Herbicide resistance management in *Phalaris minor* and resource conservation technologies in rice-wheat cropping system in India – an overview

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Abstract

Rice-wheat cropping systems occupy an area of 10.5 m ha in India and contribute 40% to the food grain production of the country. There are many constraints to productivity, profitability and sustainability in this cropping system, such as evolution of herbicide resistance in *Phalaris minor* in wheat, yield stagnation, delayed planting, water and labour availability, residue burning, nutrient loss and imbalances, deteriorating soil health, declining total productivity and farm profit margins. Herbicide resistance in *Phalaris minor* is perceived as serious issue by wheat growers and efforts are required to tackle this problem. These problems have triggered the interest of growers to consider emerging resource conservation technologies (RCTs) and alternate crop establishment techniques with a number of technologies successfully evaluated between scientists and farmers. These include zero tillage in wheat and rice, diversification through multiple land use, intercropping with bed planting and value addition, laser leveling, green manuring, leaf color charts, direct seeded rice under puddled and unpuddled conditions, zero tillage transplanted rice with or without paddy transplanter, and monitoring of long-term zero-tillage sites.

Keywords

alternate herbicides, conservation technologies, diagnostic survey, monitoring, training

Introduction

Little seed canary grass (*Phalaris minor*) infestation in wheat and decline in soil productivity were identified as important constraints for declining total factor productivity of rice- wheat cropping system in NW India. Evolution of resistance in *P. minor* against isoproturon (Malik and Singh, 1995) further aggravated the situation. The resistance affected area ranges between 0.8 and 1.0 million hectares in N-W India, mostly contained in the states of Punjab (0.3 m ha) and Haryana (0.5-0.6 m ha).Yadav *et al*. (2002) and Yadav and Malik (2005) have already reported resistance against alternate herbicides(fenoxaprop, clodinafop and sulfosulfuron) in a few biotypes of *P*. *minor*. A diagnostic survey in Haryana during 2005-06 indicated that a large number of farmers use lower than recommended dose of herbicides associated with improper spray methods. The problem of herbicide resistance in this weed may again pose a serious threat to the sustainability of wheat productivity and current situation warns for integrated management. Issues of conservation have assumed importance in view of widespread resource degradation and the need to reduce production costs, increase profitability and make agriculture more competitive and sustainable through different resource conservation technologies (RCTs). The paper here has been prepared to provide an overview regarding these issues and possible solutions in the rice-wheat cropping system in India.

Present scenario of herbicide resistance in *Phalaris minor*

The recommendation of isoproturon was withdrawn in 1998 and the use of fenoxaprop has gone down to almost negligible due to its failure against *Phalaris minor* infesting wheat. Scattered cases of resistance against clodinafop and even sulfosulfuron against a few biotypes of *P. minor* have also been reported in Haryana (Yadav and Malik, 2005) and such cases of herbicide failure are increasing every year making the situation more complex (Singh, 2007). A diagnostic survey conducted during 2006 across eight districts, involving 419 farmers using a rice-wheat cropping system indicated that large number of farmers spray lower than the recommended dose of herbicides, with suboptimal volumes with a single flood jet/cut or hollow cone nozzle instead of flat fan nozzle; 79% of these farmers blamed poor quality of the herbicides for poor efficacy. A number of brands of different herbicides not recommended for Phalaris management are available in the market, which are used and often growers do not know what they are actually spraying.

Herbicide resistance management

Combinations of the following highlighted (italics) management strategies may help avert or delay evolution of herbicide resistance in *P*. *minor* in wheat: *alternate crops* (sunflower, sugarcane, winter maize, berseem and vegetables); *cultural practices* (closer spacing, competitive varieties, higher seed rate, early sowing of wheat, restricted seed exchange, use of clean seed, avoiding wheat sowing in soils with high moisture at the surface, hand weeding or interculture with hand hoe or bar harrow/tooth harrow, avoiding stubble/straw burning); *cultivation practices* (zero tillage, furrow irrigated raised beds); *herbicide practice* (alternate herbicides, herbicide rotation, improved spray techniques).

However, the majority of the farmers are not willing to change existing rice-wheat crop rotation notwithstanding some obvious benefits from change. Farmers prefer variety PBW343, the main wheat variety for 15 years, and possibilities of its replacement with some more competitive variety seem limited. Instead of opting for any new cultural practices, most of the farmers depend on herbicides for which the choice is now limited. As happens with most herbicides, the doses required for 50 % growth reduction of fenoxaprop, clodinafop, sulfosulfuron and tralkoxydim have been consistently increasing year after year of their use (Yadav and Malik, 2005), indicating problems of cross or multiple- resistance. Pinoxaden is effective against resistant *P*. *minor* (Punia *et al*., 2006) and may be a future option. Early sowing of wheat combined with zero tillage technology has been well accepted by farmers. Most of the farmers use wheat seed from their own stores for sowing, (seed replacement is <10% each year), and inadequate cleaning occasionally leads to wheat seed contaminated with *Phalaris*.

Resource conservation technologies

Resource Conservation Technologies (RCTs) have become a critical component to growth in agriculture but require complementary innovations through multi-disciplinary, multi-institutional and farmer's participatory approach. The following RCTs have been found to have an impact on agriculture in NW India:

Zero-tillage

Zero tillage in wheat in India has reached around 2.5 M ha with more than 30,000 zero till machines manufactured during 2007-08. Long-term (11 years) yield data based on the average of 6 sites in Haryana have shown that zero tillage is sustainable (Yadav *et al*., 2005), and is particularly well suited to cropping systems which require early sowing of both rice and wheat. The results of preliminary studies on zero tillage under other systems than rice-wheat cropping system (eg. wheat in rotation with clusterbean, pearl millet and cotton) in Southern Haryana are also quite encouraging (Table 1).

Table 1. Average grain yield (kg/ha) of ZT wheat during 2006-07 in Rewari and Mahendergarh districts of southern Haryana with Pearl millet, Clusterbean, cotton or groundnut, in rotation with wheat

Locations	Tillage	
	Zero	Conventional

21 (Rewari)	4588	4379
65 (Mahendergarh)	5011	4970
Average	4799	4674

Surface seeding in wheat

The simplest no-till system is where wheat seed is placed onto a saturated soil surface without any land preparation. Sometimes wheat seed is broadcasted in standing rice crop a few days before harvest and/or rice residues are spread over seeded beds to avoid loss of moisture, reduce weed germination and encourage residue retention. This system is gaining popularity in Nepal and Bihar (India) and may have some application in low lying/water logged areas in NW India.

Bed planting

The bed planting of wheat can be used to improve the water productivity, as well as introducing intercropping and diversification and non-chemical weed control. The success of this technology will depend on the type of soil and source of irrigation water. The logic of intercropping wheat, garlic, onion and other vegetables in autumn planted sugarcane (around 1000 ha in Haryana) includes synergies in operations leading to improved profits. However, yield penalties at some locations and overall economics under bed planting pose a question mark on the success of this technique, particularly when wheat is grown alone (Yadav *et al*., 2002). Similarly, direct seeded and transplanted rice on raised beds was found not so encouraging in rice-wheat growing areas of Haryana, mainly due to very heavy weed pressure.

Crop establishment techniques in rice

The transplanting of rice under unpuddled conditions or under zero-tillage can be an alternative for improving water productivity in some soils. Based on multi-locational farmers' field trials in Haryana during 2001 to 2007, it was found that puddling, the most common practice for rice, is not necessary to achieve higher grain yields. Successful crop growth and comparable grain yields of rice under zero-till-transplant and unpuddled-transplant (dry field preparation fb irrigation prior to transplanting) were attained. Paddy transplanting machines, as used for the last three years, have been very successful for transplanting of coarse rice varieties both under no-till and unpuddled situations in Haryana. This helps avoid not only puddling and manual transplanting in rice but also saves energy, fuel, time, water (required in puddling), fertilizer and manpower besides ensuring optimal plant population (33-35 plants /m^2) and higher yields(75-85 q/ha in 15 demonstrations in district Yamuna Nagar of Haryana during 2007). In addition, experiments during 2006 and 2007 have shown that direct broadcast or drum seeding under puddled and unpuddled situations could be other alternative options for raising super fine (basmati) rice.

Diversification

The significant increase in the price of wheat and rice recently show that India cannot afford a falling share of crops like wheat and rice from States like Haryana and Punjab, therefore opportunities for crop diversification at present are limited.

Green/brown manuring

Intercropping or growing of cover crop like *Sesbania sesban* along with rice does not require additional water and this practice not only reduces the weed density but also adds nitrogen and organic matter to the soil. Growing *Sesbania* and rice (direct seeded) in co-culture will save irrigation water compared to the situation where these two crops grown separately. It keeps soil moist for long, leading to less soil cracking, thereby obviating the need to irrigate rice frequently. Green manuring is being grown on 10-20%

area prior to rice cultivation in Haryana and the government is also putting effort into its promotion. Organic farming is also being advocated but with very limited success because the relevant laws and guidelines are either not clear or not enforced and no extra premium is paid for such products.

Laser land levelling

After laser levelling the field, it has been observed that yield remains same or is enhanced from 10 to 25 %, water saving by 10-15 %, a significant reduction in weeds (40%) and labour requirement for weeding (75%) and an increase in the cultivable area by 5 to 7 per cent (Richman, 2002).This also reduces the amount of water required for land preparation. Proper land leveling is a prerequisite for the success of various RCTs particularly bed planting and direct seeded rice. The uses of laser levellers are gaining momentum in N-W India and at the moment around 650 units are working.

Crop residue management

Rice and wheat residues (7-8 t/ha) when burnt instantly generate as much as 13 tons of CO_2 /ha, contaminating the air, depriving soils of organic matter, and constraining supplies of fodder for livestock. About 400 million tonnes of crop residues are produced annually in India (Singh and Singh, 2001). In areas where combine harvesting is practised, a large quantity of crop residues are left in the field that can be recycled for nutrient supply. In a rice-wheat sequence, a yield of 7 t/ha of rice and 4 t/ha of wheat (generally attained in Haryana and Punjab), removes more than 300 kg N, 30 kg P and 300 kg K/ha (Singh and Singh, 2001). In a very short time available between rice harvesting and sowing of wheat, it is not possible for the farmers to incorporate and decompose the straw. The farmers are forced to clear the fields for wheat seeding by burning the rice straw. Recently, efforts have been focused on retaining the crop residues at the soil surface and seed the crop into the loose residues. Various second-generation machines like double disc coulters, punch planter/star wheel, Happy Seeder and rotary disc drill are being tested in RWCs.

Conclusion

Herbicide resistance in *P.minor* is still being perceived as most serious issue by the wheat growers and immediate efforts in integrated weed management are required to tackle this problem. Sustainability and profitability of rice-wheat cropping system in Indian agriculture is the lifeline and future of the Indian economy. Zero tillage, intercropping/diversification on raised beds, direct seeding of basmati rice, mechanical transplanting of coarse rice, green manuring and laser land leveling are some of the key RCTs that have really changed the mindset of growers in NW India.

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