Review article

WEED MANAGEMENT IN SORGHUM

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SUMMARY

Diversifying the use of agricultural products, in addition to human and animal nutrition, higher profitability per unit of arable land can be achieved. Thanks to its origin and biological properties, sorghum is a crop that can significantly contribute to this diversification in the global plant production system. Due to C4 metabolism, high biomass production and pronounced tolerance to stress caused by adverse environmental conditions (drought, high temperatures), in the light of global climate change, sorghum is globally one of the five most cultivated cereals, which is increasingly finding its place in the European plant production system. In agronomic practice weeds are recognized as one of the most significant limiting factors in increasing productivity and quality. The aim of this paper is to review weed impact on sorghum plants and yield, as well as contemporary management approaches with reference to the latest trends aimed at optimizing the integrated weed protection of sorghum.
KEYWORDS: herbicide, integrated management, sorghum, weed

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INTRODUCTION

Physiological parameters, growth and development of plants are strongly influenced by competition within the population of cultivated plants, but also between crops and weeds. To harness the yield potential, growers must take care of weed control during critical period, when the impact on final yield can be significant. Zimdahl (1999) defined Critical period of weed control (CPWC) as the maximum period in which weeds can be tolerated due to the negligible impact on the crop.

Sorghum is sown in late spring when the soil temperature and sufficient moisture enable relatively fast germination and sprouting. Given the slow initial growth, Sundari & Kumar (2002) emphasize the first 4-6 weeks as the most critical period in which weeds develop more intensively than sorghum weak competitors seedlings and can significantly reduce crop. After this period, with the beginning of intensive growth and closing of the inter-row space, the competitiveness of sorghum increases due to the establishment of dense canopy (Peerzada et al., 2017).

Weeds that appear later in the season have less impact on growth, but in conditions of higher weedness, they can cause a reduction in the number of productive panicles and yields through reduction tillering. In addition, a large population of weeds at maturity can affect harvesting efficiency and reduce harvested yields.

To obtain economically justified yields, when protecting against weeds in critical stages, growers should apply appropriate measures to minimize their impact.

WEED INFLUENCE ON SORGHUM YIELD

Within the agroecosystem, the application of appropriate management practices provides

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the most favorable conditions for the growth and development of crops. In addition to crops, weeds also have an affinity to provided resources. To complete their life cycle in the same habitat, crops and weeds compete for photosynthetically active radiation including sunlight and CO2, soil moisture, nutrients, and space (Korav et al., 2018).

Unlike water or nutrients, light is not stored in the plant or soil but is used by plants directly through a photosynthetic apparatus. By shading, weeds reduce the photosynthetic activity of the lower leaves of crops. Reduction of photosynthetically active radiation caused by the shedding is more pronounced in broadleaf weeds, especially if the weeds are taller than crop. According to research of Graham et al. (1988) sorghum leaf area index (LAI) was reduced to 81, 65, and 37% of the LAI of weed-free sorghum in canopies with 1, 4, and 12 pigweeds (*Amaranthus* spp.) plants m^{-2}. The decrease in sorghum grain yield due to weeding by broadleaf weeds ranges from 7% up to 40% (Knezevic et al., 1997; Unruh, 2013).

The ability of the level of competition in the absorption of water from the soil is determined by the volume and capacity of the root system and in most weeds the water use efficiency (WUE) is higher compared to cultivated plants (Silva et al., 2007). Aggressive approach to water resources in weeds such as *Amaranthus* spp. is conditioned three times and in *Chenopodium album* twice the need to produce the same amount of dry matter compared to sorghum (Robbins et al., 1942). Due to its physiological predispositions, sorghum is one of the plants that successfully develops in conditions of reduced soil water capacity, especially when transpiration efficiency is taken into account (Tolk & Howell, 2009).

The high level of biomass accumulation per unit area and faster rate of nutrients removal by the weeds significantly affects crops. According to Satao & Nalamwar (1993) uncontrolled weeds in sorghum removed from soil up to 51.05, 11.58, and 74.34 kg/ha NPK, respectively.

Sankaran & Mani (1972) stated corresponding reduction of 100 kg grain yield of sorghum for every unit of 4.5, 1.5, and 4.0 kg NPK removed by weeds.

Substantial yield losses caused by weed interference are also related to the space that individual crop and weed plants occupy. The Burnside & Wicks (1969) study confirms a negative correlation between sorghum yield and weed yield, with as weed competition increased, sorghum yields increased with narrower rows and higher plant populations.

The analysis of Dille et al. (2020) in USA for 2007 to 2016 shows that, based on optimal agronomic practices for grain sorghum, the potential yield loss of production due to weed interference ranges from 30-60%, which means also a significant monetary value loss.

WEED MANAGEMENT

When choosing the most optimal weed management for sorghum, the limited choice of selective herbicides, primarily for early and narrow-leaf weeds, should be taken into account with the dangers posed by the increased occurrence of herbicide-resistant weeds. For the maintenance of weed-free crops, primarily in CPWC, in addition to agricultural management, manual and mechanical measures are still recommended and applied.

Agricultural and mechanical management

Agricultural practices are eco-friendly methods that provide the best possible conditions for crop growth and development for increasing their competitiveness against weeds.

Crop rotation which implies successive sowing of different plant species in the same soil over time optimize the use of resources to maximize productivity. This management measure enables, above all, the rational use of herbicides and reduces the costs of mechanical weed control (Burnside, 1978).

In the crop rotation system, sorghum should also be considered as a good previous crop due to a strong allelopathic potential with numerous water-soluble allelochemicals, such as sorgoleone and phenolics which are phytotoxic to many plant species and responsible for weed suppression (Cheema et al., 2004; Jabran, 2017).

Sowing at the appropriate time and in soil with the appropriate temperature and humidity enables even plant germination, relatively fast initial growth and canopy closing. In addition to providing conditions for quality sowing, with good pre-sowing preparation early weeds are eliminated mechanically.

Given that sorghum cultivars differ in their ability to compete weeds (Mishra et al., 2015), the choice of the appropriate variety with good seed quality contribute to better crop competition primarily in the initial stages. When selecting the variety, growers should consider that higher plants, with a significant leaf area index (LAI) and longer vegetation period are better competitors to weeds (Burnside & Wicks, 1972).

Herbicide

In intensive sorghum production, herbicides are still the main component for weed management. Preparations based on triazine and alachlor (Sharma et al., 2000) were previously used for treatment after sowing and before sorghum emergence. Preparations based on 2,4-D are applied to control broadleaf weeds post-emergent (Stahlman & Wicks, 2000), in the phase of 3-5 sorghum leaves. Contemporary technology recommends for broadleaf weed control in the phase of up to 5 sorghum leaves and 2-4 leaves of weeds combination Bentazone + Terbutilazine. If sorghum seeds are treated with a protectant fluxofenim (Concep III), it is possible to safely pre-emergence application of S-metolachlor for suppression *Setaria* spp. and perennial *Sorghum halepense* sprouted from seed. Although they have proven to be quite good in practice, putting some of the preparations out of use narrows the opportunities for chemical control of weed populations.

The assumption is that the choice of herbicides for the control of broadleaf weeds in sorghum will not be a problem in the future, while the chemical control of grassy weeds is a challenge. For now, a range of herbicides is in use, but only for pre-emergency control of narrow-leaved weeds in which activation often does not occur due to too much or too little precipitation after application. Recent trends in sorghum protection against weeds include few different non-GMO approaches for the introduction of resistance to crop, with potential to enable efficient post-emergence use of herbicides to control narrow-leaved weeds.

During a scan of the elite germplasm in Argentina, a line of grain sorghum tolerant to imidazolinone herbicides was discovered. The mutation occurred spontaneously in nature and tolerance does not imply the presence of DNA from other species. A non-GMO technology called *igrowth* allows pre- and post-emergency control of summer grass and some broadleaf weeds (Advanta Seeds US, 2021).

Through the application of non-GMO tissue culture in sorghum breeding tolerance to herbicides for the control of grassy weeds is developed. Tolerance is manifested through the sensitivity reduction of the enzyme acetyl coenzyme-A carboxylase (ACCase) (S&W Seed Company, 2021).

In the early 1990s, a population of shattercane (*Sorghum bicolor*) resistant to acetolactate synthase (ALS) inhibiting herbicides used for post-control of grass weeds was detected in a Nebraska corn field (Lee et al., 1999). Studies have shown that the trait is determined by single major, partially dominant genes and two or three modifier genes, with the mutated fragment encoding a protein fragment that provides sorghum with resistance to inhibition of ALS herbicides (Tuinstra & Al-Khatib, 2008). Shattercane and grain sorghum are genetically (2x = 20) and sexually compatible, so shattercane can serve as a donor of the resistance gene in grain sorghum germplasm by applying conventional breeding methods. With the widespread application of this technology, the post-control of narrow-leaved grass weeds in sorghum would be significantly improved (Hennigh et al., 2010).

New technologies can be expected to find their application in practice, but care should be taken that they alone cannot solve the problem of weeding but must be included in an integrated weed protection system. With application of this kind of technology, growers should consider the potential cross pollination, especially between S. *bicolor* and S. *halepense*, which can increase the frequency of ALS-resistance allele through gene flow in johnsongrass populations (Massinga et al., 2003). Problems may also arise as a result more than 150 ALS-resistant weed species have been detected (Heap, 2021), and controlling such a wide population of potential weeds requires a complex approach in defining an herbicide use strategy. Therefore, management practices in herbicide resistant sorghum crop must be based on crop rotation and rotation of herbicides with different modes of action.

CONCLUSION

Given the importance of sorghum in the global crop production system, the optimization of input use efficiency implies appropriate management of weed suppression. Eco-friendly manual, cultural, and mechanical methods will continue to be an important part of integrated crop protection. Since season-long weed control also involves the application of herbicides, their application should be reduced to a low rate as possible. A combination of crop rotation and pre-emergence herbicides with mechanical weeding can satisfactorily solve the problem of weediness, especially in broadleaf weeds. Post-emergence herbicide treatment, with certain limitations, represents the perspective of successful grassy narrow-leaf weeds management.

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SAŽETAK

SUZBIJANJE KOROVA KOD SIRKA

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Širenjem upotrebe poljoprivrednih proizvoda, pored korišćenja u ishrani ljudi i životinja, može se postići veća rentabilnost po jedinici obradive površine. Zahvaljujući svom poreklu i biološkim svojstvima, sirak je biljna vrsta koja u globalnom sistemu biljne proizvodnje može značajno doprineti širenju upotrebe poljoprivrednih proizvoda. Usled C4 metabolizma, velike proizvodnje biomase i izražene tolerancije prema stresu izazvanom nepovoljnim uslovima spoljne sredine (suša, visoke temperature), sirak je sa aspekta globalnih klimatskih promena jedna od pet najviše gajenih žitarica u svetu. U poslednje vreme sve više nalazi svoje mesto i u sistemu biljne proizvodnje u Evropi. Korovi su u agronomskoj praksi prepoznati kao jedan od najznačajnijih ograničavajućih faktora povećanja produktivnosti i kvaliteta. Cilj ovog rada je da se da pregled uticaja korova na biljke i prinos sirka, kao i da se predstave savremeni tehnološki pristupi suzbijanja korova, sa osvrtom na najnovije trendove optimizacije integralne zaštite.

Ključne reči: herbicidi, integralna zaštita, korov, sirak

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