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Long-Term Changes in Adoption Status of Production Practices of Wheat in Sub-Mountainous Punjab

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Abstract

The survey was conducted to study input use in the paddy-wheat cropping pattern in Ropar district of Punjab over the period 2012-2021. Information regarding varieties sown, pesticide usage, sowing methods, fertilizer use, and improved techniques followed. Data was gathered through in person interviews from the farmers of selected district. A perusal of the data revealed that share of recommended wheat varieties has increased from 69.83 percent in 2012 to 94.59 percent in 2021. Awareness regarding importance of conservation tillage has led to increase in area under Happy seeder, Super seeder and zero till drill. In case of use of weedicides also, use of un-recommended brands for weed control have declined over the years. This study also revealed the usage pattern of Nitrogen and Phosphorous fertilizers. A majority of the farmers used 90 kg of urea per acre (58 percent), and 50 kg of DAP per acre (70percent). The understanding of the farmer practices at grass root level is essential for formulating recommendations and policies for uplifting farming community.

Keywords: conservation tillage, input use, residue management, usage pattern, varietal shift

JEL classification: Q15, Q12, Q53, Q52, Q59

Introduction

The paddy-wheat cropping system has been the principal cereal based cropping system adopted by the farmers on 13.5 million ha (Mha) of cultivated land in South Asia (Singh *et al* 2021a, Bhatt *et al* 2021). This cropping system has been the lifeline for the food security of more than one billion South Asian population (Nawaz *et al* 2019). Over the past two decades, traditional paddy-wheat system has experienced several sustainability threats; of which rapidly declining underground water (Bhatt *et al* 2019, Bhatt *et al* 2021), crop residue burning (Singh *et al* 2020, Gupta *et al* 2021, Singh *et al* 2021b), soil health deterioration (Srinivasarao *et al* 2019) and large emission of greenhouse gases (Bijay and Singh 2008, Singh *et al* 2021c) are considered important. The traditional paddy-wheat system has been highly input intensive with large energy footprints (Singh *et al* 2019a,b). Since farmers' fields are intensively managed cropland ecosystems, there have been large differences in soil management and crop production practices. The farmer's business-as-usual approach and informal knowledge perceived through their forefathers leads to large differences in the adoption of soil management and crop production practices followed in crop production. The study area in Ropar district of Punjab (India) has been highly diverse with paddy/maize-wheat cropping system as major annual cropping system, with frequent transition in area under paddy and maize during *kharif* season. Nonetheless, the development of high yielding varieties with great differences in maturity duration has led to differences in the adoption of different practices in the study region. The present study was therefore, conducted to investigate the long-term (2012-2021) differences in the adoption of different management practices followed in wheat crop in sub-mountainous Punjab. The present study would help in identifying the extent of different un-recommended component technologies which needs to be addressed through different extension activities for optimizing management practices to reduce the amount of wasteful resources, while enhancing productivity and sustainability of the system for long period of time.

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Data Sources and Methodology

Ropar (also known as Rupnagar) district lies between 30°-32′ and 31°-24′ North latitude and 76°-18′ and 76°-55′ East longitude. The district adjoins Nawanshahar (SBS Nagar), Mohali (SAS Nagar) and Fatehgarh Sahib districts of Punjab. The district has five blocks, *viz.* Sri Anandpur Sahib, Ropar, Nurpur Bedi, Chamkaur Sahib and Morinda. Ropar

district spans over 138 th.ha. out of which net sown area is 74 th.ha., while 26 th.ha. area is under forest cover. The cropping intensity of the district is 162 percent as compared to 190 percent cropping intensity of Punjab. Texture of the soils in the district varies from loam to silty clay, with the exception of river Sutlej and the *choes* found in the region where sandy patches are present. Chamkaur Sahib block has sodic soil, while the Anandpur Sahib and Rupnagar blocks are undulating. The pH of soils in the district varies from 7.5 to 8.9.

The present study was conducted over the period of 10 years (2012-2021). For this study, the information regarding the adoption of different soil management and crop production practices followed by the farmers were collected in semi-structured interview schedule. The interview schedule was pre-tested on 10 randomly selected farmers during the first year of study (in 2012), and the discrepancies were removed. Each year 10 farmers (with more than 10 years of farming experience) were randomly selected from 10 villages from different blocks of the Ropar district, spaning over an area of 534 acres. Each year the same selected farmers were interviewed with the survey questionnaire. While selecting the village, it was ensured that at least two villages per administrative blocks viz. Ropar, Sri Chamkaur Sahib, Sri Anandpur Sahib, Nurpur Bedi and Morinda were selected to give representation to the entire district. Therefore, each year 100 respondents were selected to gather information on different management practices followed by them in paddy-wheat cropping system.

Results and Discussion

Information gathered from the farmers was segregated in to different section to analyze the changes in usage pattern of varieties, pesticides, fertilizers, dosages etc. The temporal shifts indicate the change in attitude of the farmers and the efforts of the extension functionaries.

Variety

Varieties have an important role to play in Ropar district as disease yellow rust makes first appearance in the state in of sub-mountainous districts every year. Sri Anandpur Sahib and Nurpur Bedi blocks of the district have been identified as one of the main hot spots for yellow rust (Kaur *et al* 2018). The area under unrecommended varieties has decreased considerably from 30.2 percent in 2012 to 5.4 percent in 2021 (Fig 1).

The constant efforts in the form of awareness campaigns by Punjab Agricultural University (PAU), and aggressive seed selling and subsidy campaign by the State Agriculture Department and PAU has played a major role in increasing the area under recommended varieties (Dhiman *et al* 2010, Dhatt 2022). The newly introduced varieties pick up major share in the area, and this is desirable also in order to attain resistance against the yellow rust disease (Table 1). For instance, cultivation of variety HD-2967, which is susceptible to yellow rust, has declined over years from 32.7 percent in 2012 to 2.7 percent in 2021. With introduction of new varieties, the area under other varieties increased with major share under varieties HD-3086 and PBW-725 by the year 2021 (Table 2). PBW-343, a very popular variety among farmers continued to be cultivated with introduction of Unnat PBW-343 during 2017. Similarly in case of PBW-550 also it was released as Unnat PBW-550 during the same year.

Source of Seed

The source of seed is important as it can affect the performance and yield of crop and can influence the incidence of seed borne diseases like loose smut and Karnal bunt. The Punjab Agricultural University pays special attention to its seed development and production programme and caters to a large number of farmers and institutions requiring certified and breeder seed (Dhatt 2022). As a result of awareness and seed sale campaigns, farmers have shifted to procuring seed

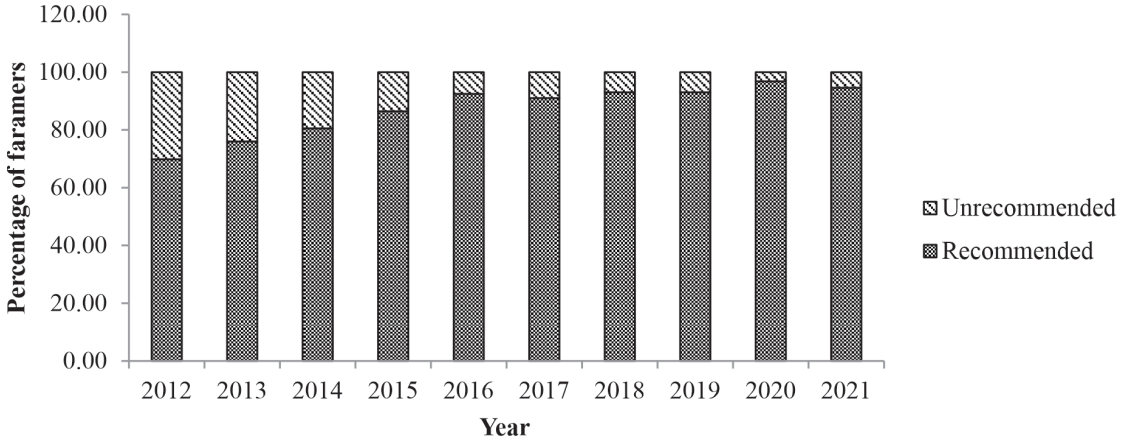

Fig. 1 Farmers' shift towards adoption of recommended varieties for wheat sowing

Table 1. Temporal shift in share of different varieties sown by farmers

Varieties	Percentage of farmers									
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
HD2967 (2011)	32.76	38.02	45.13	22.88	16.33	16.67	12.79	14.73	12.60	2.70
PBW621 (2011)	0.00	5.79	1.77	3.39	4.08	3.85	1.16	0.00	0.00	0.00
PBW550 (2007)	18.10	13.22	15.04	10.17	10.88	5.77	8.72	6.98	8.66	6.31
PBW343 (1995)	12.93	9.92	9.73	6.78	7.48	9.62	13.37	13.95	18.90	19.82
HD2733 (2001)	6.03	9.09	7.08	3.39	0.00	0.00	0.00	0.00	0.00	0.00
WH1105 (2014)	NR	NR	1.77	16.10	14.29	11.54	11.63	3.88	5.51	7.21
HD3086 (2015)	NR	NR	NR	22.03	21.77	17.95	16.86	24.03	16.54	15.32
PBW677 (2015)	NR	NR	NR	0.85	12.24	14.74	16.28	14.73	16.54	15.32
WH711 (2002)	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.00	0.00	0.00
PBW725 (2015)	NR	NR	NR	0.00	5.44	10.90	12.21	13.95	17.32	17.12
PBW-Zn1 (2017)	NR	NR	NR	NR	NR	0.00	0.00	0.78	0.79	1.80
DBW187 (2020)	NR	NR	NR	NR	NR	NR	NR	NR	0.00	9.01
UR	30.17	23.97	19.47	13.56	7.48	8.97	6.98	6.98	3.15	5.41

**UR- Unrecommended varieties; NR- Not released; Parenthesis following name of the variety indicates the year of release of the variety*

Table 2. Area under different varieties over 10 years

Varieties	Area sown (acres)									
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
HD2967	179.0	203.0	241.0	122.0	87.0	89.0	66.0	79.0	67.0	14.0
PBW621	0.0	31.0	14.0	18.0	24.0	20.0	6.0	0.0	0.0	0.0
PBW550	94.0	72.0	76.0	51.0	56.0	31.0	47.0	37.0	46.0	34.0
PBW343	72.0	53.0	48.0	36.0	40.0	48.0	68.0	74.0	101.0	105.0
HD2733	29.0	48.0	41.0	21.0	0.0	0.0	0.0	0.0	0.0	0.0
WH1105	0.0	0.0	10.0	86.0	74.0	65.0	62.0	22.0	31.0	39.0
HD3086	0.0	0.0	0.0	118.0	119.0	96.0	90.0	128.0	88.0	82.0
PBW677	0.0	0.0	0.0	5.0	65.0	79.0	93.0	79.0	88.0	82.0
WH711	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0
PBW725	0.0	0.0	0.0	0.0	29.0	58.0	65.0	74.0	92.0	91.0
PBW-Zn1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.0	10.0
DBW187	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.0
UR	161.0	128.0	104.0	72.0	40.0	48.0	37.0	37.0	17.0	29.0

**UR- Unrecommended varieties*

form the PAU and its outstations. This is evident from the share of PAU which increased from 9.8percent (2012) to 34.9 1percent (2021), and share of private seed vendors declined from 90.2 to 65.1percent over the period of 10 years (Fig. 2).

Sowing Method

In Ropar district wheat is sown with the help of seed drills as well as by broadcasting. At the start of study it was observed that more than 90percent farmers followed conventional sowing methods like broadcast and conventional drill for sowing wheat (Table 3).

In later years (2015-2021) area under conservation tillage like happy seeder, super seeder etc. increased gradually (Table 4). This can be attributed to better awareness level and government restrictions on paddy straw burning. With advent of super seeder technology, some of the farmers shifted from Happy seeder and conventional drill to Super seeder.

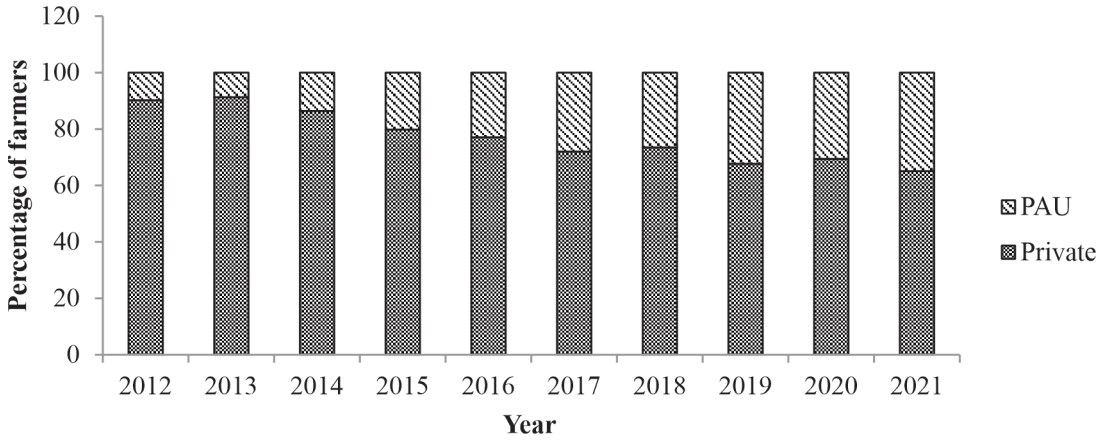

Fig. 2. Source of seed purchase

Table 3. Sowing method for wheat

Sowing method	Percent of farmers									
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Broadcasting	47.1	45.9	36	30.1	31.1	24.6	25.3	25.8	27.5	23.2
Conventional Drill	50	51.3	56.1	52.3	56.6	60.2	51.7	40	36	29.9
Happy seeder	1.9	1.4	1.4	13.3	10	12.1	20.4	24.6	21	17.8
Super seeder	-	-	-	-	-	-	-	7.4	13.6	26.7
Zero till drill	1.0	1.4	6.5	4.3	2.3	3.1	2.6	2.2	1.9	2.4

Table 4. Shift in area under different sowing methods over 10 years

Sowing method	Area covered (acres)									
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Broadcasting	249.0	245.0	192.0	159.0	166.0	128.0	135.0	138.0	147.0	124.0
Conventional Drill	270.0	274.0	300.0	281.0	302.0	321.0	276.0	214.0	192.0	160.0
Happy seeder	10.0	7.0	7.0	71.0	53.0	68.0	109.0	131.0	112.0	95.0
Super seeder	0	0	0	0	0	0	0	40.0	73.0	143.0
Zero till drill	5.0	7.0	35.0	23.0	12.0	17.0	14.0	12.0	10.0	13.0

Weedicides

The use of recommended and un-recommended brands during 2012 was 43 percent and 57 percent, respectively, which has reversed during 2021 to a share of 58 percent and 42 percent, respectively (Fig. 3).

The maximum farmers (71.3 percent) sprayed Clodinafop herbicide on wheat during 2012 (Table 3). This number reduced to 49.9 percent the next year, which can be due to development of resistance in *Phalaris minor* to this herbicide (Bhullar *et al* 2014) and introduction of some alternative herbicides like *Atlantis* and some Metribuzin based herbicides. The use of Clodinafop decreased to 30.2 percent in 2021, which is still the most used weedicide, followed by *Algrip* (Metsulfuron) which is used by 25.8 percent of the farmers. Shift in the area sprayed under different weedicides is presented in Table 6.

Urea Consumption

A majority of farmers (50-53percent) were using 100 kg/acre urea during the year 2012-14 (Fig. 3). This amounts to 2 bags of urea. The agricultural experts were continuously advising farmers for judicious use of fertilizers. A lot of efforts were made by the extension scientists to reduce excessive use of urea. But little success could be achieved. During the later period of the study, i.e. 2015 to 2021, it was observed that maximum numbers of farmers were applying 90 kg urea per acre to wheat crop. Interestingly this also made up two bags because the packing quantity of urea was reduced from 50 kg/bag to 45 kg/bag.

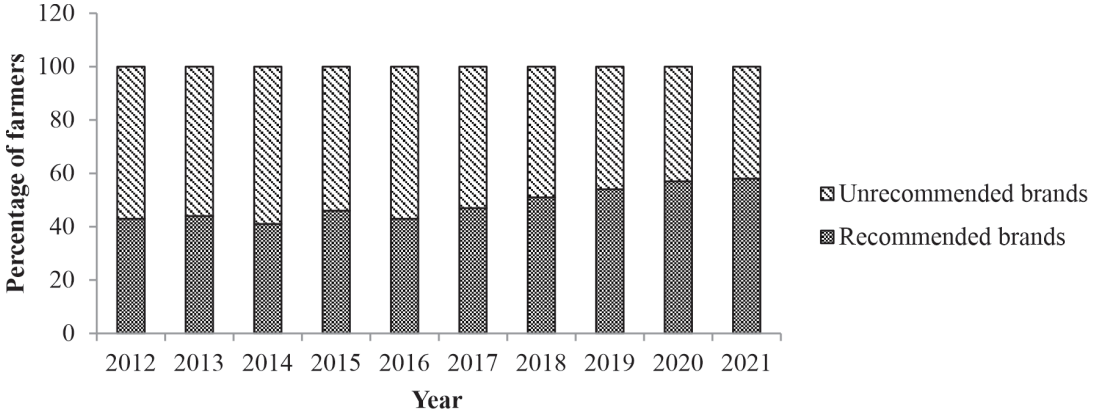

Fig. 3. Share of farmers using recommended and unrecommended brands of weedicides in wheat

Table 5. Use of weedicides in wheat

Weedicide	Percentage of farmers									
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Clodinafop	71.30	49.90	39.08	42.37	41.49	40.48	41.68	34.62	34.47	30.15
Metribuzin	0.00	1.14	1.36	2.11	1.60	2.42	2.51	2.23	2.81	5.21
Atlantis (Iodosulfuron+ mesosulfuron)	3.21	3.90	8.67	7.83	8.00	9.97	10.15	19.19	17.98	18.60
Algrip (Metsulfuron)	9.44	20.44	26.90	22.39	22.77	19.03	20.41	22.71	22.37	25.82
Sulfosulfuron	10.02	15.21	14.13	15.56	15.33	14.90	12.86	9.25	10.61	10.91
Axial (Penoxsulam)	3.21	5.04	2.63	4.22	5.17	6.24	6.87	5.66	4.82	3.77
2-4D	1.07	2.19	1.46	1.00	1.22	1.71	0.97	2.66	2.46	1.60
Total (Sulfosulfuron + metsulfuron)	1.75	2.19	5.75	4.52	4.42	5.24	4.55	3.68	4.47	3.93

Table 6. Shift in area covered under different weedicides in wheat over 10 years

Weedicide	Area covered (acres)									
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Clodinafop	391.0	283.0	212.0	225.0	235.0	215.0	230.0	216.0	210.0	201.0
Metribuzin	0.0	6.0	8.0	11.0	9.0	13.0	14.0	14.0	17.0	35.0
Atlantis (Iodosulfuron+ mesosulfuron)	18.0	22.0	49.0	42.0	45.0	53.0	56.0	120.0	109.0	124.0
Algrip (Metsulfuron)	52.0	115.0	139.0	119.0	129.0	101.0	113.0	142.0	136.0	172.0
Sulfosulfuron	55.0	85.0	79.0	83.0	87.0	79.0	71.0	58.0	65.0	73.0
Axial (Penoxsulam)	18.0	27.0	14.0	31.0	29.0	33.0	38.0	35.0	29.0	25.0
2-4D	6.0	13.0	8.0	5.0	7.0	9.0	5.0	17.0	15.0	11.0
Total (Sulfosulfuron + metsulfuron)	10.0	12.0	32.0	24.0	25.0	28.0	25.0	23.0	27.0	26.0

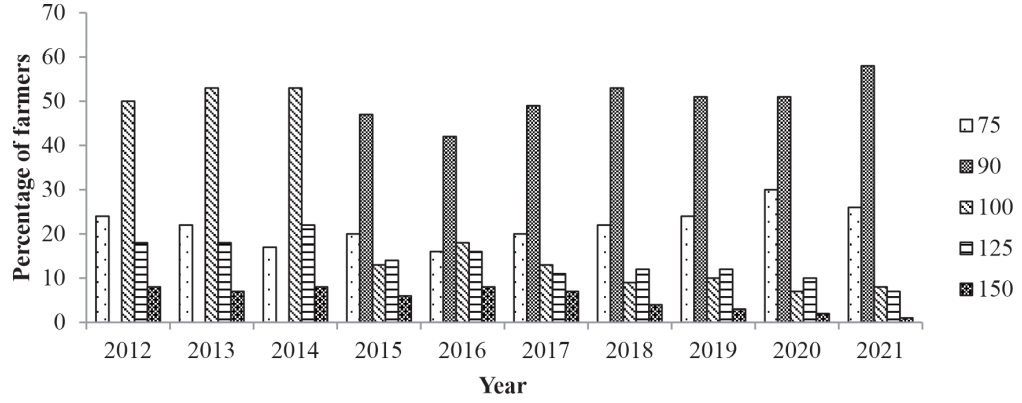

Fig. 3. Percentage of farmers using different dosages of urea (kg per acre)

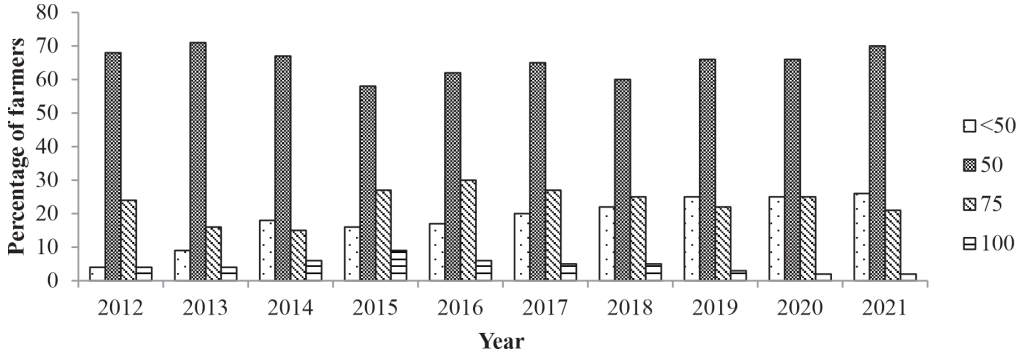

Fig. 4. Percentage of farmers using different dosages of DAP (kg per acre)

Phosphorus Consumption

Over the study period, the maximum number of farmers (58 to 70 percent) reported using 50 kg DAP per acre which makes up one bag (Fig. 4). This is in line with the recommendation of Punjab Agricultural University, which recommends 55 kg/acre DAP to be applied to the medium fertility soils. A considerable number of farmers (15 to 30 percent) though were applying 1.5 bags i.e. 75 kg, while 2-9 percent farmers were applying 100 kg of DAP. These figures stood more or less constant over the tenure of the study.

Yield

Yield of wheat in Ropar district varied from 18.01 q/acre in 2012 to 20.10 q/acre in 2021 (Fig. 5). There was little variation in the yield over the study period with the highest yield in the year 2021.

Technology Interventions

The farmers were asked for a yes or no regarding some technological interventions on their fields during 2021 (Fig 6). 17.6percent of the farmers had knowledge about bio-fertilizer use in wheat, but only nine percent of the farmers adopted this

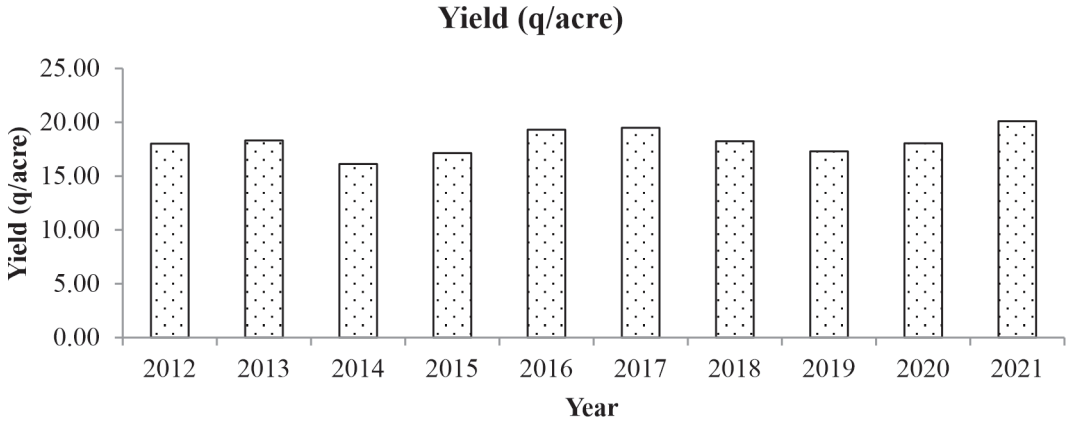

Fig. 5. Yield (q/acre) of wheat during 2012-21

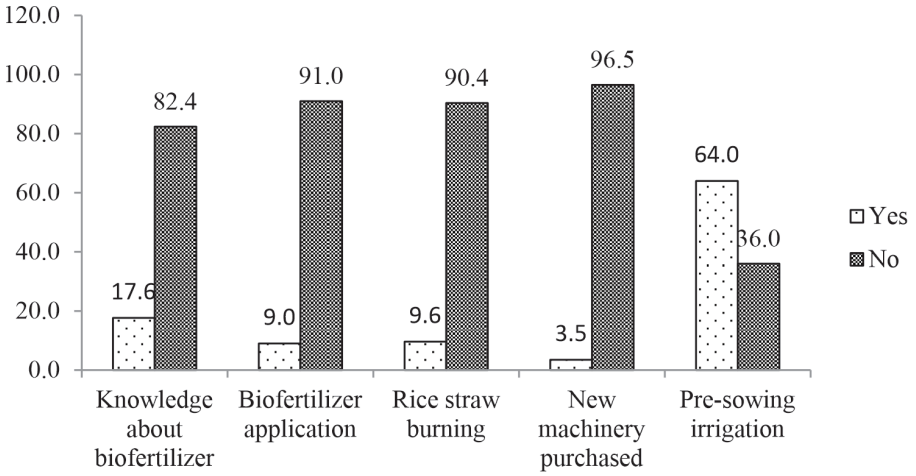

Fig. 6. Response of farmers about different technologies

practice. This may be due to lack of initiative by the farmers in adopting new techniques. Total 90.4percent farmers said they do not burn the residue after wheat harvest while 9.6percent affirmed to have burned it. Regarding purchase of new machinery for straw management or otherwise, for example, happy seeder, super seeder, mulcher, bailer etc., 96.5percent farmers reported they did not purchase new machinery and depended upon custom hiring or managing the paddy straw with the old machinery like tillers, harrows, rotavators etc. A majority of the farmers (64 percent) said that they gave pre-sowing irrigation to wheat while 36 percent said they managed the wheat sowing with the residual moisture of paddy crop.

Conclusion and Policy Implications

The different farmers have different perspective about adoption of management practices. The new technologies and cultivation practices may be perceived more by some farmers than others. The interaction with farmers revealed that there may be several factors behind adoption of new technologies. This is what essentially forms the difference between an advance farmer and a lagging one. This may pose hindrance in realising full productivity of a crop. The role of extension agencies is to ensure higher productivity for farmers while reducing the risks to environment. This study reveals the positive effects of extension machinery of the state in influencing the farmers to adopt new technologies. This helped in increasing the productivity of wheat while conserving the resources.

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