Integrated Weed Management in Minor Millets

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In India, after green revolution main focus was given on production of fine cereals, namely, rice and wheat and millets became neglected grains. Further, urbanization, increase of income and change of food habit also made millets as poor-man's food. But during recent time, millets have regained their lost pride due to re-evaluation of nutritional qualities (Maitra, 2020). Due to climate change, there is a decline in yield leading to food insecurity, more attacks of pests and diseases, soil degradation, change in crop schedules, and desertification. Considering, millets as an alternative crop is a better choice and we can say it is the future crop. There is an immediate need to promote the cultivation of millets to ensure food and nutritional security at national level. Presently, agriculture is facing tremendous problem due to climate change and global warming. The main effects of climate change are increase in temperature, uncertainties in rainfall and enhancement of greenhouse gasses emission (mainly carbon-dioxide). As C4 plants, millets can use enhanced atmospheric CO_2 and convert into biomass (Brahmachari *et al*. 2018). Millets are considered climate smart and nature friendly crops because of high nutritive value and can withstand under warm and drought conditions with short life, low external inputs requirement. tolerance to water and temperatures stress, (Yadav *et al*., 2012; Gupta *et al*., 2017; De Vries *et al*., 2020). Ten millet crops have been declared as 'Nutri Cereals' which include three major millets i.e., pearl millet, sorghum and finger millet; five minor millets i.e. foxtail millet, proso millet, kodo millet, barnyard millet, little millet; and two pseudo millets i.e. kuttu (buckwheat) and amaranthus (NAAS, 2022). Considering the importance of millets in food and nutritional security, the year 2018 as 'National Year of Millets' at national level and the year 2023 as 'International Year of Millets' was celebrated at global level. Millets are currently grown in 131 countries in over 78 million ha (FAO, 2022) with sorghum and pearl millet accounting for over 90 per cent share at global level. India is the largest grower (with 19% contribution) and producer (20% production) of millets in the world. Share of India in Asia stands at 85% in area and 80% in production of millets. In India, minor millets share an area of 0.44 million ha with a production of 0.35 million tones having productivity of 781 kg/ha and among the minor millets, finger millet occupies larger area under cultivation (Dubey *et al*, 2023). At national level maximum area (89000 hectares) and production (76000 tonnes) of minor millets was reported from Madhya Pradesh. Top seven countries in the world for pearl millet cultivation are India, Niger, Sudan, Nigeria, Mali, Burkina Faso and Chad. Thus, among the major millets India ranks first in the world with respect to pearl millet cultivation and third in sorghum cultivation. The major millets are Sorghum, Pearl Millet, and Finger Millet covering 95% of the total millet growing area in India and the rest 5% are Little Millet, Foxtail Millet, Barnyard Millet, Proso Millet, Kodo Millet, and Brown top Millet. The most important states for pearl millet cultivation are Rajasthan, Uttar Pradesh and Maharashtra having a total share of 78 per cent. Karnataka alone accounts for more than 2/3rd acreage of finger millet. Chhattisgarh and Madhya Pradesh grow more than 60per cent of small millets.

Presently, agriculture is facing tremendous problem due to climate change and global warming. To ensure food and nutritional security at national level, there is an immediate need to promote the cultivation of millets as millets are considered climate smart and nature friendly crops because of high nutritive value and can withstand under warm and drought conditions with short life, low external inputs requirement, tolerance to water and temperatures stress. Ten millet crops have been declared as 'Nutri Cereals' which include three major millets i.e., pearl millet, sorghum and finger millet; five minor millets i.e. foxtail millet, proso millet, kodo millet, barnyard millet, little millet; and two pseudo millets i.e. kuttu (buckwheat) and amaranthus. Due to sluggish growth in initial phases of life, millets proved relatively poor competitors against weeds. Manual weeding is the

most commonly adopted for weed control in millets. But the non-availability of labour and ever-increasing labour wages have compelled the farmers to seek alternate method of weed management. Herbicide use is the most viable method of weed control but their continuous and excessive use is not advisable due to its ill effects on environment and development of herbicide resistance in weeds. Very limited options are available in literature for weed control in minor millets. Thus, integrated weed management practices should be followed on site and time specific basis for effective and efficient weed management in minor millets. For integrated weed management in minor millets, 2-3 times inter-cultivation and 1–2-time hand weeding during initial 25 days after sowing in addition to pre-emergence spray with Isoproturon @ 0.5 -1.0 kg a.i./ha and post emergence spray of 2, 4-D sodium salt @ 0.75-1.0 kg a.i./ha at 20-25 days after sowing should be done for effective weed control.

Integrated weed management: The principal strategies which we can consider under an integrated weed management approach are preventive, agronomic and cultural and chemical strategies. Conceptually integrated weed management is a systematic weed management approach combining monitoring, prevention and control and not based on the complete eradication of weeds, but rather on their control below thresholds that are agronomically, environmentally and economically acceptable.

Preventive methods

As we know that "Prevention is better than cure," so it is better to prevent the weed species to spread in the croplands and infest the crop. Prevention is least cost strategy but often least used control strategy. Preventive methods, often referred to as cultural methods, include those strategies or agronomic choices, which are aimed at preventing weed germination, emergence, growth, diffusion and dispersal (Bond and Grundy, 2001). These goals could be reached by reducing the soil weed seed bank and increasing the crop competitive capacity. Soil weed seed bank may be controlled through crop rotation, Stale seedbed, Soil solarization, Good agronomic practices, ploughing, cover cropping, mulching, intercropping and green manuring, while increase in crop competitive ability may be obtained by selecting good cultivars (having better root development, fast early vigour, high leaf area development), higher crop density and proper spatial planting patterns to smothering weeds and Changing the crop calendar in accordance with prevailing climatic conditions to ensure better crop germination and establishment before weed emergence.

Mechanical methods

Removal of weeds by various means of tools and implements, hand weeding and pulling comes under mechanical and physical practices of weed control, respectively. The mechanical method of weed control helps in weed seed burial as well as the removal of weed plant and vegetative propagules from the soil of the cultivated field which reduces the weed thrust in the field eventually reducing the crop-weed competition and enhancing the crop yield.

Cultural methods

Cultural methods of weed control are the environment-friendly methods that are adopted during crop husbandry in a standing crop through different cultural management such as plant population management through seed rate, crop spacing management, intercropping, crop rotation, mulching, management of time, and method irrigation and nutrient application. Growing intercrops such as green gram, cowpea, soybean, and ground nut could suppress the weed population by their high growth rate during the early period of crop growth, which eventually smothers the weeds so that the weed plants do not get adequate sunlight.

Selection of competitive and allelopathic cultivars affected the weed seedling emergence by decreasing the light interception and releasing numerous allelochemicals (Peerzada *et al*., 2017). Crop variety play an important role in crop weed competition because of variations in morphological features, canopy structure and relative growth rate which leads to weed suppression.

Growing of intercrops in widely spaced row not only reduces intensity of weeds but also gives additional yield. Intercropping increases the use of natural resources, compared to sole crops.

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). Inclusion of leguminous crops in finger millet rotation, trigger the germination of striga but prevent its continued growth.

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 every day, 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.

Mulching is 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.

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.

Chemical methods

Weed management in millets is not accomplished by using agronomical and cultural practices exclusively. Herbicides continue to be the most powerful, economically effective and reliable way to control weeds in most crop production situations. The very first step in the direction of chemical use for weed control is the determination of weed species and their densities present at the particular field. After the identification of weed species, their densities and consideration of their economic threshold levels, the next step is to choose the application scenario for an herbicide *i.e.* optimum dose of herbicide should be chosen by keeping in mind the competitiveness of crop stand, environmental conditions, application technology and the stage of growth of weeds.

Conclusion

To avoid the development of resistance in weeds, to reduce weed seed bank, to improve the economic return, instead of any single method of weed control, all the feasible methods are to be integrated for the effective and sustainable management of weeds in minor millets. For integrated weed management in minor millets, 2-3 times inter-cultivation and 1-2 times hand weeding during initial 25 days after sowing in addition to pre-emergence spray with Isoproturon @ 0.5 -1.0 kg a.i./ha and post emergence spray of 2, 4-D sodium salt @ 0.75-1.0 kg a.i./ha at 20-25 days after sowing should be done for effective weed control. Oxyflurofen @ 0.1 lit a.i./ha as pre-emergence spray is also recommended for finger millet in irrigated areas.

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