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WHEAT ESTABLISHMENT WITH ZERO-TILLAGE FOR INTEGRATED WEED MANAGEMENT

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ABSTRACT

Through the Farmers' Participatory research, an experiment was conducted at five sites to determine the effect of resource conservation tillage (Zero-Tillage) technology on weeds in wheat crop under the rice-wheat cropping system. During first year, weed density of 22.8 weeds m^{-2} was observed in zero-till wheat crop, which decreased to 15.6 weeds m^{-2} in the third year, conversely 32.4 weeds m^{-2} were counted in the conventional till wheat crop, which declined to 24 weeds m^{-2} in the last year of studies. On average, a decrease of 32% weed density in wheat crop was observed due to zero-tillage compared to the decrease of 26% weed density under conventional tillage over a period of three years. Moreover, 52% lesser weeds were found in the zero-tillage fields than the crop established with conventional method. The findings suggest that zero-tillage technology for wheat crop depressed the germination and growth of weeds despite its other known benefits like facilitating earlier planting, saving of water, labour and land preparation cost.

Key words: Zero tillage, weed density, water conservation, wheat.

INTRODUCTION

Rice-wheat cropping system is the major one covering an area of 1.6 m ha in Pakistan. The system is highly exhaustive in nature and is continuously practiced in the same belt for several decades. Despite the use of adequate amount of chemical fertilizers and modern cultivars, the yields of both cereal crops are 30-80% lower than the potential yields of rice and wheat crops and have been even stagnant for the last many years (Khan, 2001). The wheat crop following rice is more affected, because, rice is traditionally grown on well puddled soil that poses serious limitations to timely land preparation and sowing of wheat. As a result, wheat sowing in the paddy fields is delayed which lead to a considerable reduction in grain yields (Hobbs *et al.*, 1988). However, zero-tillage technology for wheat establishment in the paddy fields has solved the problem of late sowing of wheat. This technology not only saves the cost of land preparation but also, ensures good crop stand in the poorly drained soils of Kallar Tract (Mann *et al.*, 2002). The farmers are found very keen to adopt this technology on large scale. This change of technology in rice-wheat cropping system of Pakistan has set a desired impact on weed biology and insect pest infestation in these two crops.

Weeds pose serious threat to the companion crop through its competition for nutrients, water, sunlight and space. Competition for these factors causes considerable

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reduction in grain yield. It is estimated that every year, weeds cause yield losses from 20 to 63% in rice and from 17 to 50% in wheat crop (Anonymous, 1992-93). Hence, an effective and economical weed control strategy needs to be implemented to meet the demand of food staple for increasing the population of Pakistan. Weed seed dormancy is an adaptive significance in many a weed species. Benvenuti and Macchia (1995) showed that the high CO_2 and low O_2 (hypoxia) induced dormancy while Taylorson (1970) reported otherwise. Several studies exhibit that the buried seeds of annual weeds undergo dormancy-non-dormancy cycles and even light does not stimulate germination (Karssen, 1982, Schafer and Chilcote, 1970; Taylorson, 1970). Baskin and Baskin (1985) and Benvenuti and Macchia (1994) have further added that dormancy-non-dormancy transition may be related to changes in membrane properties. Thus, in zero tillage the conditions like hypoxia, non-exposure to light etc. are the factors responsible for weed seed dormancy. Wheat establishment in the paddy fields through zero-tillage drills has changed the crop ecology and culture, which, in turn, may affect the weed species and density leading to sustain and improve the productivity of wheat crop. This paper discusses the effect of zero-tillage technology on weeds particularly in wheat crop.

MATERIALS AND METHODS

The studies were initiated during rice growing season 1999 and continued upto 2001. Five farmers in district Sheikhupura (Punjab) were selected who were the adopters of zero-tillage technology. At each farm, two fields were chosen – one with zero-tillage and the other with conventional wheat sowing. Wheat crop was sown using residual moisture after paddy harvest. For zero-till, seed rate of 100 kg ha^{-1} was used while, 125 kg ha^{-1} seed was used in conventional method of wheat sowing to get optimum plant density. In conventional method, land was well prepared and seed was broadcast before last cultivation and planking. Standard dose of fertilizer (100-60-60 NPK kg ha^{-1}) was applied to both fields.

In each field (0.4 ha), five weed sampling points of one m^2 were marked along the diagonal of the field. The first point was at a distance of 14 steps and the remaining at 25 steps each. The data on weed infestation in wheat was recorded prior to first irrigation or herbicide application. At each sampling, total number of weeds, species-wise number (weed diversity), and total number of wheat plants were recorded. Data were also recorded on dry weight (g m^{-2}) of wheat. At maturity, wheat crop was harvested from an area of 4 x 2 m^2 at three sites in each field. The mean grain yield was subsequently converted to kg ha^{-1} for each treatment.

RESULTS AND DISCUSSION

Weed density and Diversity in Wheat During 1999

Weed sampling prior to first irrigation showed that zero-tilled wheat crop had lower weed density (16 m^{-2}) than the conventionally planted crop with an average of 26 weeds m^{-2} (Table-1). The plant density of wheat was also higher in zero-tillage than the conventional crop. Although, 100 kg seed rate was used in zero-tillage compared to 125 kg ha^{-1} in conventional method. In the zero-tillage fields, *Melilotus indica*, *Phalaris minor*, *Rumex dentatus* and *Lathyrus aphaca* were dominant while, *Cyperus rotundus* and *Cynodon dactylon* were the weeds which were carried over from rice to wheat crop. However, the weeds like *Melilotus indica*, *Phalaris minor*, *Rumex dentatus* and *Lathyrus aphaca* were abundantly found in the wheat crop under conventional method. This indicates that almost similar nature of weeds were found in either tillage system, their density varied in either system.

At about 91 days after seeding, sampling of wheat plants was done to determine dry biomass for two tillage methods (Table-2). Zero-tillage crop gave dry biomass of 236 g m^{-2} as against that of 240 gm m^{-2} with the conventional method. This showed that wheat plants at anthesis stage were more vigorously growing in the zero-tillage fields compared to conventional fields. This response of wheat crop under zero-tillage technology is quite significant, because fertilizer efficiency through its banding and lesser competition with weeds is probably responsible for higher vigor of wheat.

Weed density and diversity in wheat during 2000

In the second year, wheat crop was also established on raised beds with two rows, besides zero-tillage and conventional tillage (Table-3). In the beds, wheat plant population was higher (216 plants m^{-2}) in zero-tillage as compared to conventional tillage (158 plants m^{-2}). At the same time, higher weed density (32 weeds m^{-2}) was also evident in conventional tillage as against zero-tillage (20 m^{-2}). In the beds, weeds were recorded after the first irrigation due to which, some new weeds also emerged, leading to high infestation. Low weed density in zero-tillage wheat reveals that the technology is quite effective in keeping the weed population to a low level compared to other tillage methods. The undisturbed soil surface is not favourable to emergence of many weed seeds due to their enforced dormancy through non-exposure to light, inoxia and/or hypoxia. On the other hand, the soil environment under conventional tillage or bed system is quite favorable for weed emergence and growth. These findings are corroborated with the work of Benvenuti and Macchia (1995); Karssen, 1970; Schafer and Chilcote, 1970 and Taylorson, 1970, who demonstrated enforced dormancy in their studies.

Most of the broadleaf weeds were dominant in the wheat fields (Table-4). *C. album*, *R. dentatus*, *M. indica* and *P. minor* were found as major weeds. However, *L. aphaca* and *C. rotundus* were among the minor weeds. Broadleaf weeds are less competitive for nutrients, water, etc. compared to grasses in wheat due to their anatomical and physiological similarity with the crop.

Weed density and diversity in wheat during 2001

During the third year, three tillage methods in wheat establishment were compared at all the sites (Table-5). The maximum number of wheat plants were observed in zero-tillage (224 m^{-2}), followed by conventional tillage (152 m^{-2}). The broadleaf weeds were dominant in the zero-tillage wheat, which were easy to control rather than *P. minor* which was abundant in conventional tillage wheat crop (Table-6). *P. minor* has very small seeds, which face difficulty to come out from the soil under zero-tillage system.

Trend in Weed Density over the Years

With continuous use of zero-tillage technology for wheat in the same fields, the number of weeds per unit area was reduced in almost all the fields (Table-7). For instance, at Farm A, weed density from 24 m^{-2} during 1999 dwindled to 10 m^{-2} during 2001. A similar trend was evident in other farms. With better weed management practices, a declining trend was also observed at three farms under the conventional tillage. On average, 60% lesser weeds were observed in zero-tillage than the conventional tillage. There are two possible reasons for this phenomenon. First, the weeds fail to perceive light for being not exposed and secondly, the rice straw or stubbles left over the field by the combine serves as mulch for the weeds. Weeds sense the upper storey and stay dormant due to unfavorable ecological conditions. The situation in the conventional tillage is, however, reverse. The well-pulverized soil at optimum moisture condition is highly suitable for weed emergence, exposure to light and lack of upper storey of vegetation promotes germination and growth of weeds consequently reducing the grain yield if, not controlled. These findings are supported with the work of Sahoo et al. (1995) whole communicated that conventional tillage was found to increase the total buried weed seed population by 3-4 times compared with no-tillage, but reduced the proportion of viable dormant seeds significantly ($P<0.01$) in the former. Weed seeds were found to be more concentrated in the surface layer of the soil than in deeper soil layers in no-tillage, but the reverse was true in conventional tillage. Hassan et al. (2003a&b) also evaluated lesser weeds in zero as compared to no till system in chickpea and wheat.

Trend in Weed diversity over the Years

A similar trend in the occurrence of weed species in the zero-tillage wheat crop was also observed. The most noxious weeds present during the first year were not observed in the last year (Table-8). *C. rotundus* and *P. minor* disappeared particularly in the zero-tillage fields over the years. Most of the weeds were broadleaf which were easy to control with one application of herbicide. On the other hand, the trend of weed species in the conventional tilled fields was not evident. The *P. minor* disappeared as major weed specie in most of the wheat fields. Broadleaf weeds like *M. indica* and *R. dentatus* were predominantly found under traditional tillage system.

CONCLUSIONS

The new technology of wheat establishment through zero-tillage drill is feasible and practical for the resource-poor farmers of Rice-Wheat belt of Pakistan. This technology not only ensures timely sowing of wheat but also minimizes the risk of weed infestation in the wheat crop. The grass weeds rather than the broadleaf are much affected from this new method. Hence, the yield losses due to the presence of grass weeds like *P. minor* would be lesser. Weed infestation in the zero-tillage wheat crop is reduced considerably over time, thus combining the cultural method for an integrated management of weeds. The resource-poor farmers of rice-wheat belt of Pakistan find this technology worthwhile for sustaining and improving the productivity of rice-wheat cropping system. This will, in turn, lead to farmers' prosperity and increase farm income through better use of applied inputs and saving of time and resources.

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Table-1. Density of Wheat and Weeds (m^{-2}) under Two Methods, 1999-2000

Farm	Zero-Tillage			Conventional		
	No. of Wheat Plants m^{-2}	No. of Weeds m^{-2}	Major weed species	No. of Wheat Plants	No. of Weeds	Major species
Farm A	232	24	*C. rotundus*	216	32	*M. indica*
Farm B	200	20	*M. indica*	188	24	*M. minor*
Farm C	186	24	*C. rotundus*	164	56	*P. minor*
Farm D	128	16	*C. dactylon*	162	24	*M. indica*
Farm E	216	12	*M. indica*	198	34	*P. minor*
Means	192± 40	19 ± 6		180 ± 28	34 ±16	

Table-2. Dry Weight of Wheat Plants (g m^{-2}) under Two Methods during 1999

Farm	Sampling Time (DAS)	Dry Weight (g m^{-2})	
		Zero-Tillage	Conventional
Farm A	94	264	218
Farm B	98	318	222
Farm C	97	223	272
Farm D	72	142	198
Farm E	92	231	290
Means	91	236	240

Table-3. Weed Density in Wheat Crop Established with Two Methods, 2000

Farm	Wheat Plants m^{-2}		Weeds m^{-2}	
	Z- Tillage	Convl.	Z-Tillage	Convl.
Farm A	226	152	16	24
Farm B	216	160	22	32
Farm C	188	138	26	48
Farm D	198	166	18	18
Farm E	252	178	14	36
Means	216 ± 34	158 ± 20	20 ± 6	32 ± 12

Table-4. Major and Minor Weed species in Wheat crop with Two Methods during 2000

Farm	Major Weed species		Minor Weed species	
	Z-Tillage	Convenl.	Z-Tillage	Convenl.
Farm A	*C. album*	*M. indica*	*M. indica*	*R. dentatus*
Farm B	*P.minor*	*P. minor*	*R. dentatus*	*C. album.*
Farm C	*R. dentatus*	*R. dentatus*	*M. indica*	*M. indica*
Farm D	*M. indica*	*R. dentatus*	*C. rotundus*	*L. aphaca*
Farm E	*R. dentatus*	-	*R. dentatus*	*M. indica*

Table-5. Weed Density (m^{-2}) in Wheat Crop established with two methods during 2001

Farm	Wheat Plants		Weeds	
	Z- Tillage	Convl.	Z-Tillage	Convl.
Farm A	222	154	10	22
Farm B	246	164	22	38
Farm C	218	140	16	36
Farm D	228	170	12	14
Farm E	202	132	18	30
Means	224 ± 22	152 ±18	16 ± 6	24 ± 10

Table-6. Major Weed Species in Wheat Crop Established with Two Methods, 2001

Farm	Major Weed species	
	Zero Tillage	Conventional
Farm A	*C. album*	*M. indica*
Farm B	*R. dentatus*	*P. minor*
Farm C	*M. indica*	*R. dentatus*
Farm D	*R. dentatus*	*R. dentatus*
Farm E	*C. album*	*M. indica*

Table-7. Trend of Major Weed Densities in Wheat Crop over the Years

Farm	Zero Tillage			Conventional		
	1999	2000	2001	1999	2000	2001
Farm A	24	16	10	30	24	22
Farm B	32	24	22	40	32	38
Farm C	24	26	16	46	48	36
Farm D	14	18	12	22	18	14
Farm E	20	14	18	24	36	30
Mean	22.8	19.6	15.6	32.4	31.6	28.0

Table-8. Trend of Major Weed Species in Wheat Crop over the time

Farm	Zero Tillage			Conventional		
	1999	2000	2001	1999	2000	2001
Farm A	*C. rotundus*	*C. album*	*C. album*	*M.denticulate*	*M. indica*	*M. indica*
Farm B	*C. rotundus*	*P. indica*	*M. indica*	*P. minor*	*P. minor*	*P. minor*
Farm C	*P. minor*	*P. minor*	*R. dentatus*	*P. minor*	*P. minor*	*P. minor*
Farm D	*M. indica*	*M. indica*	*R. dentatus*	*P. minor*	*P. minor*	*P. minor*
Farm E	*M. indica*	*R. dentatus*	*C. album*	*P. minor*	*R. dentatus*	*M. indica*

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