

Herbicide resistant *Phalaris minor*

A challenge for sustainable wheat production

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Phalaris minor Retz. (little seed canary grass) is a rabi weed that mimics wheat crop and if left unattended, may lead to 15-40% or more yield loss. It predominates in the rice-wheat cropping system in Haryana, Punjab, Western Uttar Pradesh and states of the north-western Indo-Gangetic plains of India. Being morphologically similar to wheat, it often escapes from manual and mechanical control. Thus to control this weed, application of herbicide is the most appropriate tool. However, use of same herbicide repeatedly develops selection pressure resulting resistant weed population. Herbicide resistance started from the use of isoproturon to clodinafop, fenoxaprop, sulfosulfuron. Also, some of the biotypes developed resistance to some new herbicide viz., pinoxaden, mesosulfuron+iodosulfuron. As of now, multiple herbicide resistance has evolved in *Phalaris minor*, due to which sustainability of the wheat remains doubtful. To tilt the selection pressure in favour of resistant biotypes and to sustain wheat production, the use of new herbicides and its compatible mixtures having multifaced modes of action and herbicide rotation from year to year is necessary. To improve crop safety, the practice of optimized rate of the herbicide in combination with appropriate doses of other herbicides need to be followed, which will also broaden the spectrum of weed control and delay the evolution of resistance in weed species.

Keywords: Herbicide resistant, Indo-Gangetic plains, *Phalaris minor*, Wheat

Status of wheat in Haryana

Wheat (*Triticum aestivum* L.) belongs to family poaceae, is a staple food and main cereal crop around the world. India with 13.9 % share stands second in the global area of wheat and produce 99.9 mt with average yield of 3368 kg/ha. Haryana is the major wheat-growing state of India producing 10.76 mt from an area of 2.44 M ha with a mean of 4,412 kg/ha. The mean yield of wheat in both Haryana as well as country is still behind the yield potential of high yielding varieties, hence there is a large scope for enhancement in productivity through improved agronomic practices including weed management. Weeds are main factor responsible for declining of productivity by ≥ 15 -40% and quality.

Major weeds of wheat

Weeds predominant in the wheat

field are lambs quarters (*Chenopodium album* L.), canada thistle (*Cirsium arvensis* L.), scarlet pimpernel (*Anagallis arvensis* L.), field bind weed (*Convolvulus arvensis* L.), vetch (*Vicia hirsute* L.), white sweet clover (*Melilotus indica* All.), bur clover (*Medicago denticulata* Willd), meadow pea (*Lathyrus aphaca* L.), golden dock (*Rumex dentatus* L.), fumatory (*Fumaria parviflora* Lamk.), mexican poppy (*Argemone maxicana* L) in broadleaf category. Similarly, grassy weeds viz., littleseed canary grass (*Phalaris minor* Retz.), wild oat (*Avena ludoviciana* Durieu.), wild onion (*Asphodelus tenuifolius* Cav.), etc. that levy serious problems in wheat fields. Moreover, bermuda grass (*Cynodon dactylon* Pers.) is a major perennial weed. *Phalaris minor* Retz. (littleseed canary grass) is a mimic weed (i.e. unable to be distinguished from the crop at early

growth stages) of wheat in rice-wheat cropping system and severely infests wheat fields in the north-western Indo-Gangetic plains (IGPs) of India including Haryana. It is an annual grassy weed (family: poaceae), non-native cropland weed of India. It is originated in the Mediterranean region and introduced in India through the import of Mexican wheat. It is self-pollinated, C₃ monocot weed (2n=28), associated with winter crops having morphological similarity to wheat up to the flowering stage.

How to identify *Phalaris minor*?

Phalaris minor and wheat can be distinguished at early growth stage as it has a purplish pigmentation at base of the stem, narrow dropping leaves, purplish-orange sap oozes out when the stem is broken from the base. High tillering and branching leads to

prolific seed production (300–450 seeds/panicle) whereas, wheat has no branching habit. *P. minor* has ligule three times lengthier (3.0–8.5 cm) without auricles than that of wheat; mature earlier (nearly 20 days) with an unsynchronised pattern. Thus, more than 90% *P. minor* seeds shed on the ground before harvesting of the wheat crop. Mature seeds after harvesting remain dormant for the period of six months and thereafter germination increases up to 98%. Even under anaerobic conditions, their seeds enter into secondary dormancy. It has more competitive ability in late sown wheat with 6, 7 and 54% higher uptake of nitrogen (N), phosphorus (P) and potash (K), respectively. At maturity, inflorescence of *P. minor* may be taller than dwarf wheat, with plant height ranging <30 to >100 cm.

Losses due to *Phalaris minor*

P. minor has superior growth traits and competitive advantage over wheat. Cultivation of semi-dwarf wheat varieties requires frequent irrigation along with high fertilizer doses, modifies the agro-ecological conditions, provides favourable and conducive micro-climate for growth and development of *P. minor* that helps to compete vigorously with wheat (Fig 1). The occurrence of 60–70 plants/m² of *P. minor* in wheat field may impose penalty of 10 % on its yield which may go upto 50% under *P. minor* population of 500 plants/m². Heavy infestation of *P. minor* (2,000–3,000 plants/m²) result in complete crop failure. Huge population pressure of *P. minor* causes heavy crop lodging and makes harvesting operation very difficult and sometimes impossible. Therefore, on an average large-scale dominance of *P. minor* in field, leads to reduction in the wheat yield ≥ 25–50% and quality of produce.

Status of herbicide resistance

Worldwide, 512 unique cases (species × site of action) of herbicide resistance have been recorded, with 262 weed species (152 dicots and 110 monocots) having resistance to 23 of the 26 known herbicide sites of action. In wheat, five weeds species



Fig. 1. Infestation of *Phalaris minor* in wheat field

viz., *Phalaris minor*, *Avena ludovicinana*, *Rumex dentatus*, *Polypogon monspeliensis* and *Chenopodium album* have developed herbicide resistance. It is estimated that *Phalaris minor* invades about 50% (15 Mha) of the cultivated wheat areas in India, out of that multiple herbicide-resistant *Phalaris minor* affected area is about 3.0 Mha.

Resistance development in *Phalaris minor*

Due to the morphological similarity of *Phalaris minor* with wheat, it is very difficult to control through physical means and manual weeding, which makes it to emerge as a single dominant grassy weed in the wheat field. During 1978–79, the

numbers of herbicides come into the market to control *Phalaris minor*. Among those herbicides, isoproturon found quite effective and recommended for use in the late 1970s. Due to its broad-spectrum effectiveness in weeds, the majority of farmers depended on isoproturon or isoproturon + 2,4-D for effective weed control in wheat. It informed effectively for nearly 20 years. In 1992, first confirm case of isoproturon resistance in *Phalaris minor* biotype was registered in Haryana, India. This was due to extensive use of isoproturon herbicide over the years with inappropriate application method and dose. Thus, isoproturon recommendation was withdrawn in

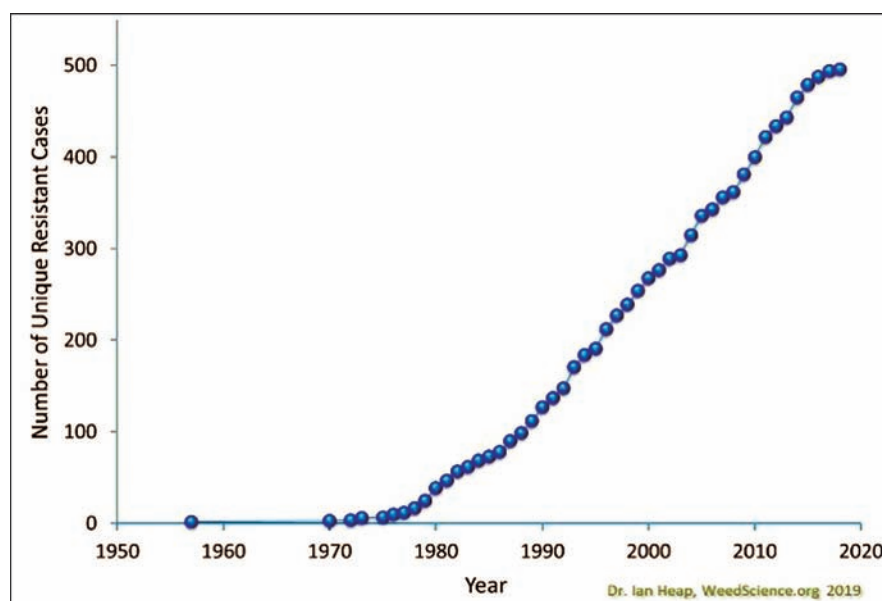


Fig. 2. Global unique herbicide resistance case

1997-98 and four new herbicides viz. clodinafop, sulfosulfuron, tralkoxydim and fenoxaprop were recommended in 1997-98 as alternative herbicides for control of isoproturon-resistant *Phalaris minor* biotypes. These herbicides were applied at the three-leaf stage with recommended dose of clodinafop (60 g/ha), sulfosulfuron (25 g/ha), tralkoxydim (350 g/ha) and fenoxaprop (120 g/ha), provides 82-95% weed control. However, due to sole dependency of ACCase inhibitor (clodinafop, fenoxaprop) and ALS inhibitor (sulfosulfuron, pyroxulam, mesosulfuron) herbicides for 10-15 years, *Phalaris minor* resistant biotypes developed cross-resistance (resistance to two or more herbicide of same class (or) two or more herbicide with similar mode of action) over a period of time due to high selection pressure of herbicides. Thereafter, multiple herbicide-resistance (i.e., resistance to herbicides of different chemical classes having different mode of action) in *Phalaris minor* has evolved against PS-II, ACCase and ALS inhibitor herbicides. This leads to large scale failure of herbicides. Then, the efficacy of newly introduced pinoxaden, mesosulfuron +

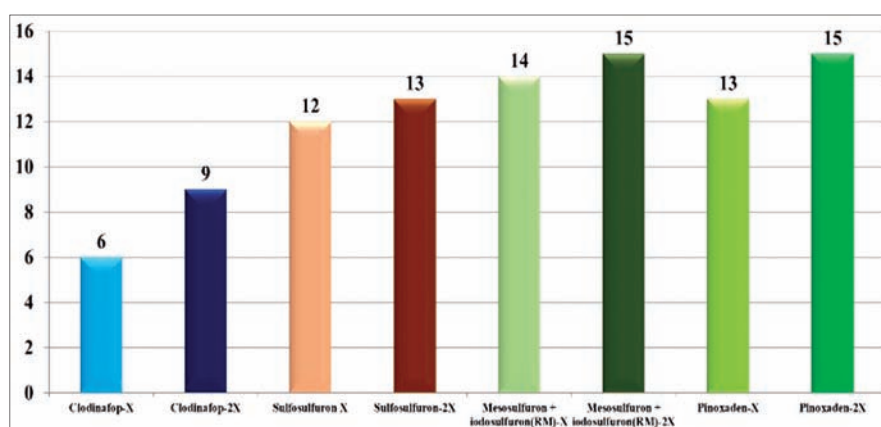


Fig. 3. Efficacy ($\geq 80\%$) of different herbicides against *P. minor* biotypes

iodosulfuron (RM) herbicides was tested against *Phalaris minor* biotypes in Haryana and other intensively wheat growing states. However, after its continuous use, it also exhibited cross-resistance signs in some of the resistance biotypes of *Phalaris minor*.

To examine the status of *Phalaris minor* herbicide resistance in Haryana, the pot-culture study was conducted at CCS HAU, Hisar in 2016-17 with 16 biotypes of *P. minor* collected from different parts of Haryana based on farmers feedback about the decrease in efficacy of herbicides against *Phalaris minor*. Out of 16 *Phalaris minor* biotypes, only 6, 12, 14 and 13 biotypes were got effectively controlled at the

recommended dose (RD) of clodinafop (60 g/ha), sulfosulfuron (25 g/ha), mesosulfuron + iodosulfuron (14.4 g/ha) and pinoxaden (50 g/ha), respectively. Whereas 9, 13, 15 and 15 biotypes were efficiently controlled at double RD (2X) of clodinafop (120 g/ha), sulfosulfuron (50 g/ha), mesosulfuron + iodosulfuron (28.8 g/ha) and pinoxaden (100 g/ha), respectively (Fig. 3 & 4). This indicates the development of cross-resistance against clodinafop in majority of areas. However, pinoxaden, sulfosulfuron and mesosulfuron + iodosulfuron (RM) may play an important role in the management of resistant populations

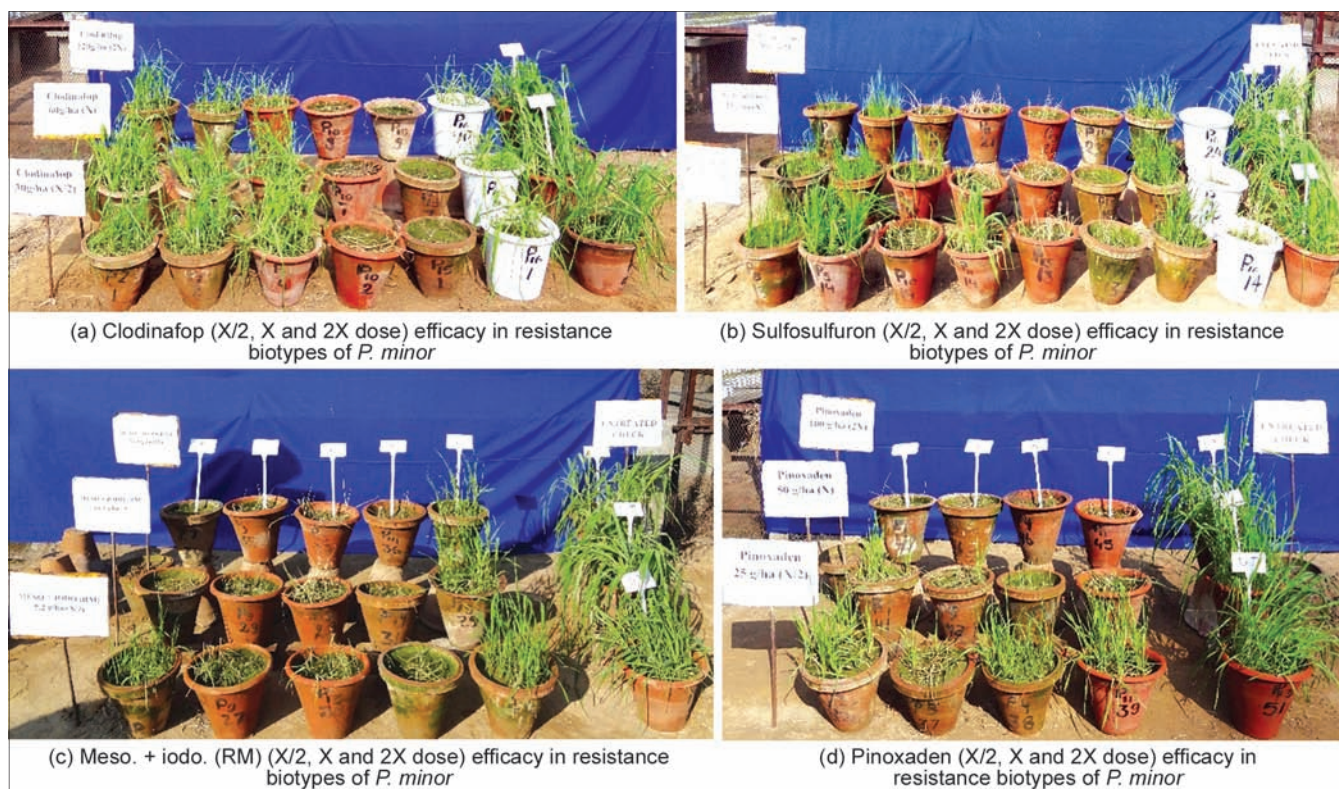


Fig. 4. Effect of different dose of herbicides on *P. minor* biotypes

Table 1. Herbicides recommended for wheat

Herbicide name	Dose (a.i. g/ha)	Time of * Application	Trade names
<i>For grasses</i>			
Clodinafop propargyl	60	25-30 DAS	Topik/ Jhataka
Fenoxaprop-p-ethyl	100-120	25-30 DAS	Puma Super
Pinoxaden	40-50	25-30 DAS	Axial
<i>For broad leaf weeds (BLWs)</i>			
2, 4-D	400-600	30-35 DAS	Weedmar/Jura
Carfentrazon	20	25-30 DAS	Affinity
Metsulfuron methyl	4	25-30 DAS	Algrip
Metsulfuron methyl +carfentrazone	4 + 20	30-35 DAS	Ally Express
<i>For grasses and BLWs</i>			
Metribuzin	175-210	30-35 DAS	Sencor
Isoproturon	750-1000	25-30 DAS	Tolkam
Pendimethalin	1000	0-3 DAS	Stomp/ Pendistar
Sulfosulfuron	25	25-30 DAS	Leader
Sulfosulfuron + metsulfuron	30+2	25-30 DAS	Total
Mesosulfuron + iodosulfuron	12+2.4	25-30 DAS	Atlantis
Clodinafop propargyl + metsulfuron methyl	60 + 4	30-35 DAS	Vesta/Sandesh
Clodinafop propargyl + metribuzin	60 + 105	25-35 DAS	ACM-9
Metribuzin + fenoxaprop-p-ethyl	100+175	30-35 DAS	Accord Plus
Pyoxasulfone	125-150	0-3 DAS	Awkira

*DAS – Days after sowing

thought its judicious use with alternate application.

Management of herbicide resistant *Phalaris minor*

A number of herbicide/ herbicides mixtures have been recommended for efficient weed management in wheat (Table 1). Herbicide combination and/or its compatible mixture offers advantage like broad-spectrum action, enhanced herbicide efficiency through synergistic or additive effect, requirement in lesser quantity, reduce the cost of weed management, arrest weed shifts, prevent herbicide resistance in weeds and enable improvement in overall weed

management. Intra-group combinations of herbicides viz., ACCase inhibitor (clodinafop/ fenoxaprop/ pinoxaden) with ACCase inhibitor and ALS inhibitor (sulfosulfuron/ mesosulfuron + iodosulfuron) with ALS inhibitor were compatible and resulted in effective control of *Phalaris minor*. While inter-group mixtures were not found suitable. Also, the use of herbicides with a different mode of action either as herbicide mixture, or sequential application of herbicide rotation year after year will be helpful for the effective management of *P. minor* resistance and delay the resistance development.

Conclusion

Phalaris minor became a major problematic weed in the wheat crop in vast area of rice-wheat cropping system due to its similarity with the wheat crop. Therefore, use of herbicide is the best possible way for its effective control. However, due to the over dependence on single herbicide and its use year after year in the same field developed enormous selection pressure resulting in development of herbicide resistance in *Phalaris minor*, leading to large scale crop failure. This raises the development of some herbicides with newer modes of action, with alone or tank mixed application that broaden weed control spectrum. Based on different studies, herbicides found effective for controlling isoproturon-resistant *P. minor* biotypes are clodinafop, fenoxaprop, metribuzin, sulfosulfuron, pendimethalin, pinoxaden, mesosulfuron + iodosulfuron (RM) and clodinafop+metsulfuron (RM). As synthesis of herbicides having newer modes of action is dripping and to prolong the life span of these alternative herbicides, care has to be taken to apply alternative herbicides in rotations or as mixtures at the optimum dose and time, with appropriate application technology.

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Jai Kisan, Jai Vigyan

- A total of ₹ 788.33 crores have been sanctioned for opening six new agricultural colleges for eastern India under Central Agricultural University, Imphal, and a new Central Agricultural University in Meghalaya.
- For the establishment of two new agricultural research institutes in Assam and Jharkhand, a sum ₹ 100 crores is allocated.
- First academic session of the Rani Lakshmbai Central Agricultural University has been allocated for four new agricultural colleges in Datiya and Jhansi.
- A Memorandum of Understanding was signed for transforming the Rajendra Central Agricultural University, Pusa, Samstipur, Bihar. A proposal of ₹ 400 crores is submitted in EFC.
- Post-Graduate Institute of Horticulture is being established in Amritsar, Punjab.
- Foundation stone of the Indian Institute of Agricultural Biotechnology is laid in Ranchi for promoting Agricultural Biotechnology.