

Weed management in zero tillage of wheat

problems and solutions

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*The major concerns in wheat production are weed infestation, increasing cost of cultivation and degradation of natural resources. Zero till wheat after rice is the most widely adopted resource conserving technology in the north-eastern and north-western plains of India. Its wider acceptance is due to yield improvement by timely planting and reduced tillage cost leading to greater profitability to farmers. Although zero tillage favours some of the annual (*Rumex dentatus*, *Medicago denticulata* and *Polypogon monspeliensis*) and perennial (*Cynodon dactylon*) weeds yet this provides the opportunity to use non-selective or less selective herbicides as pre-planting options to control the resistant or tolerant weed species in wheat. Also, zero tillage wheat reduces the problem of *Phalaris minor*. Further if zero tillage is adopted with residue retention it will have added advantage of better weed control along with other potential benefits.*

Key words: Herbicides, Weeds, Wheat, Zero tillage

Wheat is the second most important cereal crop in India grown on an area of about 31 m ha with a production of 98.61m tonne during 2017-18. India is the second largest producer of wheat in the world after China but our average productivity is low (3.2 tonne/ha). To meet the future demand of the growing population, we have to increase the production through, increasing the productivity as there is little scope for area expansion. The

weed infestation is one of the main biotic constraints limiting the wheat yield. The average losses in wheat due to weed infestation are 20 to 25% in India. By adopting efficient weed management we can curtail the yield reduction in wheat due to weeds. Also, there is concern of the natural resource degradation, reduced factor productivity and reduced profit margin of the farmers. Moreover, there is focus on doubling the farmers' income by 2022. For

addressing these issues zero tillage technology of wheat cultivation can play a prominent role.

Weed flora of zero tillage wheat

A shift from conventional intensive tillage system to reduced/zero tillage can cause the major changes in weed population dynamics due to altered micro-climate, which may also affect the herbicide efficacy. Micro-climate changes due to modified soil structure, soil moisture,



Fig. 1a. Zero till wheat crop after rice and maize



Fig. 1b. Zero tillage + RR + NPK + Farmyard manure



Fig. 2. Turbo Happy Seeder for seeding in to loose crop residue



Fig. 3. CA wheat crop after maize

diurnal temperature fluctuation and light exposure affects the weeds.

Reduced or zero tillage increases the population of perennial weeds such as *Cynodon dactylon* and *Convolvulus arvensis*, and annuals viz., *Polypogon monspeliensis*, *Medicago denticulata*, *Malva parviflora* and *Rumex* spp. However, zero tillage provides the opportunity to control *Phalaris minor*, the most problematic weed in wheat. The surface weed seed bank in zero tillage fields is depleted faster by emergence and mortality as well as destroyed by the seed predators. Further if zero tillage is combined with early sowing and surface residue retention, there will be additional reduction in population of some of the weeds like *P. minor* owing to mulching.

Machines for seeding into crop residues

Ordinary, zero tillage machine has the capability of seeding in anchored crop residue (Fig. 1 a & b). Manually harvested rice fields having anchored residue even up to 45 cm poses no problem but loose residue interferes in seeding by zero tillage machine due to dragging along with the times. For seeding in to loose crop residues, Turbo Happy Seeder (Fig. 2) can be used effectively. The adoption of these machines will reduce the burning problem. The residue retention at soil surface has many benefits such as moisture conservation, improved soil organic carbon and will help in reducing weeds by acting as a mulch.

Weed management in zero tillage wheat

In zero-till system, mostly the weeds seeds are present on the surface or in the upper 2 to 3 cm soil

layers germinate. It reduces the emergence of many weeds requiring light for germination by avoiding the exposure to the light as well as offering the mechanical impedance to the weed seed. The zero tillage should be adopted without residue burning, as the burnt residue ash can reduce the activity of soil applied herbicides due to adsorption. Residue retention also influences the soil temperature and soil moisture which in turn affect the weed germination depending on the type of weed flora, soil conditions, type of crop residue and quantity. The infestation decreased drastically with residue load (Fig 1.) of higher than 4 tonne/ha. However, for optimum yields and effective weed management, residue retention should be integrated with herbicide application. Further, the detailed study on the efficacy of herbicide with residue load needs to be evaluated particularly for the soil applied herbicides.

The important herbicides for weed control in wheat are listed in Tables 1 and 2. In general, the herbicide recommended for conventional

system can also be used under zero tillage conditions. However, some of the pre-emergence herbicide needs some adjustment in herbicide applications.

- For control of broad-leaved weeds, metsulfuron @ 4.0 g/ha or carfentrazone @ 20 g/ha or 2,4-D @ 500 g/ha should be applied. Pre-emergence pendimethalin (1,000 g/ha) is also quite effective in controlling broad-leaved weeds. Ready or tank mixapplication of metsulfuron + carfentrazone, 2,4-D + carfentrazone or Halauxifen + florasulam or pyroxsulam provide the control of diverse broad leaved weed flora.
- For the control of complex weed flora combination of herbicides should be applied.sulfosulfuron + metsulfuron and isoproturon with 2,4-D or metsulfuron can be used as tank mixture. Grass herbicides (clodinafop, fenoxaprop, and pinoxaden) should not be tank mixed with either 2,4-D or metsulfuron and to avoid antagonism the grass and broad-leaved herbicides should be applied

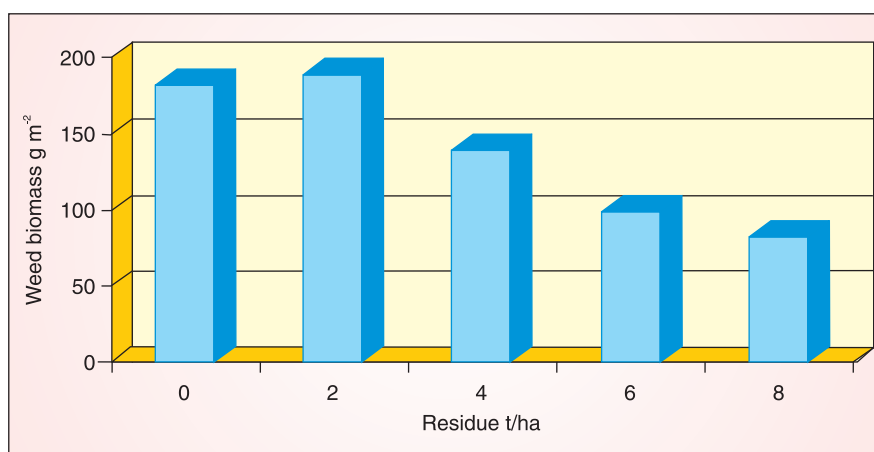


Fig. 4. Effect of crop residue load on weed flora in wheat

Table 1. Chemical weed control in wheat

Herbicide	Dose g a.i./ha (Product dose or ml/ha)	Time of application (DAS, days after sowing)	Weed control	
			Grasses	Broadleaf
Pinoxaden	50 (1000)	Post emergence 30-35 DAS	✓	
Clodinafop	60 (400)	Post emergence 30-35 DAS	✓	
Fenoxaprop- ethyl	100-120 (1000-1200)	Post emergence 30-35 DAS	✓	
Sulfosulfuron	25 (33.3)	Post emergence 30-35 DAS	✓	✓
Sulfosulfuron + metsulfuron	30+2 (40)	Post emergence 30-35 DAS	✓	✓
Sulfosulfuron + Carfentrazone	25+20	Post emergence 30-35 DAS	✓	✓
Mesosulfuron+ iodosulfuron	12+2.4(400)	Post emergence 30-35 DAS	✓	✓
Isoproturon	750-1000 (1000-1333)	Post emergence 30-35 DAS	✓	✓
Metsulfuron	4 (20)	Post emergence 30-35 DAS		✓
Metsulfuron+ Carfentrazone	5+20(50)	Post emergence 30-35 DAS	✓	
Carfentrazone	20(50)	Post emergence 30-35 DAS		✓
2,4-DEE	500(1315)	Post emergence 30-35 DAS		✓
Pendimethalin	1000-1500 (3333-4500)	Pre-emergence 0-3 DAS	✓	✓
Flumioxazine	125(250)	Pre-emergence 0-3 DAS	✓	✓
Pyroxasulfone	127.5(150)	Pre- to early post emergence 0-20 DAS	✓	✓
Flufenacet	300-400) (600-800	Pre- to early post emergence 0-20 DAS	✓	

sequentially at a gap of 3-5 days. Clodinafop and fenoxaprop have incompatibility with broadleaf herbicides particularly 2,4-D and metsulfuron resulting in decreased control of grassy weeds (*P. minor*) and requires sequential application for efficient weed control. Some of the ready mix combinations like sulfosulfuron + metsulfuron (Total), mesosulfuron + iodosulfuron (Atlantis), clodinafop + metribuzin (Sagun 11-21 and ACM 9) and sulfosulfuron + carfentrazone are effective to control diverse grassy and broadleaf weeds in wheat. Sulfosulfuron has longer soil persistence and affects succeeding sensitive crops like sorghum,

maize, and cotton when planted soon after wheat harvest. In resistance affected area clodinafop + metribuzin or pinoxaden + metribuzin are largely used by the farmers but higher amount of metribuzin due to improper application method as well some sensitive wheat cultivars like PBW 550 and Raj 3,765 had some injury. In north-western plains heavy infestation of *P. minor* sometimes causes complete crop failure, where it has also evolved herbicide resistance. *P. minor* has evolved multiple herbicides resistance against isoproturon, clodinafop and sulfosulfuron in northern-western plains. Herbicides effective for the control of multiple herbicide resistance

populations of *Phalaris minor* are pendimethalin, flumioxazine, pyroxasulfone, flufenacet and metribuzin (Table 2). For effective and economical management, early wheat sowing under zero tillage should be combined with above-mentioned post-emergence herbicides.

- Early sown wheat (last week of October) had less *P. minor* population compared to late sown.
- Zero tillage wheat production could be an important tool for controlling herbicide -resistant weeds like *Phalaris minor*, which appeared to decrease. However, other annual weeds -like wild oats, *Rumex dentatus*, *Malva parviflora*, *Medicago* spp. have the potential to increase under zero tillage. Hence, zero tillage does require different strategies for pre-seeding weed control. In zero tillage systems; the absence of tillage as a means of weed control must be compensated for by an increase in herbicide use and cultural weed control strategies. In fields heavily infested with perennial or annual weeds, spray 0.5-0.75% Glyphosate (Roundup or Glycel 41 % SL 12.2-18.3 ml/ litre of water) 1 to 2 days before sowing.
- To break the association of some of the problematic weeds, follow proper crop rotation. Like intensification of rice-wheat system by including short duration vegetable pea followed by late wheat effectively controlled the weeds.
- Regulation of plant density, time of sowing, variety, seed rate, spacing, quantity and time of fertilizer and irrigation application are important factors which influence the crop-weed competition. Combinations of cultural and chemical methods should be adopted for reducing the infestation of weeds in zero tillage wheat crop.
- Farmers must rotate the herbicides every year to avoid or at least delay the problem of development of resistance against these herbicides.

Table 2. Herbicides for control of multiple herbicide resistant *Phalaris minor*

Herbicides	Dose (g/ha)	Time of application (DAS)
Flumioxazine	125	Pre-emergence (0-3 DAS)
Pendimethalin	1,000-1,500	Pre-emergence (0-3 DAS)
Pyroxasulfone	127.5	Pre- to early post emergence (0-20 DAS)
Flufenacet	300-400	Pre- to early post emergence (0-20 DAS)



Fig. 5. *Phalaris minor* infested wheat field



Fig. 6. Zero tillage favours *Rumex dentatus*

Herbicide resistant weeds and their management

Herbicide resistance cases are more frequent with usage of same herbicide or group of herbicides continuously. In case of wheat presently five weed species were evolved herbicide resistance. Among these the most serious case is of *P. minor* as it is wide spread and also evolved multiple herbicide resistance (more than one mechanisms of resistance) against most commonly used post-emergence wheat herbicides (isoproturon, clodinafop, pinoxaden, sulfosulfuron). There are cases of complete crop failure and farmers are facing huge economic losses in the absence of effective alternative safe post-emergence options against multiple herbicide resistant populations of *P. minor*. Pyroxasulfone, flumioxazine, flufenacet and pendimethalin, are effective against resistant populations of *P. minor* and the first three herbicides are in process of registration. Also the efficacy of these herbicides may vary depending on soil texture, soil tilth, soil OM and soil moisture. Pyroxasulfone is being used in Australia for control of multiple herbicide resistant *Lolium rigidum* and there are indication of evolution of resistance where used at lower rates for 3-4 years. Usage of lower rates were found to be associated with evolution of metabolic resistance in many weeds species. To prolong its effective existence life, care should be taken to use it at optimum doses and proper application better, if it is applied in combination with other herbicides of

different chemistry.

Although, isoproturon has lost its efficacy against resistant populations of *P. minor* but it is providing good control of ALS inhibitor resistant *Polypogon monspeliensis*, *Rumex dentatus* and *Chenopodium album* as well as AC Case inhibitor herbicide resistant wild oat. It is also effective against some of the other broadleaf weeds. Therefore, combination with other herbicides it can be used for diverse weed flora control.

Sole dependence on herbicides is likely to be a failure as being observed with *P. minor* in India and other weed species globally. Management strategies must be developed to prevent the selection and spread of herbicide resistance. The different ways of reducing the selection pressure in favour of herbicide resistance, are herbicide rotation, herbicide mixture, crop rotation and other agronomic practices favoring the crop over weeds.

Presently the adoption of zero tillage with early sowing is providing immense help to the farmers as emergence of *P. minor* is less compared to CT system. Moreover, if no-till system with surface residue retention (Conservation Agriculture) is adopted, it has more reduction in the weed infestation. However, the herbicide efficacies in such situations depend on the selection of herbicide and application timing. Integration of other agronomic practices will further improve the weed control.

Future research needs

- Selection of genotypes well adapted to CA (ZT+ residue) for

early growth

- Need to fine tune the spray technology for conservation agriculture wheat with respect to the time and spray volume for pre emergence and pre planting herbicides.
- Need to evaluate zero tillage technology in other wheat based cropping sequences
- Also we have to develop effective strategies to combat the emerging multiple herbicide resistance problems in weeds and to address the issue of weed management in the inter cropping systems

SUMMARY

The zero tillage and seeding into surface retained residue with minimum soil disturbance have combined benefits of yield advantage and cost saving along with broader weed control options. Non-selective herbicide like glyphosate and paraquat can be used before wheat seeding, if weeds are present in no till conditions at the time of seeding. Thus in comparison to conventional system, there are more chemical weed management options in zero tillage which can be explored as pre planting opportunities. Hence, zero tillage wheat technology provides economical and sustainable weed management and wheat production option for long term sustainability of natural resources.

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