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INFLUENCING FACTORS OF ADOPTION OF WEED MANAGEMENT TECHNIQUES AMONG FARMERS IN DIFFERENT CROPPING SYSTEMS OF THE PUNJAB, PAKISTAN

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This study explores the different factors influencing the adoption of weeds management techniques among farmers in Rice-Wheat, Rice, Potato, Rice-Maize and Rice-Peas cropping systems of the Punjab, Pakistan using a probit model of statistics. The influencing factors were grouped and categorized into demographic, mass media, extension advisory services providers and precautionary factors. Total 356 farmers, selected through proportionate sampling technique from the four cropping systems from district Gujranwala of Punjab were interviewed through face to face interview technique. Age, education and farming experience of the respondents showed a significant difference ($P<0.05$) across the four cropping systems. The results of the probit model indicated that age, farming experience and use of mobile phone were statistically associated with the adoption of weeds management technology in Rice-Wheat cropping system. In Rice-Potato cropping system, age of respondents, tenancy status, access to Extension Field Staff of the public sector had statistically positive whereas use of clean seed had statistically negative association with the adoption. Farming experience of the farmers and use of clean seed were significantly negative associated with adoption in Rice-Maize cropping system. Age of respondent was statistically negatively associated with adoption in Rice-Peas cropping system followed by the statistically positive association between education, income and use of clean seed with the adoption of weed management in Rice-Peas cropping system. The findings of the present study suggest that there is need to pursued farmers towards the adoption of an integrated weed management approach in order to curtail the yield losses. In this regard, the institutional role such as public sector extension should materialize the educational and training campaigns for the farmers regarding effective weed management.
Keywords: Adoption, awareness, chemical, weeds, probit.

INTRODUCTION

The share of agriculture to the GDP of Pakistan is declining over time. Right now, the share to GDP has trickled to 19.3% (GOP, 2019). But, still, agriculture is the largest constituent of the national economy with special reference to labour participation. Moreover, the majority of the population is directly or indirectly dependent on agriculture for their sustainable livelihoods. About 43.5% of the population is engaged with farming as labour and 60% of the people residing in rural areas are engaged in farming in order to generate income for their survival. Conversely, the population of the country has surpassed 220 million and anticipated to grow fast in coming years exerting a pressure on agriculture to grow more food to feed the future generations (GOP, 2019). Farming communities in Pakistan grow major as well as minor crops due to the favourable environment across Pakistan conducive for the cultivation of multiple crops throughout the year. The production of major and minor crops in Pakistan is less than the potential followed by the higher cost of production. Aslam *et al.* (2016) identified a yield gap of 45-84% in the production of wheat, cotton, rice, maize and sugarcane crops. The farmers in Pakistan were found getting 53-82% less production of wheat, cotton, rice, maize and sugarcane crops as compared to global nations (Kamal *et al.*, 2012; Aslam *et al.*, 2016). The less production of major and minor crops in Pakistan is associated with the penetration of agronomic, irrigation management related, environmental, institutional, technological and socio-economic constraints (Aslam *et al.*, 2016; Iqbal and Ahmad, 2005).

Weeds are one of the prominent challenges for the farmers and dully responsible for the significant reduction in the production of major crops (Khan *et al.*, 2011). Weeds are regarded as the ancient enemies of crop production as compared to insects, pests and diseases. Weeds play important role as host for many invading insects and pests which can easily enlarge the damage to 15-20% once they are successfully developed in the crop (Rubiales, 2014). Across Pakistan, a major part of yield loss is associated with the weeds infestation. Hafeez (2011) reported that if the weeds are not controlled in the first 40 days, they can damage 50% of the production. The study of Maqbool *et al.* (2006) unveiled that weeds can cause 20-55% yield loss in cotton, 10-18% in potato and close to 45% in maize by sharing the

nutrient that we thought to be utilized by the crop. Safdar *et al.* (2019) found 28% yield loss in wheat crop; while, the weeds showed significant impact on the grain quality and thousand-grain weight.

In order to obtain the potential production of crops, controlling different weeds is obligatory. Weeds cannot be alleviated unless effective techniques are not adopted (Chamanabad, 2011; Smith *et al.,* 2015). To minimize the yield losses, preventive, mechanical, cultural, biological and chemical control techniques should be utilized at the farm level (Tanveer *et al.,* 2005; Gerhards *et al.,* 2011). Chemical control is often adopted by the farmers to control weeds because of being less time consuming and showing quick response (Olorunmaiye and Olorunmaiye, 2009). The chemical control does have negative impacts on the soil, plants and the environment. Due to lack of knowledge farmersheavily rely on chemical control rather than the other integrated techniques. Wilson and Tisdell (2001) reported farmers had limited awareness regarding safe use of pesticides and were found continuously relying on the chemical conrol of weeds. The findings of Talib *et al.* (2018) confirmed that farmers were more inclined towards chemical control rather than any other technique such as biological control of weeds. Hashim *et al.* (2019) argued that the farmers had poor knowledge of weeds management and in the result of continuous and improper application of herbicides the weeds have become resistant. Laizer *et al.* (2019) found the same that farmers had used the local techniques to control weeds and didn't bother to contact extension field staff for their guidance. In a study, Talib *et al.* (2018) found that 83.2% and 62.4% respondents were familiar with pre-emergence and post-emergence weeds, respectively. As for as control was concerned, 71.1% of respondents were unfamiliar with the management of weeds.

This situation indicates a need fora holistic approach to control weed and mitigate yield losses. Weed management has become critical in terms of sustainable crop production, erratic climatic patterns and food security nexus in Pakistan (Matloob *et al.,* 2019). According to Hashim *et al.* (2019), the farmer's education regarding weed management and the adoption of appropriate technology is of utmost importance. The development of knowledge among farmers regarding weed management is inevitable (Chauhan *et al.,* 2017). Unfortunately, of the previous studies conducted, none have been focused in Pakistan to examine the adoption of weed management practices in the different cropping systems of Pakistan. Therefore, this study was planned to examine the different factors contributing to the non-adoption of weed management practices in different cropping zones. This study is aimed at exploring the gap needs to be filled in future in order to expedite the adoption of specific and safe techniques.

METHODOLOGY

***Study site and sample selection*:** The present study was conducted in the district Gujranwala of the Punjab province of Pakistan. The Gujranwala district is famous for its agricultural potential four types of cropping system such as rice-wheat, rice-peas rice-maize and rice-potato that are widespread across the district. The district has a total five tehsils (Sub-districts) such as Gujranwala city, Gujranwala Sadar, Wazirabad, Kamuke and Nowshera Virkan. Considering the time and resources, the study was further downsized to three sub-districts. Of the total five tehsils, three such as Wazirabad, Kamuke and Nowshera Virkan were selected purposively. The Gujranwala Sadar and Gujranwala city had the lowest number of farmers, therefore, both were not selected as a study area.

Regarding sample selection, it was decided to adopt a proportionate sampling technique. The list of farmers was obtained from the office of Deputy Director of Agriculture (Extension), Gujranwala. The list contained 4782 farmers practising farming under different cropping systems. Of the total farmers in the list, 1645 farmers were from rice-wheat cropping system, 1360 from rice-maize, 935 from rice-potato and 842 from rice-peas cropping system. The online software www.surveysystem.comwas used to generate the sample size taking 4782 farmers as the known population for the study at95% confidence level and confidence interval of 5%. The total sample size for the study was 356 respondents. Through proportionate sampling technique, 122 farmers from rice-wheat, 101 farmers from rice-maize, 70 farmers from rice-potato and 63 farmers from rice-peas cropping system were selected as respondents.

***Data Collection*:** A structured questionnaire was used for data collection. The questionnaire was prepared in line to study objectives. For the preparation of questionnaire, an extensive literature from the periodicals, scholarly journals, books and reports was reviewed. The questionnaire was administered through face to face interview technique. Formal acceptance was sought from the respondent before starting the interview. The respondents were assured that anonymity of the information will be ensured. Each interview took 30 to 45 minutes. The questionnaire was quantitative followed by the observations and few informal questions to validate the quantitative answers. The researcher itself collected the data and data collection lasted for a year.

Data Analysis: The collected data was coded to excel and the Statistical Package for Social Sciences (SPSS) was used for the analysis of techniques. Both descriptive and inferential statistical techniques were applied to the data.

***Demographic profile of respondents*:** Data were analyzed quantitatively. Descriptive statistics were applied to explore the demographic attributes of the respondents by frequency and percentages. The analysis of variance (ANOVA) was used on the data to examine the differences in demographic

Table 1. Variables of the probit model used to identify the influencing factors of the adoption of weed management techniques.

Notation	Variable name	Description	Variable type/criteria
Y	Adoption (Dependent Variable)	Farmers adoption of weeds management techniques	1 If adopted, 0 Otherwise
X1	Age	Age of the respondents/farmers	Continuous variables
X2	Education	Level of the farmers' education possessed by respondents	Independent variable. 1 for illiterate, 2 for primary, 3 for middle, 4 for matric, 5 for post matric.
X3	Family Size	Numbers of family members	Continuous variable
X4	Tenancy	Land tenure ship status	1 for owner, 2 for owner cum tenants and 3 for tenant
X5	Farming experience	Number of years that an individual is practicing farming	Continuous variable
X6	Income	Amount of income earned from farming and non-farming ventures	Continuous variable
X7	TV	Information source. Access to TV	1 for yes, 2 for otherwise
X8	Internet	Access to internet for information	1 for yes, 2 for otherwise
X9	Mobile	Access to mobile for connectivity with advisory service providers	1 for yes, 2 for otherwise
X10	Newspaper	Access to newspaper for information	1 for yes, 2 for otherwise
X11	EFS Public	Access to public sector extension services	1 for yes, 2 for otherwise
X12	EFS Private	Access to private sector extension services	1 for yes, 2 for otherwise
X13	Clean seed	Access and information about the use of clean seed	1 for yes, 2 for otherwise
X14	Clean Irrigation channels	Awareness about the clean irrigation channels to restrict weeds	1 for yes, 2 for otherwise
X15	Clean farm Tools and machinery	Awareness about the cleanliness of agriculture machinery and tools to restrict weeds	1 for yes, 2 for otherwise

attributes of the participating farmers from rice-wheat, rice-peas rice-maize, rice-potato cropping systems.

***Factors influencing adoption of weeds management*:** A probit model was run to examine the different factors likely to affect the adoption of weed management techniques among farmers in different cropping systems (Dandedjrohoun *et al.*, 2012; Tetteh, 2015; Chuchird *et al.*, 2017).

$$Y_i = \beta_0 + \sum_{i-1}^{15} \beta \mathrm{i} \mathrm{Xi} + \upsilon$$

Where, Yi refers to the adoption of weeds management techniques (1 if adopted, 0 otherwise), β_0 refers to intercept, βi is the vector of parameter estimates, Xi is the vector of explanatory (independent) variables, υ shows the random disturbance term

Table 1 shows the dependent and independent variables. The dependent variable was the adoption of weed management techniques. Whereas, the independent variables (X1-X15) included as the age, education, family size, tenancy, farming experience, income, TV, internet, mobile, newspaper, EFS public, EFS private, use of the clean seed, clean irrigation channels and clean machinery and tools. The independent variables X1-X15 were entered into the probit model in order t explore the effect on adoption of weed management techniques. The total influencing factors (X1-X15) were classified as demographic (X1-X6), mass media (X7-X10), extension advisory services providers (X11-X12) and Precautionary factors (X13-X15).

RESULTS AND DISCUSSION

Demographic profile of the respondents: The data depicted in Table 2 portrays the demographic profile of the farmers involved in the study as respondents concerning the adoption of different weed management techniques in different cropping zones such as Rice-Wheat, Rice-potato, Rice-maize and Rice-Peas The demographic attributes as brought under discussion were Age (X1), Education (X2), Household size (X3), Tenancy status (X4), Farming experience (X5) and income sources (X6).

***Age of the respondents*:** Data depicted that 29.2% of the respondents were young (under 30 years) followed by the 41% of respondent who was in the middle of the ages (36-50 years; Table 2). Almost 30% of respondents were old (>50 years). The F-value indicates there was a statistically significant difference in the age of the respondents concerning the adoption of weed management practices among the farmers (*P<0.05*).

***The education level of respondents*:** Moreover, data revealed

Table 2. Demographic profile of respondents.

Attributes	Rice Wheat		Rice-Potato		Rice Maize		Rice-Peas		Total	
	F	%	F	%	F	%	F	%	F	%
Age										
Young (<30 years)	32	26.2	19	27.1	25	24.8	28	44.4	104	29.2
Middle (30-50 years)	53	43.4	36	51.4	40	39.6	17	27.0	146	41.0
Old (>50 years)	37	30.3	15	21.4	36	35.6	18	28.6	106	29.8
F= 0.416 df=4 Sig.=0.000										
Education										
Illiterate	23	18.9	17	24.3	25	24.8	14	22.2	79	22.2
Primary-Middle	57	46.7	27	38.6	38	37.6	15	23.8	137	38.5
Matric	25	20.5	19	27.1	33	32.7	15	23.8	92	25.8
Above Matric	17	13.9	7	10.0	5	5.0	19	30.2	48	13.5
F=0.342 df=4 Sig.=0.002										
Household size										
Up to 5	42	34.4	29	41.4	36	35.6	24	38.1	131	36.8
6-10	50	41.0	26	37.1	42	41.6	20	31.7	138	38.8
Above 10	30	24.6	15	21.4	23	22.8	19	30.2	87	24.4
F=1.04 df=4 Sig.=0.404										
Tenancy Status										
Owner	81	66.4	46	65.7	72	71.3	32	50.8	231	64.9
Owner-cum-tenant	37	30.3	18	25.7	22	21.8	20	31.7	97	27.2
Tenant	4	3.3	6	8.6	7	6.9	11	17.5	28	7.9
F=0.784 df=4 Sig.=0.543										
Farming experience										
Low (Up to 10)	31	25.4	22	31.4	19	18.8	32	50.8	104	29.2
Medium (>11-20)	34	27.9	30	42.9	33	32.7	17	27.0	114	32.0
>20	57	46.7	18	25.7	49	48.5	14	22.2	138	38.8
F=0.101 df=4 Sig.=0.00										
Income sources										
Farming only	47	38.5	56	80.0	69	68.3	47	74.6	219	61.5
Farming + non-farming	75	61.5	14	20	32	31.7	16	25.4	137	38.5
F=0.981 df=4 Sig.=0.430										

that 22.2% were illiterate and 77.8% of respondents had formal education (Table 2). Among the participating farmers, 38.5% had an educational level of primary to middle followed by one fourth (25%) of respondents qualified to matric level. Of the total respondents, 13.5% had a qualification level of more than matriculation. The ANOVA indicates the statistically significant difference between educational level about the adoption of weed management techniques in different cropping zones (*P<0.05*).

***Households Size of the respondents*:** Table 2 indicates that 36.8% of the respondents had less than 5 members in their households. Almost 39% of respondents had 6-10 family members. One fourth (24.4%) of the households had more than 10 family members. Perhaps, these large families were joint. There was a statistical insignificant difference between household size for the adoption of weed management practices under different cropping zones (*P>0.05*).

***Tenancy Status*:** Results delineated that the majority of respondents (64.9%) were owners of their lands (Table 2). Greater than one fourth (27.2%) of respondents were owner-cum-tenants and 7.9% of respondents were tenants. This implies that owners outnumber the owner-cum-tenants and tenants. The tenancy status was statistical insignificant across the cropping systems about the adoption of weed management techniques (*P>0.05*).

***Farming experience*:** Table 2 shows that 29.2% of the participating farmers (219 farmers) had the farming experience of fewer than 10 years. Very close to one-third of respondents (32%) had the experience of farming between 11 to 20 years. Of the total respondents, 38.8% (138 farmers) were the highly experiences farmers entailing an experience of over two decades (Table 2). Farming experience of the respondents showed statistically significant differences across the cropping systems concerning weed management techniques.

***Income sources of the respondents*:** This study figured out that that for 61.6% of respondents, farming was the sole and key income sources (Table 2). Of the total respondents, 38.5% of respondents had an emphasis on multiple income sources to generate income for their sustainable livelihoods. Income

source had a statistically insignificant difference regarding the adoption of weed management techniques under different cropping systems. The frequency distribution of different income sources is given in Figure 1.

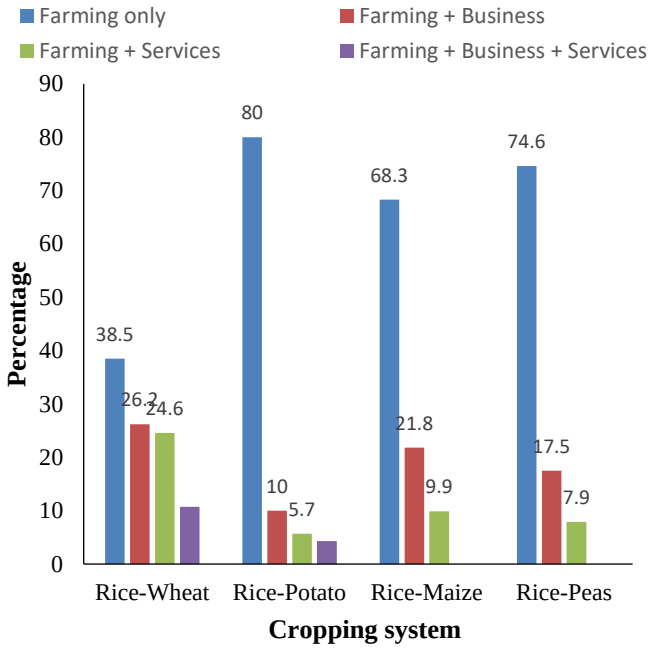

Figure 1. Frequency distribution of income sources of the respondents.

Note: In the Rice-Wheat cropping system, 38.5% of respondents were reliant on farming for income. In Rice-Potato, (80%), 68.3% in Rice-Maize and 74.6% of respondents in Rice-Peas had key reliance on only farming to generate income. The private business and services were the secondary income sources accompanied by farming as well.

***Influencing factors of the adoption of different weed management techniques*:** The findings of the probit model analysis of the factors (X1-X15) impacting the adoption of weed management techniques in different cropping systems in the study area are depicted in Table 3. The weed management was statistically significant with the education (β=0.650), farming experience (β=0.700) and mobile (β=0.659) among farmers in Rice-Wheat cropping system. The adoption of weed management practices was statistically related to the age of respondents (β=0.202), tenancy (β=0.352), EFS of the public sector (β=2.012) and clean seed (β=-0.143). Farming experience (β=-1.077) and clean seed (β=-0.608) were statistically associated with the adoption of weed management in Rice-Maize cropping system. Adoption of weed management was statistically associated with age (β=-1.118), education (β=0.114) income (β=1.347) and clean seed (β=0.556) among farmers in Rice-Peas cropping system (Table 3).

***Age of the respondents*:** Age was statistically positively significant with the adoption of weed technologies in Rice-Potato cropping system (β=0.202, *P<0.05*). This implies that the older age farmers were more receptive to the adoption of weed management techniques in Rice-Potato cropping system. In Rice-Peas cropping system, the age of respondents was statistically negatively significant (β=-1.18, *P<0.05*). This indicates the respondents in young age opted differently. The young farmers tend to be more receptive in adopting different weed management techniques to curtail the potential yield losses. The findings are endorsed with those of Udensi *et al.* (2012) who also found that with the increasing age, the risk aversion among farmers increased and adoption of the innovation kept lower. Findings are also consistent with previous studies (Sharma *et al.*, 2005; Wasula, 2000) who also identified the statistically significant association of age with the adoption. They also found that age had the significant impact on the adaptability of technology. Though, the young age farmers were more inclined towards adoption rather than the old age farmers.

***Education*:** Education was statistically significant with the adoption of weed management techniques in Rice Wheat cropping system (β=0.650, *P<0.05*) and Rice-Peas cropping system (β=0.114, *P<0.05*). Among the farmers in Rice-Potato and Rice-Maize cropping system, the education was insignificant with the adoption of weed management but the association was positive. This indicates, with the unit increase in education, there was a chance of more adoption among farmers. The significant association confirms that the farmers with a higher level of education were more receptive to weed management and had an increased rate of adoption regarding weeds management. It can be deducted that, the educated farmers had more exposure and access to information related to innovative techniques. They had a greater understanding about the production practices and were keen to learn each day something new about farming ventures. The findings are similar to those of Nzomoi (2007) who found that the educated farmers were more conclusive towards agricultural innovations and had greater willingness to adopt the recent technologies. Hence, the association between the education and adoption of technologies was highly significant. The educated farmers tended to obtain full information about the specific technology and it helps to alleviate the uncertainty about the performance of the technology. This association brought the change in behaviour of farmers (Caswell *et al.*, 2001). Asa result of more education, the farmers witnessed higher yields, increased income and higher rates of adoption (Nzomoi, 2007).

***Family size*:** Family size of the respondents was insignificant with the adoption of weed management techniques. The association in Rice-Peas cropping system was negative. This indicates, with the increasing numbers of family size the rate of adoption would be lower. Whereas, in the other three cropping systems the association was positive but insignificant showing a notion of an increase in the chance of adoption with the increase in the size of the family. Recently, Li *et al.* (2020) and Peshin *et al.* (2018) reported that the

Table 3. A probit model results for the factors influencing the adoption of weed management practices .

Variables	Rice-Wheat		Rice-potato		Rice-Maize		Rice-Peas	
	Coefficient	Std. Err	Coefficient	Std. Err	Coefficient	Std. Err	Coefficient	Std. Err
Age	3.121	0.757	0.202**	0.418	1.205	0.733	-1.118**	0.901
Education	0.650**	0.323	0.530	0.766	0.656	0.487	0.114**	0.857
Family Size	0.321	0.663	1.982	0.494	3.514	0.928	-1.545	0.807
Tenancy	-0.962	1.010	0.352**	0.952	-0.612	0.688	0.421	0.561
Farming Experience	0.700**	0.474	-0.933	0.976	-1.077**	0.467	0.017	1.448
Income	0.747	0.532	2.87	0.719	3.561	0.752	1.347**	0.621
TV	1.167	0.780	-1.00	0.211	-1.004	0.629	0.001	0.667
Internet	0.301	0.103	0.675	1.669	0.055	1.318	-4.181	0.811
Mobile	0.659**	0.902	0.043	0.418	0.893	0.602	0.854	1.040
Newspaper	1.407	0.751	0.344	0.418	-0.535	0.805	-0.912	1.109
EFS Public	0.169	0.697	2.012**	0.594	0.608	0.223	0.834	0.553
EFS Private	-2.137	3.543	1.695	0.663	0.167	0.747	0.383	0.221
Clean Seed	0.281	0.531	-0.143**	0.161	-0.608**	0.220	0.556**	0.195
Irrigation	-0.383	0.436	-0.490	0.451	-0.653	0.406	0.416	0.269
Tools	0.731	0.396	-0.373	0.903	0.021	0.034	0.834	0.446
Constant	11.32	2.95	2.528	1.784	4.698	3.23	-1.543	2.682
Log Likelihood	-28.414		-11.200		-19.082		-11.451	
LR (Likelihood Ratio)	50.930		14.972		11.022		18.964	
Test Chi^2	28.912		4.795		6.251		4.471	
Pseudo R^2	0.594		0.622		0.680		0.602	

** Significant at 0.05 level (95% confidence interval).

family size of farmers was significantly associated with the adoption of agricultural technologies. It can be deducted that the large size of the family can advance their farming and curtail the cost of production by rendering their services as family labour. The major crops like cotton and rice require a considerable amount of time in planting and weed management. For this purpose, the timely availability of labour remains vital. Udimal *et al.* (2017) reported that for the farmers who had access to family labour they were more receptive towards the adoption of agricultural technologies.

***Tenancy*:** The tenancy had a significant relationship with the adoption of weed management techniques in Rice-Potato cropping system (β=0.352, *P<0.05*). Being an owner of the lands gives farmers privilege and the courage to take risks for new techniques. Findings are consistent with those of Adusumilli and Wang (2019) as they identified that the owner cultivators were way better adopters of technologies as compared to tenants. The major reason was the tenurial rights and confidence in the result. Paltasingh (2018) also concluded the same that the owner cultivators had tenurial rights which led them to adopt the modern techniques as compared to tenants.

***Farming experience*:** Farming experience showed significant association with the adoption of weed management techniques among the farmers in Rice-Wheat cropping system (β=0.700, *P<0.05*). This implies that with the increase in years of farming the adoption rate of weed management increased. The association of farming experience with weed management was significant but negative among the farmers in Rice-Maize cropping system. The findings infer that with the increase in experience of farming the adoption rate of the weed management reduced. Perhaps, with the increasing farming experience, the age of farmer increases and he may become risk-averse, and likely to ignore the technology. As compared the young farmers having differing years of experience in farming would be more inclined towards adoption. Amengor *et al.* (2018) reported that the farmers who had less experience were highly associated with the acquisition of new information and adoption of technology. This stance endorses the findings of the current study where the farmers with less experience were keener to adopt technologies. The years of farm experience is indeed a viable way to gather the knowledge, learn by practising and accessing information from informal channels, that is what old age farmers rarely do (Nejadrezaei *et al.*, 2018).

***Income*:** Income was statistically significant with the weeds management techniques adoption among the farmers in Rice-Peas copping system (β=1.347, *P<0.05*). Income had an insignificant but positive relationship with the adoption of weed management techniques in Rice-Wheat, Rice-Maize and Rice-Potato cropping systems. The positive association affirm the vitality of income in the process of adoption. With the unit increase in income of the farmers, the chances of the adoption will be high. The income earned by the farmers increases the ability of the farmers to understand and adopt the recent technologies (Hu *et al.*, 2019; Barnes *et al.*, 2019). Therefore, the focus of farmers to earn more income can lead him to expand the farming area and earn more income to

expedite the process of adoption. The significant impact of income on the adoption of technologies was further established by Kassie *et al.* (2011). Whereas, Suri (2011) identified that farmers with low net return hardly adopt the technologies.

***Television*:** Television (TV) had a statistically insignificant relationship with the adoption of weed management techniques (*P>0.05*). The TV is viewed as a key source to access information, build awareness and set pathways to the adoption of innovation. But, the key role of TV is creating awareness and persuading farmers towards adoption (Muhammad *et al.*, 2004). The positive association accentuates the importance of TV in the adoption process. As it is anticipated that with the increased access to the TV, the farmers are more likely to adopt the particular technologies.

***Internet*:** Internet was insignificant with the adoption of the weeds management techniques among the farmers in different cropping systems. The Internet has penetrated within the farming communities and most of the farmers have started to benefit from it. The access to the internet reduced the constraints faced by the farmers and strengthened their abilities to access more information to decide about the adoption (Park and Mishra, 2003). The use of internet is more critical in awareness building and helping farmers in decision making. Once the decision making becomes strong the rate of adoption among the farmers will increase significantly. According to Hammond *et al.* (2000), internet users were more receptive towards technology and they had more interest in technology adoption as compared to non-users. Jose and Lokeswari (2018) urged more motivation and training of farmers in using the internet to help them envision the adoption of recent technologies.

***Mobile phone*:** The use of mobile phone was statistically significant with the adoption of weed management techniques in Rice-Wheat Cropping System (β=0.659, *P<0.05*). In other cropping systems, the relationship between mobile phone use was insignificant but positive. This infers that there was a greater likelihood of increased rates of adoption with the increase in the use of the mobile phone by the farmers. Findings are endorsed with those of Hasan (2015). He opined that increased use of the mobile phone can resolve the issues of access to information, affordability and interest of the farmers. The mobile phone users can help farmers to encounter the different challenges in wake of technology adoption through the mighty access to information, learning opportunities, financial assistance and market access (Baumuller, 2012). The mobile phone users were more engaged in information mechanism as compared to non-users and the users had multiple purposes of mobile use which lured them to adoption (Goodman, 2005). This augments the tremendous potential of mobile phone use in helping farmers to adopt recent weed management techniques.

***Newspaper*:** The newspaper had an insignificant association with the adoption of weed management techniques among farmers in all cropping systems under investigation. However, the positive association defined the important role of the newspaper in creating awareness among farmers about the particular technology. Farooq *et al.* (2007) had viewed the newspaper, one of the key information source for the farmers. It has the potential for farmers' persuasion but also has certain limitations. For instance, Ali (2011) and Apata (2010) also found that the use of newspaper limited to educated farmers whereas the information flow through newspaper was one dimensional.

***Access to EFS of Public Sector*:** Access to public sector extension was significant with the adoption of weed management technologies among farmers in Rice-Potato cropping system (β=2.012, *P<0.05*). The more access of farmers to public sector extension field staff gave them more insight towards the adoption of weed management techniques. There is also a chance of an increase in adoption rate with the increase in access to public sector extension field staff , as the insignificant but positive association of access to extension staff and adoption of weed management techniques.

***Access to EFS of Private Sector*:** Access to extension field staff of the private sector had an insignificant association with the adoption of weed management techniques among farmers. The association was negative in Rice-Wheat cropping system. This infers that with the increased access of farmers to private sector extension, the adoption rate declined. The private sector extensions staff is often involved in marketing inputs such as weedicides. Perhaps the element of marketing and excessive cost upheld the farmers decisions to adopt their traditional techniques rather than adopting the recommended techniques of weed control.

***Use of clean seed*:** Use of clean and adulteration free seed was statistically significant with the adoption of weed management techniques among farmers in Rice-Potato (β=-0.143, *P<0.05*), Rice-Maize (β=-0.608, *P<0.05*) and Rice-Peas (β=0.556, *P<0.05*) cropping systems, respectively. The negative values of the β confirm that with the increased use of clean seed the adoption rate of weed management was higher but probably the cost decreased and the effectiveness of control increased significantly. The use of clean seed gave natural control to the emergence of weeds. Thus, access to pure seed can expedite the control of weeds.

***Clean irrigation channels*:** Clean irrigation channels were insignificant to the adoption of weed management techniques across the four cropping systems. This indicates cleaning of irrigation channels have no impact on the adoption of weed management techniques. However, cleaning the watercourses and channels over time through manual, mechanical or chemical control can curtail the seed spread of different weeds.

***Clean farm tools and machinery*:** Clean farm tools and machinery had a non-significant impact on the adoption of weed management techniques. The use of clean farm tools and machinery could help eliminate the spreading of weed

seeds. This is strongly linked with the awareness and understanding of the farmers. With the increase in awareness, the level of cleanliness of tools and machinery will increase as it can serve as natural control over weeds.

Conclusion and recommendations: This study aimed to explore the influencing factors for the adoption of different weed management techniques among farmers in different cropping systems of Punjab. The probit model analysis affirmed that age and educational level, tenancy status, farming experience and income of the respondents were significant with the adoption of weed management techniques. Among different information sources, mobile phone was significant with the adoption of weed management in Rice-Wheat cropping system. Whereas, television, internet and newspaper were insignificant with the adoption of weed management techniques. Regarding extension service providers such as Public Sector Extension Field Staff and Private Sector Extension Field Staff, the access of farmers to public sector extension staff was significant with the adoption of weed management whereas the relation of the private sector was inverse to adoption.

This study concludes with the remarks that the demographic profile of the farmers had a key role in determining the adoption of weed management techniques. There is a need to focuson young, educated and experienced farmers in order to motivate them to adopt the integrated weed management techniques. The safe use of the chemicals should be promoted among farmers to control weeds. The farmers with the large family size should use their family labour to curtail the cost of production and effectively manage the weeds. In this regard, the public sector Extension Field Staff should interact with farmers and educate them regarding the effective control of weeds. The extension staff should launch their YouTube channels to educate farming communities on agriculture and weed management in particular. We need to revamp the use of newspapers and familiarize the role of agriculture journalism. The articles in indigenous language could help farmers to record, share and adapt the guidelines.

Adopting precautionary measures can help farmers to control the infestation of weeds. use of clean and adulteration free seed was statistically significant with the adoption of weed management technique. The use of clean seed tends to help farmers to curtail the reliance over chemicals to control weeds. This stud urges the development of a mechanism to ensure the purity of crops seeds.

In the end, the study further concludes that adoption of weed management techniques is associated with the several factors including personal factors of farmers, extension advisory services related, information access and institutional role. The synergistic working and widespread integrated approach of weed management could help the farmers in defeating the infestation of weeds, saving cost and increasing the production of major and minor crops.

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