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Research Article

Understanding Farmers' Knowledge, Attitude, and Practices in Managing Water Quality for Effective Insecticide Performance: A Case Study in Agriculture

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Abstract: Pesticides are frequently used in agriculture to manage the pest populations below threshold levels; however, most of the time, their applications do not get the desired outcome. There are many factors for the low performance of pesticides, the quality of water being one of them. Local farmers of Sindh, Pakistan have little or no knowledge of the role of water quality in the performance of pesticides. Therefore, a survey study was conducted to determine the farmer's knowledge, attitude, and practice regarding it. Ten villages were selected from each Hyderabad and Tando Allahyar districts as the information was obtained from five farmers from each village. Descriptive analysis results indicated that most of the respondents prefer to grow cotton (average 24.07 acres) with the majority of them being illiterate (54 %) averaging 39.74 years of age and averaging 18.80 years of farming experience. Most farmers (92 %) used groundwater for spray solution, whereas only 3% of farmers tested the water in their fields. The majority (74.51 %) of farmers considered lower-quality pesticides for their poor performance. Therefore, farmers normally apply up to sixteen sprays to control pests. It was also observed that although farmers have knowledge about the role of water quality in the performance of pesticides to get pest control, they lack the attitude and practice it in their fields. Therefore, it is suggested that awareness should be created among the local farmers regarding water quality to be used in spray solutions to get desired pest control.

Keywords: Water Quality Management, Pesticides, Insecticides, Pest Control.

1. INTRODUCTION

The application of pesticides on crops is although discouraged at large, nevertheless the pesticide is supposed to be an inevitable component by the farming communities to keep their crops safe from pest infestations and to maximize crop production [1]. Likewise, in Pakistan, the habit of applying insecticides to various crops is referred as a common practice as only during 2020-2021, 37,441 tons chemical insecticides of worth Rs. 30,083 million were imported to manage crop pests [2]. The phenomenon of 'injudicious use of pesticides' is normally correlated with inefficacy of pesticides [3]. While the related literature concludes that the number of factors involved in failure or lessening of the pesticides' efficacy in controlling pest problems. In this regard, insect resistance is also considered a huge issue these days [4, 5]. Yet some of the researchers are of the opinion that the mishandling, improper calibration, and selection of incorrect pesticides could also contribute as significant causes behind pesticides ineffectiveness [6]. Therefore, the general opinion of farmers, researchers and institutional representatives related to insecticide incompetency are quite diverse and somehow complicated.

All the contributors of this study believe that before applying pesticides to the crops, the farmers

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must be aware and should adopt all the significant measures and steps that may not disturb the effectiveness of a pesticide. In this regard, the water quality has always been ignored by most of the farmers. However, improper quality of water may potentially bring adverse impact on the performance of pesticides, as water functions as a solvent for mixing pesticides before applying. Hence, recommended water quality plays an imperative role in maintaining pesticide's effectiveness [7]. The available literature is correspondingly evident that the water hardness, pH, turbidity, and temperature display negative effect on the performance of various synthetic pesticides [8-15]. The pH of the spray solution can impact significantly on insecticide efficacy. The variation in pH of solution may lead to hydrolysis which cleaves the chemical molecules into smaller compounds. Pesticides may undergo alkaline hydrolysis, in which a pH greater than seven causes chemical degradation of certain pesticides in the presence of ions. The rate of alkaline hydrolysis is enhanced as the pH increases [16]. For example, organophosphate (acephate and chlorpyrifos), carbamate (methiocarb), and pyrethroid (bifenthrin, cyfluthrin, and fluvalinate) undergo alkaline hydrolysis in the presence of alkaline water. Moreover, the half-life of many insecticides can also be affected with the variation in pH of solvent or spray mixture [15]. Therefore, it is strongly recommended by various researchers that for most of the insecticides favor to use water with pH only ranging from 4 to 7 for preparation of spray mixture [16, 17]. As it was earlier discussed that 80 percent of the total pesticides are applied merely on cotton crop for the purpose of plant protection [18].

In Pakistan, cotton is not only a cash crop which contributes 1.0% in Gross Domestic Product (GDP) but also covers a share of 5.5% in value added goods of agriculture. Furthermore, the cultivation area has increased at 6.5% in 20119-20 as compared to 2018-19, however, there was a decline in the production from 1,676,000 metric tons to 1,560,000 metric tons. Moreover, during the same period of time, cotton backed up to US$ 10.22 billion to foreign exchange of Pakistan [19]. Logically, increasing in cotton yield may directly proportion to the pesticides' application, which may disturb the foreign exchange reserves at one end, on the other hand it may also augment environmental degradation and health hazards to the local people. Hence, the sustainable development requires certain level of awareness among farming communities to find out real issue related to 'ineffectiveness of pesticides. Once the matter of water quality prerequisite to pesticide spray mixture is carefully managed then one can go beyond it and think about pest resistance [1].

It is the foremost important to have considerable knowledge regarding basic or suggested parameters to make a mixture of pesticides, but unfortunately the literacy rate of rural people is quite unsatisfactory where only 53.3% can have ability to read and understand simple text in local languages [20]. On the contrary, the labels of pesticides especially from international companies are in English and have technical terms which are not possible for the local farmers to understand. Therefore, current situation of farmers motivated the researchers to conduct a study in which the level of farmers' knowledge, their attitude and practice regarding water quality for preparing a pesticide mixture may be investigated. The outcome of the study may help to identify the real issue regarding pesticide ineffectiveness and could propose some implications to resolve targeted issues.

2. MATERIALS AND METHODS

2.1 Data Collection from Farmers

A comprehensive single-time survey was conducted using multi-stage cluster sampling method, in which two major cotton growing districts of Sindh, Pakistan i.e., Hyderabad and Tando Allahyar were selected. Both districts are rich with agricultural land and variety of crop cultivation. In next stage, ten villages were selected from each district, and five farmers were interviewed from each village (Table 1; Figure 1). Keeping in mind the specific objective (gathering perceptions of farmers), a descriptive research design was selected, and a cross-sectional data were gathered on a reliable and valid scale [21–25]. Information was collected via primary sources through interviewing method, where close ended questionnaire using 10-point Likert scale was used supposing the pronounced variation in farmers' perceptions [26]. Descriptive research was used for obtaining people's perceptions of social issues and social facts concerning with the status of phenomena, in which central tendencies and cross tabulation are calculated [22].

Table 1. GPS coordinates various villages of Hyderabad and Tando Allahyar Sindh, Pakistan.

District	Union Council (UC)	Village	GPS		Respondents
			Latitude	Longitude	
Hyderabad	Moosa Khatyan	Imam Bux Pusio @ Pasha farm	N 25°27'33.453"	E 68°32'05.882"	5
		Muhammad Bachal Gopang	N 25°26'49.312"	E 68°32'10.381"	5
		Abu Talib Sipio	N 25°27'55.433"	E 68°31'05.432"	5
		Moosa Khatyan	N 25°28'11.455"	E 68°31'19.362"	5
		Mureed Sipio	N 25°28'56.294"	E 68°30'18.239"	5
	Shahpur @ Arif Khatyan	Arif Khatyan	N 25°28'46.567"	E 68°33'27.262"	5
		Suleman Khan Khatyan	N 25°28'16.607"	E 68°32'18.905"	5
		Allah Dino Sandh	N 25°29'54.390"	E 68°31'45.355"	5
	Tandojam	Noor Khan Lashari	N 25°26'23.959"	E 68°32'03.637"	5
		Piyaro Khan Behan	N 25°26'48.725"	E 68°32'47.318"	5
Tando Allahyar	Shah Inayat	Tando Soomro @ Qazi A. Majeed	N 25°30'46.627"	E 68°40'09.261"	5
	Dasori	Jhando Mari @ Piyaro Lund	N 25°35'32.647"	E 68°41'43.081"	5
	Missan Wadi	Shadiyoon Walhar	N 25°23'33.739"	E 68°52'55.562"	5
	Purani Mirabad	Mirabad	N 25°38'54.459"	E 68°40'52.635"	5
	Tajpur	Jam Samo, Kisana Mori	N 25°27'53.643"	E 68°34'16.469"	5
	Nasarpur	Abdul Rouf Kakepoto	N 25°30'07.748"	E 68°37'31.507"	5
	Shahpur Rizvi	Shaikh Moosa Khabar Chachar	N 25°32'20.974"	E 68°43'30.441"	5
	Sawan Khan Gopang	Darya Khan Nahyoon	N 25°23'33.918"	E 68°43'55.038"	5
	Khokhar	Bukera Sharif, Darya Khan Masak	N 25°21'53.801"	E 68°39'17.908"	5
	Tando Allahyar	Dhingano Bozdar	N 25°26'17.022"	E 68°39'12.390"	5
2 Districts	13 UCs	20 Villages	-	-	100

2.2 Data Analysis

The collected data were subjected to statistical analysis software SPSS-21 for descriptive analysis to access the knowledge, approach, and practical nature of farmers in preparing the insecticide solution.

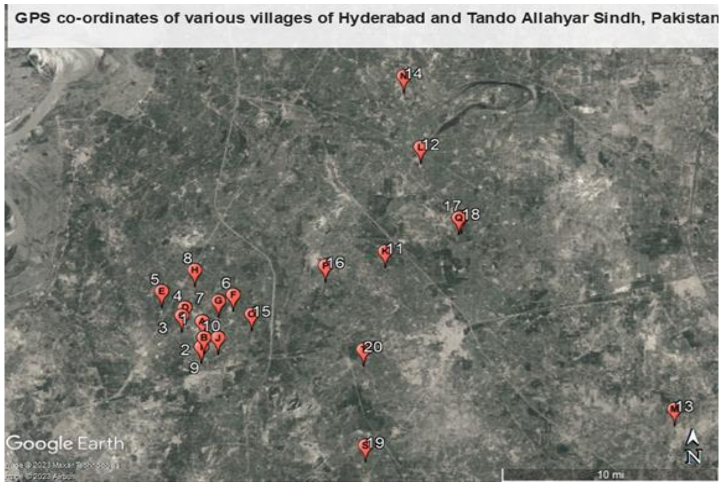

Fig. 1. GPS co-ordinates (landmarks) of various villages of Hyderabad and Tando Allahyar Sindh, Pakistan.

The present research focused on the district Hyderabad and Tando Allahyar because both districts are also well-known in cotton production, where cotton is grown over 72,894 acres. Likewise, local farmers consume a big proportion of pesticides to save their cotton crop from various insect pests. Hence, using purposive sampling method [25], one hundred cotton growers were approached, and multi-stage cluster sampling method was used to reach at respondents. For this purpose, total fifteen union councils from both districts were selected, followed by twenty villages were visited to collect data from one hundred farmers/respondents. In this regard, the researchers employed KAP (Knowledge, Attitude and Practice) method to know the levels [26, 27], yet the procedure (KAP Assessment) is quite common for perception-based studies in public health discipline [27, 28] but rarely considered for agricultural studies. The data collected using KAP scale is not only beneficial to identify the respondents' knowledge, but their behavior could easily be segregated for future implications [29].

To the best of researchers' knowledge, the issue (water quality used for insecticide mixture) has not been attempted by any other researcher, however, few related articles [30, 26] were reviewed that were on herbicide spray mixture. In addition, some companies' brochures also supported and guided to develop and finalize questionnaire for this research. Ten-point Likert scale (1 = Nil to 10 = Excellent) was decided to perceive the perceptions of the respondents. After questionnaire was developed, it was translated into Sindhi language in order to make the data collection process easier and comprehensive. The respondents for this study were confined to the farmers those were making pesticide mixture and applying to their crops.

Validity and reliability of data are the most important steps in scientific research. Without considering these steps, generalization and prediction cannot be achieved which is the rudimentary target of scientific research. As far as the content and validity of the questionnaire (scale) is concerned, the validity was ensured through Confirmatory Factor Analysis (CFA), because CFA is a satisfactory tool to establish validity of a scale [31], where factor loadings of items ≥ 0.40 are acceptable if items are in lesser quantity [32].

The AMOS software was used to know confirmatory Factor Analysis (CFA) through Average Variance Extraction (AVE) and found that Knowledge (AVE = 0.59), Attitude (AVE = 0.59) and Practice (AVE = 0.54) were valid to a greater extent [33], where four items in each variable were recorded valid (Figures 2, 3 and 4) through quantified analysis.

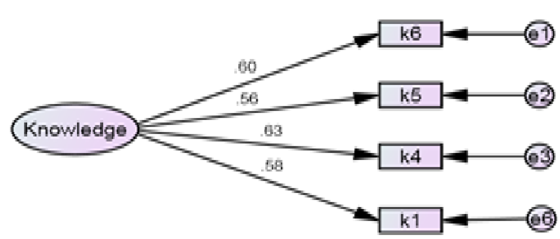

Fig. 2. Knowledge level of farmers regarding the use of water in insecticide application.

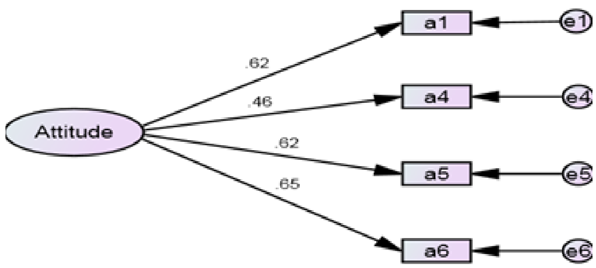

Fig. 3. Attitude of farmers regarding the use of water in insecticide application.

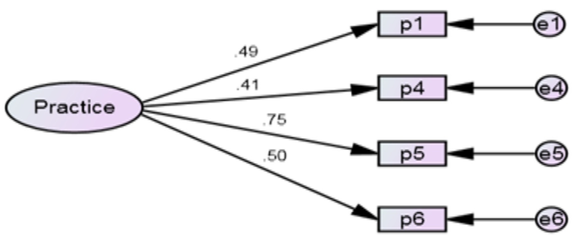

Fig. 4. Practice of farmers regarding the use of water in insecticide application.

The four items which were found valid includes: water and pesticide ration; temperature of water and timing of the spray; nozzle size or type with pesticides sprayed; and related pesticides used for the spray. However, two main questions concerning to water quality to prepare spray solution were identified as invalid by the software because of extreme variations in responses, therefore eliminated for final analysis. Cronbach's alpha technique was applied to confirm the reliability of the instruments by inserting initially twenty-five questionnaires [33] into SPSS [4]. The acceptable Cronbach's Alpha value varies from 0.70 to 0.99, while less than 0.7 is viewed as questionable. The concepts/variables' reliability was estimated, and results found accordingly as described in (Table 2).

Table 2. Reliability of the constructs.

Appendix	Concept/ Variable	No. of Items	Rank	Cronbach's *Alpha*
I	Knowledge	4	Good	.811
II	Attitude	4	Excellent	.915
III	Practice	4	Good	.853

3. RESULTS AND DISCUSSION

Table 3 shares the demographic information of the respondents, which shows that the majority (mode) of the respondents were of the age of 46 years,

Table 3. Demographic information.

	Mean	Maximum	SD	Mode
Age of the farmers (years)	39.74	58	11.108	46
Farming experience (Years)	18.80	43	10.345	15
Status of respon-dents	Farmers (*Haari*)		74%	
Education	Illiterate		54%	

where average age of the respondents was almost 40 years, however one among them was aged 58 years. The result also indicated that the majority of the respondents were well-matured and averagely they spent 19 years with agricultural profession. Moreover, less than three fourth (74%) respondents were farmers (haari) and had direct relationship with crop management and one could easily rely upon the perceived related (crop management) practical information. Yet, more than simple majority (54%) of the respondents were illiterate, therefore the researchers were not expecting any progression from them, where they were commonly using their previous experience and traditional methods for crop management.

Table 4 indicates about the crop cultivation trend of the respondents, which shows the worth of cotton crops by the local farmers in the study area. According to survey results, average 24.07 acres out of 29.51 acres of land was used during the year 2019 for cotton cultivation which refers the priority or common practice to grow cotton crop in summer season. However, only an average 1.28 acres agricultural land remained fallow due to variety of reasons, which included water logging and salinity area of 1.07 acres, conflicts, etc. Some farmers also

Table 4. Cotton crop cultivation trend among the selected respondents.

Area (In acres)	Mean	SE	SD	Mode
Total land	29.51	4.865	46.457	10
Cotton culti-vated area	24.07	4.590	45.898	8
Fallow land	1.28	0.193	1.928	1
Water logging and salinity	1.07	0.026	0.256	1
Area for other crops	1.19	0.176	1.764	1

responded that they have domestic animals to feed therefore at least 1.19 acres normally allocate for fodder crop.

The information given in Table 5 revealed that an overwhelming majority (92%) of the respondents preferably use underground water to make insecticide mixture for spraying, whereas only 3% farmers confirmed that they tested their irrigation water used in their fields. Moreover, an informal discussion with the farmers during survey also disclosed, normally water quality is fixed by its taste. A significant majority of the respondents generally prefer underground water for spray because underground water is crystal clear, which does not interrupt/block the nozzle, resultantly the process saves their time and also avoid bothersome, and more importantly, the underground water is easily available round the year. It was also shared by the simple majority (51%) of the respondents/ cotton growers that usually they could not achieve desired results, and out of them almost three fourth majority (38 farmers) of the respondents blamed the companies in response to failure of any insecticide. While the related literature concludes that a number of factors are involved in failure or lessening the pesticides' efficacy in controlling pest problems. In this regard, insect resistance is also considered a huge issue these days by the many research studies [34 – 37], yet some of the researchers are of the opinion that the mishandling, improper calibration, and selection of incorrect pesticides could also contribute as significant causes behind pesticides ineffectiveness. Therefore, the general opinion of farmers, researchers and institutional representatives related to insecticide incompetency are quite diverse and somehow complicated.

Table 5. Water quality and performance of pesticides.

	Total farmers	Frequency	%
Using underground water for pesticide mixture	100	92	92
Water was tested	100	3	3
Often fail to achieve desired results of pesticides	100	51	51
Blaming pesticides for inefficiency	51	38	74.51
Spray frequency for cotton crop	M=5.34; SD=1.32	Mode=6	Max.=16

It was also disclosed that local farmers normally do 5 to 6 sprays of various pesticides on cotton crop to achieve a reasonable pest control to maximize its production [35]. Moreover, studies also suggested that in Pakistan around 80% of total pesticides used in the country are sprayed on cotton [37], showing an upward trend by 11.69 % in last two decades, where the number of sprays has reached to fifteen with an average of nine [37]. Therefore, in continuity of the same one farmer in the study area also claimed that he sprayed sixteen times to his cotton crop to achieve a maximum output, however, the researchers agree to eliminate that figure (16 sprays) before final analysis because it could disturb the whole mean value.

Table 6 explains the results regarding farmers' knowledge, attitude and practice related to the impact of different water features on the performance of pesticides to spray. The results show a logical description in which 'knowledge' remained bit higher as compared to 'attitude' and 'practice.' However, respondents' knowledge in relation to importance of water for making pesticide mixture was quite rudimentary (M = 3.44, SD = 0.68), as some of the farmers responded amazingly against the water quality questions that "is there any effect of water quality on a pesticide performance?". In addition, the majority of the respondents' educational level (illiterate) was also evident that the selected farmers could have quite a little knowledge on the issue. Neither they receive any directions from their landlords about the caring of water quality nor any governmental or non-governmental organization guided them about the acceptable features of water to make a pesticide mixture for achieving desired results. However, farmers must be aware about optimum quality of water while making a pesticide mixture because substandard water may potentially bring adverse impact on the performance of pesticides [7]. In this regard, any variation in water hardness, pH, turbidity, and temperature may contribute negatively on the performance of synthetic pesticides [9, 13, 14, 38]. For example, water having pH greater than 7 may cause chemical degradation of certain pesticides in the presence of ions. The rate of alkaline hydrolysis is enhanced as the pH increases on the other hand, for most of the insecticides favor to use water with pH only ranging from 4 to 7 for preparation of spray mixture [15, 38].

Table 6. Cotton farmers' perception about water quality to make a pesticide mixture using KAP scale.

KAP Scale	Items	Mean	St. Deviation
Knowledge	4	3.4417	0.68591
Attitude	4	3.1710	1.2580
Practice	4	3.0683	0.81184

Since, knowledge makes attitude, the lesser the knowledge may be predicted as the lower the attitude to adopt a certain thing. An attitude is a settled way of thinking or feeling about something that may brought from having knowledge. Results described in (Table 5) divulges the same situation where 'attitude' of the respondents representing their knowledge level about the matter and recorded (M = 3.17, SD = 1.25) again at lower level. Followed by the behavior of the respondents in shape of 'practice' were perceived concerning to water features for pesticide mixture and results (M = 3.06, SD = 0.81) indicates that only a few farmers do care about the water features while making a pesticide mixture; however, there is no such practice (caring about water quality for pesticide mixture) being implemented in the study area. Neither from governmental personnel nor from pesticide companies guide them about the matter. Hence, a significant majority of the respondents were of the opinion that it is wastage of time caring about water features. If the water taste is acceptable it is fit for all purposes to use. However, most of the scholars believe that before applying pesticides to the crops, the farmers need to adopt all the significant measures, but water quality has always been ignored by a significant majority of the farmers [15]. The pH of the carrier water or spray solution can impact significantly on insecticide efficacy. The variation in pH of solution may lead to hydrolysis and organophosphate (acephate and chlorpyrifos), carbamate (methiocarb), and pyrethroid (bifenthrin, cyfluthrin, and fluvalinate) undergo alkaline hydrolysis in the presence of alkaline water. Moreover, the half-life of many insecticides can also be affected with the variation in pH of solvent or spray mixture [16].

4. CONCLUSIONS

Most of the farmers in Sindh use underground water for pesticide mixture, however, they seldom test it before the application because, apparently, it looks clear without any impurities. Most farmers were also unaware of water quality standards for the pesticide mixture, hence their effectiveness on their performance. Generally, 5–6 sprays are made in cotton as pesticide companies are mostly blamed if the farmer fails to get desired results. Therefore, it is suggested to take appropriate measures to aware farmers regarding water quality parameters to get optimum pesticide effectiveness, which could help in reducing pesticide hazards to humans and their environment.

5. CONFLICT OF INTEREST

The authors declare no conflict of interest.

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