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Managing the weed problems in wheat

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ABSTRACT

Weed infestation is one of the major concern in wheat production. The losses caused by weeds vary depending on the weed species their density and environmental factors. For controlling weeds in wheat crop, herbicides are preferred. For control of grass weed in wheat in wheat clodinafop, fenoxaprop, pinoxaden, pendimethalin and sulfosulfuron are effective. Whereas, broad-leaved weeds control can be effectively achieved with use of 2,4-D, metsulfuron and carfentrazone. For controlling complex weed flora combination of herbicides are required and emphasis should be on to avoid antagonism. The most problematic weed of irrigated wheat under rice-wheat system in India is *Phalaris minor.* This weed has also evolved multiple resistance against clodinafop, fenoxaprop, pinoxaden sulfosulfuron and mesosulfruon. The multiple resistance is an emerging threat to wheat production. For control of multiple resistant population's pendimethalin and terbutryn are effective. The long term strategies of efficient weed management and susatinbility of wheat production should include the use of herbicide rotation, herbicide mixture, crop rotation along with other non-chemical methods.

Key words: weed management, herbicide resistance, wheat, *Phalaris minor*, grass weeds, broad-leaved weeds

Weed infestation is one of the main factors limiting crop productivity. For realizing full genetic yield potential of the crop, the proper weed control is one of the essential ingredients. Weeds not only reduce the yield but also make the harvesting operation difficult. Therefore for sustaining food grain production and to feed ever-increasing population weed management is very essential.The average losses caused by weeds in wheat are about 25 to 30% but losses depend on weed species and density; time of emergence; wheat cultivar; planting density; soil and environmental factor. In extreme cases losses caused by weeds can be up to complete crop failure (Afentouli and Eleftherohorionos 1996; Chhokar and Malik 2002; Malik and Singh 1995; Cudney and Hill 1979; Khera *et al.* 1995; Malik and Singh 1995; Mehra and Gill 1988). The cases of complete crop failure were quite common after the development of isoproturon resistance in *P. minor* (early nineties), when the farmers harvested their immature wheat crops as fodder (Malik and Singh 1993; Chhokar and Malik 2002). The critical period of weed control in wheat is 30-45 days after sowing and crop should be kept weed free during this period.

WEED FLORA AND WEED FLORA SHIFT

Weed flora of wheat differs from area to area and field to field depending on environmental conditions, irrigation, fertilizer use, soil type, weed control practices and cropping sequences. The predominant weeds associated with wheat crop are *Phalaris minor* Retz., *Avena ludoviciana* Dur., *Lolium temulentum, Poa annua* L, *Polypogon monspliences* Desf., *Chenopodium album* L., *Vicia sativa* L., *Lathyrus aphaca* L., *Circium arvense* L., *Melilotus alba* Lamk, *Coronopus didymus* L., *Rumex dentatus, Anagallis arvensis* L., *Argemone mexicana* L., *Asphodelus tenuifolius* Cav., *Carthamus oxycantha* Beib, *Convolvulus arvensis* L., *Cannabis sativa* L., *Euphorbia helioscopia* L., *Fumaria parviflora* Lamk., *Malva parviflora, Medicago denticulata* Willd, *Polygonum plebejum* R. Br., *Spergula arvensis* L.

Yellow thistle (*Carthamus oxycantha* Beib) was main weed before green revolution but increased irrigation and tillage along with increased cropping intensity have almost eliminated this weed. Similarly, wild oat has been eliminated from heavy soils where rice is grown. Although, Maize-wheat rotation allows its gradual build up. Among grassy weeds, *Phalaris minor* Retz. and among broad-leaved weeds *Rumex dentatus* L. and *Medicago denticulta* are of major concern in irrigated wheat under rice-wheat system in India (Singh *et al.* 1995; Chhokar *et al.* 2006; Balyan and Malik 2000). Since R-W system provides favourable conditions to these weeds. *P. minor* is major problem in heavy soil soils, whereas, wild oat is more prevalent in light textured soil. Both *P. minor* and *Rumex dentatus* are highly competitive weeds and can cause drastic yield reduction under heavy infestation. Resistance has evolved in *P. minor* (Malik and Singh 1993; Chhokar and Malik 2002) against isoproturon and as a result, it has emerged as a single weed species limiting wheat productivity in the North Western plains of India.

For the control of isoproturon-resistant *P. minor,* clodinafop, fenoxaprop and sulfosulfuron have been found effective (Chhokar and Malik 2002). Clodinafop and fenoxaprop control only grasses, whereas, sulfosulfuron controls grasses and some of the broad-leaved weeds (Chhokar and Malik 2002; Chhokar *et al.* 2006). The continuous dependence on a single herbicide for a long time, besides resistance development, also leads to a shift in the weed flora (Chancellor 1979). In areas where the farmers are using graminicides like clodinafop and fenoxaprop the broad-leaved weed flora particularly *Rumex* spp. has increased. Continuous use of isoproturon also led to increased infestation of *Medicago denticulata, Convolvulus arvensis, Cirsium arvense.* Under these conditions, broad-spectrum weed control is essential and for that combinations of herbicides as well as weed control methods are needed.

TILLAGE AND WEED

A shift from an intensive tillage system to reduced tillage system can cause major changes in weed population dynamics (Buhler 1995; Chhokar *et al.* 2007), ultimately affecting the herbicide efficacy due to change in microclimate and weed flora. The differential distribution of weed seeds during puddling for rice transplanting as well as changes in microclimate (soil structure, moisture, diurnal temperature fluctuations and light exposure) due to tillage in wheat can influence the weed seedling recruitment. ZT wheat had lower *P. minor* infestation under rice-wheat system (Chhokar *et al.* 2007) and this grassy weed is the main threat to the sustainability of wheat production. Further besides helping in the management of *P. minor,* ZT also reduces the cost of cultivation. Therefore ZT in conjunction with other weed control measure can offer a more economic and sustainable options of wheat cultivation.

Reduced tillage favours the growth of *Cirsium arvense* and *Convolvulus arvensis* (Koch and Hess 1980; Catizone *et al.* 1990). *P. minor* can also be effectively managed through integration of herbicides with ZT under rice-wheat system. As the population of *P. minor* will be less under ZT and further if encouraged to germinate through pre sowing irrigation and killed with non-selective herbicides (like glyphosate/paraquat) followed by seeding under ZT conditions. The subsequent populations will be less due to minimum disturbance of soil. An integrated approach consisting of ZT with slightly advanced sowing (last week of Oct.) with higher seed rate and narrow row spacing of competitive cultivars can drastically reduce *P. minor* population. Further if ZT is practised with residue retention then weed infestation will be lesser. This is because crop residues alter environmental conditions related to weed seed germination, physically impede seedling growth, or inhibit germination and growth by allelopathy (Crutchfield *et al.* 1986). Wicks *et al.* 1994 found that each 1000 kg/ha of winter wheat residue on the soil surface reduced 14% weed seedling establishment. Such an integrated approach, consisting of multi-tactic can offer a viable solution if the choice for selective herbicides is restricted.

- Early sown wheat (Last week of Oct.) reduces *P. minor* infestation compared to late sown. In early sown wheat temperature is not optimum for *P. minor* germination (Chhokar *et al.* 1999). Contrary to it population of wild oat (*Avena ludoviciana*) is more in early sown wheat compared to late sown (Singh *et al.* 1995). They reported the increased mortality of wild oat from 38% to 72 to 87% in November 10, November 30, and November 20 sowing, respectively.
- Crop rotation is a very effective cultural practice in breaking the association of problematic weeds like *P. minor* in wheat. Intensification of Rice-wheat system by including short duration veg pea or potato followed by late wheat effectively controlled the weeds without herbicide application. Also, inclusion of berseem or oats for fodder once in three year reduced the weed infestation (Chhokar *et al.* 2002).
- Adopting planting pattern like closer row spacing or criss-cross sowing increases the smothering effect of the crop on weeds through better early canopy coverage. Increasing seed rate of wheat to 150 kg/ha reduces the losses caused by weeds. Integration of narrow rows and increased crop density offer advantages for weed control.
- Fast growing or early canopy forming and spreading types during early stages are less susceptible to weed competition.

Table 1 List of wheat herbicides, their optimum doses and target group

Herbicide	Dose g /ha	Weed Control	
		Grasses	Broadleaf
Clodinafop (Topik 15WP)	60 (400)	√	
Fenoxaprop-ethyl (Puma Super 10EC)	100-120(1000-1200)	√	
Pinoxaden (Axial 5 EC)	35-40 (700-800)	√	
Sulfosulfuron (Leader 75 WG)	33.3 (25)	√	√
Isoproturon (Arelon 75 WP)	1000 (1333)	√	√
Atlantis 3.6 WG (Mesosulfuron+Iodosulfuron)	400 (12 +2.4)	√	√
Total 80 WDG (Sulfosulfuron+metsulfuron)	40 (30+2)	√	√
2,4-D-E (Weed war 38 EC)	500 (1315)		√
Metsulfuron (Algrip 20 WP)	4 (20)		√
Carfentrazone (Affinity 50 WDG)	20 (50)		√
Pendimethalin (Stomp 30EC)	1000-1500(3333-4950)	√	√
Terbutryn (Igran 500 SC)	1000-1500(2000-3000)	√	√

Herbicides found effective against isoproturon resistance biotypes of *Phalaris minor* are sulfosulfuron, clodinafop, fenoxaprop, tralkoxydim, pendimethalin, Atlantis and pinoxaden. Sulfosulfuron, Atlantis and pendimethalin are effective against both grassy and non-grassy weeds whereas, clodinafop, fenoxaprop, tralkoxydim and pinoxaden are specific to grasses. However, sulfosulfuron and pendimethalin are not effective against

Rumex dentatus and *Avena ludoviciana*, respectively. For control of broad-leaved weeds 2,4-D has been used for a long time, however due to malformation in some of the genotypes, the farmers prefer metsulfuron. Recently carfentrazone has been recommended for broad-leaved weed control and the added advantage with this herbicide is that it has very fast action and control *Malva spp* and *Solanum nigrum.* These two weeds are not controlled by 2,4-D, isoproturon and metsulfuron. Isoproturon is also poor against some of the weeds like *Convolvulus arvensis, Rumex spp, Lathyrus aphaca, Vicia sativa, Cirsium arvensis, Anagallis arevensis and Melilotus spp.* (Mustafee 1991; Malik and Singh 1993)

Wheat is generally infested by mixture of grassy and broad-leaved weeds. For the control of complex weed flora combination of herbicides are needed. A combination of two or more herbicides besides broadening the spectrum of weed control also helps in reducing the cost of weed control. The effectiveness of grass herbicides are generally reduced when mixed with broad-leaved herbicides (Vidrine 1989; Holshouser and Coble 1990; Grichar 1991; Vidrine *et al.* 1995; Damalas and Eleftherohorinos 2001). About 80% of the interactions that has been observed in species of the family Poaceae (grasses) refer to cases of antagonism (Zhang *et al.* 1995). Whereas synergism/compatibility has been found to occur more frequently in mixtures where the companion herbicides belong to the same chemical groups (Damalas, 2004). Sulfosulfuron + metsulfuron are compatible (Chhokar *et al.* 2007) but tank mix application of grass herbicides (clodinafop, fenoxaprop, tralkoxydim and pinoxaden) with either 2,4-D or metsulfuron is antagonistic (Mathiassen and Kudsk 1998). Antagonism between herbicides can be avoided by altering the application timing of herbicides. Ideally, it is desirable to select herbicide combination that have synergistic effect on weeds and antagonistic effect on crop. To avoid antagonism the grass and broad-leaved herbicides should be applied sequentially.

RESIDUAL EFFECT OF WHEAT HERBICIDES ON SUCCEEDING CROPS

Sulfonyl urea herbicides have long persistency and as a result it may affect the sensitive succeeding crops (Chhokar *et al.* 2006). Sulfosulfuron and chlorsulfuron applied in wheat were found to have their residual effect on succeeding maize and sorghum crops (Chhokar *et al.* 2002). Therefore, selection of herbicides for a crop should be in a system perspective.

WHEAT BASED INTERCROPPING SYSTEM

Wheat is generally grown with mustard and under such system clodinafop, fenoxaprop, isoproturon and pendimethalin can be used depending on the type of weed flora. Whereas in situation where wheat is intercropped with sugarcane in bed planted system, broad-spectrum weed can be controlled with combination of sulfosulfuron with metsulfuron. Isoproturon can also be used in areas having no resistance problem.

INTEGRATED WEED MANAGEMENT

The dependence on single method of weed control can not give the desired results in all situation. The best approach is integrated weed management in which all suitable methods of weed control are used in a compatible manner to reduce weed population. Integrated weed management strategies consisting of closer row spacing (15 cm) and reduced dose of herbicide have been found effective in reducing weed and increasing grain yield (Prakash *et al.* 1986). Ahuja and Yaduraju (1989) also reported cross sowing of wheat and placement of fertilizer below seed more effective in controlling weeds and increasing yield compared to unidirectional sowing and broadcast fertilizer application.

HERBICIDE RESISTANCE- A THREAT TO WHEAT PRODUCTION

Littleseed canarygrass (*Phalaris minor)* is the most troublesome winter season grass weed of wheat under rice-wheat sequence in India. Cases of herbicide resistance evolution are more frequent with continuous usage of a herbicide or herbicides belonging to the same group (Beckie 2006). Similar might have happened with isoproturon resistance in *P. minor*, because isoproturon alone at reduced doses was used continuously in uninterrupted rice-wheat system. The factors which favoured the development of isoproturon resistance in India are monocropping (Rice-wheat), monoherbicide (Isoproturon use only) and underdosing.

Resistant *P minor* biotypes required about 5-10 times more isoproturon compared to susceptible biotypes for 50% growth reduction. For the control of isoproturon resistant *P. minor*, different herbicides were recommended but farmers mainly used sulfosulfuron and clodinafop. Now again there has been a gradual decrease in the efficiency of these alternate herbicides due to evolution of resistance. The multiple resistance problems at few locations are so severe that it caused huge grain yield reductions. If the problem of resistance is not tackled, it may lead to serious consequences leading to decrease in wheat production in rice-wheat sequence.

Management strategies must be developed to prevent selection and spread of herbicide resistant populations. The different ways by which we can reduce the selection pressure against R populations are alternative herbicide, herbicide mixture, crop rotation and other agronomic practices providing the crop with a competitive edge over the weed (Cavan *et al.* 2000; Gressel 1990; Wrubel and Gressel 1994). Attention will also have to be paid to ensure that timing, rates and method of application of herbicides are most effective and least likely to lead to the development of resistance.

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