Crop Protection 85 (2016) 89–103

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Review

Weed management in resource conservation production systems in Pakistan

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ARTICLE INFO

Article history:
Received 14 November 2015
Received in revised form
18 March 2016
Accepted 2 April 2016

Keywords:
Allelopathy
Herbicide resistance
Resource conservation technologies
Weeds

ABSTRACT

Resource conservation technologies (RCTs) offers pragmatic options to cut down fuel, labor and water resources. In Pakistan, the use of RCTs started in the form of a New Zealand imported zero tillage wheat (ZTW) drill in 1983, and now the ZTW plantation has reached to an area of 507,050 ha. However, initially, the widespread adoption of the ZTW plantation was hampered because of insufficient training and dissemination of information on the proper use of the machinery and planting techniques in Pakistan. In the past few years, rapid uptake of RCTs has been noted in rice-wheat cropping system (RWCS) in Punjab region of Pakistan, the main hub of RCTs, due to direct involvement of farmers during experimentation, and strong collaboration with local machinery manufacturers. In 1992, the inverted 'T' openers' technology, was introduced in locally manufactured ZT drills, which helped to make zero tillage (ZT), a user-friendly technology, acceptable at farm level. Now ZT drills equipped with inverted 'T' coulter technology are available at cheap and affordable rates. Still many farmers do not have access to RCTs machinery, which requires serious attention of policy makers. After the preliminary experiments on direct seeded aerobic rice (DSAR) in RWCS by rice-wheat consortium and Cereal System Initiative for South Asia, the technology has been widely spread on large area in RWCS in Pakistan in recent years. The other RCTs such as laser land levelling and bed planting of crops are also taking roots in various cropping zones of Pakistan, especially in RWCS. Although, RCTs resolves time and edaphic conflicts, reduces the production cost and save plenty of water; nonetheless weed problem has emerged as serious issues in the adoption of RCTs (especially ZTW, DSAR) in Pakistan. In ZT systems, no preparatory tillage is carried out, which favors the growth of many weeds (e.g., perennial weeds). Likewise, absence of flooding conditions in DSAR favors the growth of many weeds. Change in weed flora from annual to perennial weeds has been observed in ZT systems. However, pre-emergence application of pendimethalin, thiobencarb, butachlor, oxyfluorfen oxadiazon, and nitrofen followed by post-emergence herbicides such as ethoxysulfuron, bispyribac sodium, acetochlor and butachlor provides fair weed control in DSAR in Pakistan. Nonetheless repeated use of herbicides with similar mode of action for managing weeds in ZTW and DSAR in Pakistan may induce herbicide resistance in weeds as has been reported in various parts of the world. In this scenario, the integrated weed management strategies may be useful to control weeds in ZTW and DSAR. The strategies for weed management in DSAR may include the use of stale seedbed technique, use of mulches of allelopathic crops like sorghum, crop rotations with allelopathic crops, intercropping with allelopathic crops, use of allelopathic water extracts, and breeding of competitive crop cultivars. Moreover, strong socio-economic mobilization at farmer fields, extensive research, development, extension and training strategies are required for long term sustainability and tackling the problems of weeds in Pakistan for the rapid uptake of RCTs.

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http://dx.doi.org/10.1016/j.cropro.2016.04.002
0261-2194/

Contents

1. Introduction

Resource conservation technologies (RCTs) offers pragmatic options to enhance/sustain crop yields, improve soil quality, and reduce the cost of production in developing countries (Krishna et al., 2012; Farooq and Siddique, 2015). RCTs such as zero tillage wheat (ZTW), direct seeding of aerobic rice (DSAR), laser land levelling (LLL), and bed plating are getting momentum in the Indo-Gangetic Plains (IGP) of Pakistan, India, Bangladesh, and Nepal-the food bowl feeding billions across the globe. ZTW, LLL and bed planting are being followed on an area of 2.14%, 3.79% and 1.16% of the total cropped area in Pakistan (Gill et al., 2013). With the commissioning of the Rice-Wheat Consortium (RWC) in 1994, zero tillage (ZT) and reduced-till practices spread very rapidly, increasing from just few thousand hectares (ha) in 1997–1998 to more than 2.18 million hectares (Mha) in 2004–2005, and 2.6 Mha in 2010–2011 in IGP including Pakistan. Currently, ZT is being followed on an area of about 5.0 Mha in South Asia (Friedrich et al., 2012), including Pakistan. In Pakistan, the use of RCTs started in the form of a New Zealand imported ZTW drill in 1983, and now the ZTW plantation has reached to an area of 507,050 ha (Gill et al., 2013, Fig. 2). However, initially, the widespread adoption of the ZTW plantation was hampered because of insufficient training and dissemination of information on the proper use of the machinery and planting techniques in Pakistan (Rehman et al., 2014). In past few years, rapid uptake of RCTs has been seen in rice-wheat cropping system (RWCS) in Punjab region of Pakistan (Fig. 2), the main hub of RCTs, due to direct involvement of farmers during experimentation and strong collaboration with local machinery manufacturers. In 1992, the inverted 'T' openers' technology, was introduced in locally manufactured ZT drills, which helped a lot to make ZT, a user-friendly technology, acceptable at farm level. Now ZT drills equipped with inverted 'T' coulter technology are available at cheap and affordable rates. Still many farmers do not have access to RCTs machinery, which need serious attention of policy makers. Although, RCTs resolves time and edaphic conflicts in conventional RWCS, reduces production cost and save plenty of water; nonetheless weed problem has emerged as serious issues in the adoption of RCTs (especially ZTW, DSAR) in Pakistan. In ZT systems, no preparatory tillage is carried out, which favors the growth of many weeds (e.g. perennial weeds). On the other hand, repetitive use of similar kind of herbicides to manage weeds in ZTW and DSAR in Pakistan may give birth to herbicide resistance weeds, as has been reported in various parts of the world. In this, we have discussed various farming and cropping systems being practiced in Pakistan, the history of development and adoption of RCTs in Pakistan, history of herbicide usage for weed management in DSAR and ZTW, challenges associated with repeatable use of same herbicide, and changes in weed flora when switching from plough tillage (PT) to ZT systems. Some effective weed control tactics in ZT systems in Pakistan, the socio-economic influence on the adoption of RCTs technologies, and research, development, extension and training strategies for the future sustainability of weed management in ZT systems in Pakistan are also discussed.

2. Cropping and farming systems of Pakistan

The irrigated farming system of Indus plains (IFSIP), rainfed farming system of northern plains and plateaus, and the rainfed and irrigated system of mountainous areas are the most prominent farming systems in Pakistan. Among these farming systems, IFSIP is the largest farming system in Pakistan, and is blessed with well-organized irrigation system, being followed on an area of 16 Mha (67% of total cropped area) (Byerlee and Husain, 1993). In this farming system, the farmers adopted the green revolution technologies very rapidly. The soils in IFSIP (central irrigated Punjab, Khyber Pakhtunkhwa (KPK), and Sindh) vary from clay-loam to silt-loam (Baig et al., 1985). These soils are very productive, developed by alluvium of the river Indus and can further be divided into 3 major groups: (i) Bongar soils of alluvium-very productive when irrigated and fertilized. These include most of the area in the Indus plain (from Punjab, Peshawar, Mardan, Bannu and the greater part of the Indus Plain in Sindh). (ii) Khaddar soils, which are formed from the flooded layers of silt, loam and silty clay loam, and usually dominate near rivers e.g., soils of Mardan (in KPK) and Bahawalpur (in Punjab). These soils are also very productive provided that surplus water is available. (iii) Indus Delta soil, which spread from the south of Hyderabad to the Arabian Sea coast covering the majority of Indus Plains. About 1/3 of these soil are clayey developed under flooded water conditions, and are very useful for the production of rice and other cash, food and fiber crops.

The climate of Indus Basin Plains varies from subtropical-arid/semi-arid to temperate-subhumid on the plains of Sindh/Punjab to alpine in mountainous areas of the north (Punjab, KPK). Annual rainfall ranges between 100 and 2000 mm (FAO, 2011). In the lower plain, mean monthly temperatures vary from 14 to 20 °C in coldest months (December to February) to 42–44 °C in hottest months (March to June). In the upper plain, mean temperature ranges from 23 to 49 °C during summer and from 2 to 23 °C during winter. On the lower plain, average annual rainfall is about 90 mm (Larkana and Jacobabad areas), while on upper plain, annual rainfall vary from 150 mm (e.g. Multan) to 510 mm (e.g., Lahore) (WCD, 2000, FAO, 2011). Although, the farmers in the Indus plains of Pakistan mainly grow grain and cash crops, nonetheless they also rear farm animals; the cut-and-carry feeding playing crucial role in animal production. Every farmer assigns specific land pocket for fodder crop production. Green fodder and concentrates are used for feeding the milking animals (buffaloes, cows, goats), while crop