemicals are released into the environment through evaporation, leaching, root leakage and plant decay. Allelochemical compounds can affect the processes such as germination, growth and development, nutrient uptake, cell division, membrane permeability, enzyme activity and fatty acid metabolism. Visible effects of allelochemicals on the growth and development of plants includes inhibited or retarded germination rate, darkening and swelling of seeds, reduced root and shoot growth or coleoptile extension, swelling or necrosis of root tips, discoloration of roots, lack of root hairs, reduction in dry matter accumulation and reproductive capacity (Bhadoria, 2011). Jabran *et al*. (2015) reported that use of allelopathic cover crops, allelopathic intercrops, inclusion of allelopathic crops in rotation and the use of allelopathic plant residues as mulches have an important role in the management of weeds in sustainable agricultural systems.

Sorgaab (sorghum water extract) controlled 35-49 per cent weeds in wheat and increased the wheat yield by 10-21 per cent. It was also observed that, incorporation of chopped mature sorghum into the soil at the time of sowing of wheat controlled 40-50 per cent weeds and increased the wheat yield by 15 per cent (Cheema and Khaliq, 2000). Yang *et al*. (2004) observed that, sorgoleone, an allelochemical exuded from the root hairs of sorghum was phytotoxic to broad-leaved weeds and grasses at concentrations as low as 10 μmol. Water extract of foxtail millet leaves and stems had significant allelopathic effects on *Amaranthus retroflexus*, *Chenopodium album* and *Setaria viridis* (Dong *et al.,* 2020).

Physical methods of weed management

It is one of the oldest and the most common method of weed control in millets. Different methods of physical methods of weed control are as follows:

Tillage

The effect of primary tillage on weeds is mainly related to the type of implement used and depth of tillage. These factors influenced the distribution of weed seeds and propagules over the soil profile and directly affected the number of weeds emerged. Irrespective of weed species, conventional tillage significantly reduced the density of weeds compared to reduced tillage and minimum tillage. The inversion of soil in conventional tillage resulted in deeper placement of weed seeds and caused significant reduction in the density of weeds in rainfed pigeon pea + finger millet cropping system (Vijaymahantesh *et al.,* 2013). Sidar and Thakur (2017) reported that, weed density and weed dry matter were significantly higher in conventional and minimum tillage compared to summer ploughing in finger millet. Das (2016) reported that minimum or zero tillage effectively reduced the infestation of striga. Inter-cultivation followed by hand weeding twice at 20 and 40 DAS recorded the lowest weed biomass and the highest weed control efficiency in pearl millet (Patel *et al*., 2013).

Hoeing

Hoeing is a post-planting operation, which stirs the soil and makes the soil more loosened. Hoeing was effective against annual weeds but not against perennial weeds. Line sowing was a prerequisite for hoeing. Among the weed management practices, significantly lower density, dry matter of weeds, higher weed control efficiency and lower weed index were noticed in hoeing twice by wheel hoe between the rows in finger millet (Kujur *et al*., 2018).

Manual weeding

Hand weeding is the common method of weed control in millets. Though effective it is time consuming, labour-intensive and often costlier than chemical method of weed control. It effectively controls annual weeds, but not perennial weeds. Among the various weed management practices, hand weeding twice at 20 and 40 DAS recorded the highest grain yield and the lowest weed index in pearl millet (Thanmai *et al.,* 2018).

Chemical method of weed management

Chemical control with herbicides was considered to be the easiest method of weed control. Several herbicides have been evaluated for weed control efficacy in sorghum. However, in other millets, specifically small millets, the herbicide recommendations have been limited. The recommended herbicides for millets, their time of application, doses and weeds controlled by them are listed in (Table 3). Atrazine was the most commonly used pre-emergence herbicide for weed control in millets. Ramesh *et al.* (2019) reported that pre-emergence application of pretilachlor (450 g ha^{-1}) on 3 DAS followed by one hand weeding on 30 DAS had significantly reduced the weed density and dry weight. Vinothini and Arthanari (2017) reported that pre-emergence application of isoproturon 750 g ha^{-1} followed by hand weeding at 40 DAS significantly reduced the density of weed species in irrigated kodo millet. Lower weed dry weight and higher WCE were recorded in pre emergence application of bensulfuron methyl 0.6 G at 60 g ha^{-1}+ pretilachlor 6 G at 600 g ha^{-1} *fb* early post emergence application of bispyribac sodium 10 SC at 25 g ha^{-1} (Shanmugapriya *et al*. 2019).

Biological method of weed control

Biological control is an effective, environmentally safe and technically appropriate means of reducing or mitigating pests. Biological method involves the use of living organisms such as insects, other animals and competitive plants to reduce the vigour, reproductive capacity, density or impact of weeds. The strategies of biological control can be classified in two broad categories: (i) classical or inoculative and (ii) inundative or mass exposure. A development of the inundative strategy is the bioherbicide approach. Bipolaris, a bioherbicide of *Bipolaris sorghicola* controls Johnson grass. *Bactra verutana* controls *Cyperus rotundus* which is a major weed in millets. *Smicronyx umbrinus* (gall forming weevil) and *Ophiomuya strigalis* (leaf miner) were the potential biocontrol agents against striga (Das, 2016). AMF root colonization in sorghum reduced the production of stimulant and reduced the emergence of striga (Lendzemo and Kuyper, 2001). Rebeka *et al.* (2013) reported

Table 3: The recommended herbicides for millets.

Herbicide	Trade name	Dose(kg ha^{-1})	Time of application	Crops
Atrazine	Atrataf	0.75-1.0	Pre emergence, Early-post emergence	Sorghum, pearl millet, proso millet
Pendimethalin	Stomp	0.75-1.0	Pre emergence	Sorghum, pearl millet
Alachlor	Lasso	1.5-2.0	Pre emergence	Sorghum, pearl millet
Metolachlor	Helmet	1.0-1.5	Pre emergence	Sorghum
Saflufenacil	Kixor	0.05	Pre emergence	Pearl millet, proso millet
Oxadiazone	Ronstar	0.75-1.0	Pre emergence	Sorghum, pearl millet, finger millet
Isoproturon	Arelon	0.50-0.75	Pre emergence	Finger millet, kodo millet
Butachlor	Mechete	0.75	Pre emergence	Finger millet
Propazine	Propinex	0.28-0.56	Pre emergence	Proso millet
Atrazine + alachlor	Lariat	0.75+0.75	Pre emergence	Sorghum
2,4-D	Weedar	0.50-0.75	Post emergence	Sorghum, proso millet

that myco-herbicides developed from the fungus *Fusarium oxysporum* showed striga inhibition by reducing its attachment to cereals and decreasing the seed bank.

Biotechnology

Acetolactate synthase (ALS)-inhibitor herbicides, *viz.* nicosulfuron and rimsulfuron are widely used to control broad-leaved and grassy weeds in corn (*Zea mays*), but the sorghum is susceptible to these herbicides. Kansas State University (KSU), USA had developed a grain sorghum line resistant to ALS inhibiting herbicides like Steadfast (nicosulfuron), Accent (nicosulfuron), Resolve (rimsulfuron) and Ally (metsulfuron) by transferring a resistant gene from wild sorghum (Tuinstra *et al*., 2009). Foxtail millet line resistant to atrazine was developed through interspecific hybridization between *Setaria viridis* and *S. italica*. It was also reported that the atrazine resistant line produced yield comparable with that of high yielding varieties (Darmency and Pernes, 2006).

COCNCLUSION

Slow initial growth and wider spacing were the major reasons for severe crop weed competition in millets. In general, 20-35 DAS was the critical period for crop weed competition in millets. Instead of relying on any single method of weed control, all the feasible methods are to be integrated for the effective and sustainable management of weeds in millets. Integrated weed management can effectively overcome the problems of weed shift and development of resistance in weeds and reduce the weed seed bank and manage the weeds below the economic threshold level to avoid any economic loss.

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