REVIEW ARTICLE

A REVIEW ON EFFECT OF VARIOUS WEED MANAGEMENT APPROACHES IN SORGHUM [*SORGHUM BICOLOR* (L.) MOENCH]

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Abstract: Sorghum is crop which is facing the problems like lacking inputs, grown in marginal lands that too without proper care. These situations lead to weed infestation as it is mostly grown in monsoon periods; pest and disease attack is more common due to improper management. But most importantly weeds are the greatest menace in case of sorghum due to its slow growing nature in early days of its life cycle. Different types of weeds compete with the crop for different kinds and levels of inputs like water, nutrients, CO_2, sunlight and space. Hence, weeds become a great threat to sorghum growth and development.

Keywords: Forage sorghum, Weeds, Herbicide, Mode of action, Intercropping

INTRODUCTION

Sorghum belongs to the family Gramineae. Sorghum is a diploid crop with 20 chromosomes to its genome. Sorghum is a grass that usually grows to a height of 0.6 to 2.4 metres (2 to 8 feet), sometimes as high as 4.6 metres (15 feet). Stalks and leaves of sorghum are coated with a white waxy layer, and the central portion (the pith) of the stalks of few varieties is juicy and sweet. The length and breadth of the leaves varies from 76 cm (2.5 feet) and 5 cm, respectively. The inflorescence is called panicle and it bears tiny flowers which are from loose to dense across varieties; each panicle bears 800–3,000 kernels. The seeds vary widely in size, colour and shape.

Sorghum is a versatile crop with multiple uses with almost every part of the crop in one way or another. However, it is mainly grown for its grains and stalk which are important for food and feed purposes.

The plant stem and foliage are used in many ways to feed cattle such as green chop, hay, silage and pasture. In some parts of the world, the stem is used for hut making. The stover is used as fodder for livestock because of its rapid growth, wide adaptation, drought tolerance, high green and dry fodder and ratoon ability. Forage sorghum is most common in North India and in West Africa. Forage sorghums are fed to animals freshly as green chop or quick dried hay.

Challenges in sorghum production

Sorghum is crop which is facing the problems like lacking inputs, grown in marginal lands that too without proper care. These situations lead to weed infestation as it is mostly grown in monsoon periods; pest and disease attack is more common due to improper management. But most importantly weeds are the greatest menace in case of sorghum due to its slow growing nature in early days of its life cycle. Different types of weeds compete with the crop for different kinds and levels of inputs like water, nutrients, CO_2, sunlight and space. Hence, weeds become a great threat to sorghum growth and development.

Weed flora in sorghum

According to Kumar *et al*. (2012) *Cyperus* spp. and *Echinochola colona* were dominating weeds with densities of 38.9% and 28%, respectively, in fodder sorghum at Modipuram, Meerut during the *kharif* season of 2001 and 2002.

Mishra *et al*. (2012) from Hyderabad, Andra Pradesh reported that the grassy weeds like Chloris *barbata, Dactyloctenium aegyptium* and *Brachiaria ramose* contributed 15.07%, *Digitaria sanguinalis* around 9.06% and others like *Echinochloa colona, Dinebra retroflexa, Panicum repens* were of 3.57%; The sedge *Cyperus* recorded 5.6%; broad-leaved weeds *Parthenium hysterophorus* (24.7%) *Tribulus terrestris* (11.7%), *Euphorbia hirta* (8.77%), *Digera arvensis* (7.15%), *Corchorus olitorius* (6.1%), and others like *Amaranthus viridis, Ageratum conyzoides, Trianthema portulacastrum, Alternanthera sessilis, E. geniculata, Cleome viscosa, Achyrantheus aspera* and *Cyanotis axillaris* (7.72%) were also predominant in the sorghum throughout the experiment period.

Jat *et al*. (2013) reported that the weeds *viz*., *Cyperus rotundus* (L.) in sedges; *Cynodon dactylon, Echinochloa* sp., in grassy types; among broad leaf weeds *Amaranthus sp. Commelina benghalensis* (L.), *Digera arvensis* (L.), *Trianthema monogyna* (L.) and *Parthenium hysterophorus* (L.) were most common in their sorghum field at Udaipur, Rajasthan during the year of 2010 in *kharif* season.

Cynodon dactylon, Cyperus rotundus, Digera arvensis, Euphorbia geniculata and *Parthenium hysterophorus* were intense weed species found in sorghum research field at Prabhani, Maharashtra (Jadhav, 2013).

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Thakur *et al*. (2016) reported that sedge like *Cyperus rotundus*, grass like *Echinochloa* spp. and broad-leaf weeds of *Amaranthus viridis, Commelina benghalensis, Digera arvensis* etc. were great menace to the sorghum crop during rainy season of 2011 and 2012 at Indore.

Deshmukh and Usadadia (2017) has found that *Acalypha indica, Ageratum conyzoides, Amaranthus viridis, Digera arvensis, Eclipta alba, Euphorbia geniculate, Phyllanthus niruri* and *Phyllanthus maderaspatensis* and *Portulaca oleracea* were commonly found broad-leaf weeds, wheras *Cyperus rotundus* was prominent sedge in sorghum field at Navsari.

Nutrient removal by weeds

Uncontrolled weeds in sorghum field removed 29.94–51.05 kg/ha nitrogen, 5.03–11.58 kg/ha phosphorus and 30.38–74.34 kg/ha potassium respectively, at Hyderabad, Andra Pradesh (Mishra *et al.*, 2012).

According to the research conducted by Priya and Kubsad (2013) in vertisols of Dharwad, Karnataka during rainy season, weeds removed 20.5 kg/ha of nitrogen, 14.9 kg/ha of phosphorus and 22.3 kg/ha of potassium in the weedy check plots.

Nitrogen, Phosphorus and Potassium uptake by weeds were found significantly lower with atrazine 0.5 kg/ha PE + HW and IC at 20 DAS (Deshmukh and Usadadia, 2017) from the experiment that has been conducted at Paria, Gujarat.

Weed management approaches in sorghum

Atrazine

Jat *et al.* (2013) reported from Udaipur, Rajasthan that atrazine @ 0.5 kg/ha produced 8822.64 kg/ha sorghum stover yield.

According to Deshmukh and Usadadia (2017) application of the treatment atrazine 0.5 kg/ha + pendimethalin 0.25 kg/ha PE as tank mixture provided the complete control over all types of weeds at 20 days after sowing in an experiment that has been conducted at Paria Gujarat.

Verma *et al.* (2017) conducted an experiment in sorghum crop during summer season at Gujrat and reported that atrazine @ 0.50 kg/ha as pre-emergence *fb* atrazine @ 0.50 kg/ha post emergence at 25 DAS *fb* hand weeding 40 DAS gave higher stover yield of 6929.67 kg/ha.

Saini *et al*. (2018) conducted a field experiment during *kharif* season of 2010 and 2012 at Navsari Agricultural University, Gujrat in that they observed that when atrazine @ 1.5 kg a.i./ha applied as pre-emergence recorded higher seed and stover yield of 3612 and 14495 kg/ha in sorghum which was at par with treatment of atrazine @ 0.5 kg a.i./ha + 1 hand weeding at 35 days after sowing.

Metolachlor

The s-metolachlor herbicide as pre-emergence herbicide when applied alone, resulted in better control over D. *ciliaris* between 84.3 % and 87.5 %, among different sorghum cultivars in Brazil; Furthermore, the treatment of mixture of atrazine + s-metolachlor (1,665 g ha-1 + 1,035 g ha-1) was found to have better control of U. *plantaginea*, and resulted in higher plant density, when compared to the other treatments, this might have led to a greater shading of weeds in Brazil conditions (Galon *et al*., 2016).

The pre-formulated mixture of atrazine + S - metolachlor @ 1,480 + 1,160 g a.i./ha respectively, guarantees the safe use of this new formulation for weed chemical control in sorghum crop, and the efficacy of these kind of herbicides gave a high level of control over wide range of species at Colorado, United States (Takano *et al*., 2018).

Bararpour *et al*. (2019) from Arkansas, USA reported that application of S-metolachlor *fb* mesotrione along with crop oil concentrate controlled *Ipomoea lacunose* up to 98% in sorghum, which was significantly better than all other treatments that has been used (87% to 91%).

According to the experiment of Reis *et al.* (2019) at Brazil, atrazine + S-metolachlor gave the weed control efficiency up to 90% but the dose of metolachlor should be under 960 g a.i./ha to avoid negative impact on sorghum plants.

Based on the results obtained from the experiment conducted by Bowman (2020) in sorghum crop at Fayetteville, control of the weed palmer amaranth upto 93% was observed at 2 weeks after planting by the application S-metolachlor as pre-emergence herbicide and 99% control was obtained when it was sprayed with atrazine + S-metolachlor. Furthermore, the standard herbicide treatment (S-metolachlor PRE fb atrazine + S-metolachlor POST) gave 98 and 94% control of Palmer amaranth and goosegrass respectively, but only 61% of control of johnsongrass is obtained.

Pyroxasulfone

Pyroxasulfone (KIH-485) is a novel experimental herbicide which is used for weed control in soybean and field corn (*Zea mays* L.) that may have weed management potential in sweet corn (Sikkema *et al*., 2008).

Nurse *et al.* (2011) conducted a field experiment in Canada on sweet maize to find out the dose that required to control more than 90% of weeds without affecting the yield of sweet maize not more than 5%. He reported that when pyroxasulfone applied @ of 93,111 and 499 g a.i./ha, it reduced the biomass of redroot pigweed, greenfoxtail and common lambsquarters respectively by 90%. Furthermore, large crabgrass, velvetleaf and barnyard grass were also controlled more than 95% at the dose of 31.25 g a.i./ha.

Yamaji *et al*. (2014) conducted the experiment in Japan on corn with the application of pyroxasulfone and observed that it has given more than 90% control against seven grass weed species @ 16 g a.i./ha and of *Eriochloa villosa*, *Sorghum halepense*, *Urochloa platyphylla* and *Amaranthus retroflexus* @ 32 g a.i./ha. *Cyperus esculentus* and other broadleaf weeds were controlled @ 63 or 125 g a.i./ha. Pyroxasulfone was very effective against grassy weeds than on broadleaf weeds.

According to Bond *et al*. (2014) pyroxasulfone application @ 0.16 kg a.i./ha controlled the glyphosate resistant Italian ryegrass more than 93% in the fields of United States.

The two-year field experiment of Jha *et al*. (2015) at northern Great Plains of the United States showed that residual control of wild buckwheat and common lambsquarters was higher with the application of pyroxasulfone at 298 g a.i./ha dose; The tank mixture of pendimethalin with pyroxasulfone has recorded the weed control efficiency of 94, 89 and 81% against common lambsquarters at 21, 35 and 63 days after emergence respectively, in corn field.

Pyroxasulfone controls grassy weeds like *Alopecurus myosuroides, Avena fatua, Bromus tectorum, Cenchrus longispinus, Digitaria ischaemum*, D. *sanguinalis* and *Echinochloa crus-galli* as well as broadleaf weeds like *Abutilon theophrasti, Amaranthus albus*, A. *hybridus*, A. *palmeri*, A. *powelli*, A. *retroflexus* and A. *rudis* in the crops like wheat, corn and soybean in countries like Japan, Australia, the USA, Canada, Saudi Arabia and South Africa (Nakatani *et al*., 2016).

Application of pyroxasulfone alone or atrazine + pyroxasulfone as pre-emergence herbicide had controlled palmer amaranth weed up to 93-96% in corn field of Louisiana and Mississippi (Stephenson *et al*., 2017).

Goodrich *et al*. (2018) from Urbana, Illinois reported that sequential application of pyroxasulfone as pre-emergence herbicide resulted in significant range of weed control and also didn't cause much injury to the sorghum crop than single high-rate application. But single high-rate application was resulted in sorghum injury.

Sodium 2,4-dichlorophenoxyacetate (2,4-D Na salt)

Sequential application of herbicides atrazine @ 0.75 kg/ha, 2,4-D @ 1.0 kg/ha and mechanical weeding have recorded lowest weed density and highest yield in sorghum crop in Karnataka (Shantveerayya *et al*., 2012).

Post-emergence application of 2,4-D @ 0.75 kg a.i./ha in sorghum crop at 20 days after sowing have been on par with the yield given by weed free check; improved the yield by 38.9 percent over weedy check and 6.5 percent over farmer's practice at Dharwad region of Karnataka (Priya and Kubsad, 2013).

Chepkoech *et al*. (2021) from Kenya reported that 2,4-D was very effective against most of the broad-leaved weeds among the herbicides that they have used in sorghum field. Furthermore, it resulted in lower weed density over the un-weeded check.

Intercropping with cowpea

The ability of cowpea to suppress weeds by smothering effect as an intercrop provided with better yield in quantity as well as quality and gave highly nutritious and palatable forage product for cattle in Bihar conditions (Kumar *et al*., 2012).

Jat *et al.* (2013) reported from Udaipur, Rajasthan that intercropping of sorghum with cowpea+1 HW was found at par with the treatment atrazine alone and its integration with 1 hand weeding. Also, the intercropping with cowpea +1 HW recorded in higher B: C ratio than other treatments.

Pal *et al*. (2014) observed the maximum green fodder yield of sorghum in sorghum + cowpea (50%) intercropping system which was significantly at par with sorghum + cowpea (25%) intercropping system. They also observed a significant reduction in green fodder yield in intercrop system than sole sorghum which was probably due to the effect of competition between the crops for the nutrients and space. The same legume intercropping system with sorghum resulted in high crude protein yield and net returns at Pantnagar.

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