



ADOPTION AND ECONOMIC EVALUATION OF UAF FERTILIZER PREDICTION MODEL UNDER IMPROVING SOIL FERTILITY PROJECT, ICARDA

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ABSTRACT

It is widely recognized that by balancing the present use of N (Nitrogen) and P (Phosphorous), the yields of important crops in Pakistan can be increased from twenty five to forty five percent. University of Agriculture, Faisalabad has developed Fertilizer Prediction Models that can be used to predict the exact quantity of N and P for the desired yield of major crops on the basis of soil test values of the specific field. These models were validated and disseminated under the project titled "Improving Soil Fertility and Soil Health in Pakistan Through Demonstration and Dissemination of Best Management Practices for Farmers" from 2014-18. The particular aspect of the model investigated through the present research was disseminated by Agricultural Service Providers (ASPs) in three villages viz; 81 JB Pansera, 109 JB Jarawala and 411 GB Tandailiawala of Faisalabad district. The basic objective of research was to quantify the economic benefits of fertilizer prediction model disseminated and implemented through ASPs in the selected villages. ASPs applied doses of fertilizers to selected farmers after soil tests in accordance with UAF fertilizer model in case of wheat crop. A primary data was collected through random sampling technique from 60 wheat growers including 10 adopters and 10 non adopters from each village. The data was analyzed by applying descriptive statistics in SPSS software. The survey results revealed that overall income gain from balanced use of fertilizer and higher yield of wheat crop was Rs. 4194.6 per acre. Further, the balanced use of fertilizers also helped in improving the fertility status of sampled farms. There was definitely increase in awareness and adoption intention of model among the farmers of selected villages after the project campaign. It is concluded that a continuous effort from public or private sector is required to adopt the UAF model by the farming community and reap maximum benefits from it.

Keywords: adoption, economic gains, fertilizer model, Pakistan, soil fertility

INTRODUCTION

The cultivated soils of the country are low in plant nutrients including nitrogen, phosphorous, potassium, sulphur, zinc, copper, iron and manganese. Further, the soil fertility status of the country is declining over time due to extensive agricultural practices and highly imbalanced use of fertilizers (Khan *et al.*, 2012; Rahim *et al.*, 2020). The fertilizers have become very costly input over time, therefore, the general recommendations of their use are outdated and not giving returns in comparison to the investment made. Consequently, it is need of time to apply the soil nutrients in proportional to the requirement of particular crop in a specific

soil for the desired yield. University of Agriculture, Faisalabad (UAF) has developed Fertilizer Prediction Models with the collaboration of data generated by Soil Fertility Research Institute (SFRI), Punjab. These models are available on the website: www.fertilizeruaf.pk (Rashid, 2016).

These models can be used to calculate the exact quantity of Nitrogen (N) and Phosphorous (P) of specific crop for the desired yield on the basis of soil test values of Phosphorous and Organic Matter of the particular field. These models were validated through field trials on wheat, cotton, rice and sugarcane in the leading districts of Punjab province under first phase of the project entitled "Improving Soil Fertility and Soil Health in Pakistan through Demonstration and Dissemination of Best Management

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Practices for Farmers”. This project was implemented through International Centre for Agricultural Research in Dry Areas (ICARDA). The basic objective of the said project was to disseminate the promising soil related technologies to the farmers which will improve soil fertility and soil health in addition to improvement in crop yield (ICARDA, n.d.). Fertilizer prediction models proved highly reliable to predict the exact quantity of N and P for the desired yield. Then in the second phase of the project, these fertilizer prediction models were disseminated among the end users through different means including print media, electronic media, Information and Communications Technologies (ICT) and agricultural service providers (ASPs).

The system of predicting the yield with proper recommendations of required fertilizer use based on soil parameters of land is an emerging field of research (Bhanumathi, 2019). Machine learning is a well-established technique that has shown their merits in a wide range of application domains (Kolli *et al.*, 2021). The target yield innovation was historically the concept of (Ramamoorthy *et al.*, 1967). It was later modified by Kanwar 1971 (Mazumdar *et al.*, 2018). There are varieties of machine operating technologies invented and evaluated by researchers in the world for agriculture field and other disciplines (Kumar *et al.*, 2021). This process of machine learning algorithms involves predictive analysis of historical data. Many steps are part of it from cleaning of raw data to its evaluation. Thus, this machine learning algorithms will help to forecast yield with more accuracy (Patil and Sarswarthi, 2020). Presently, extracting useful information from raw data is necessary to take effective decisions in different fields including agriculture for maximizing the overall benefits (Hassan, 2018). There is limited research work carried out with respect to data mining in Pakistan. Hence, it is imperative to undertake research on adoption and efficiency of these models developed for various fields in Pakistan. Keeping all this in view, social sciences team from PARC carried research on the particular aspect of UAF fertilizer prediction model disseminated by Agricultural Service Providers (ASPs) in three villages viz; 81 JB Pansera, 109 JB Jarawala and 411 GB Tandailiawala of Faisalabad district in 2018. The research in hand primarily focused on the economic benefits of fertilizer prediction model disseminated and implemented through ASPs in wheat crop in the above-mentioned

villages. The specific objectives of research are as under:

Objectives

- To undertake economic analysis of UAF fertilizer prediction model in the selected villages of Faisalabad in case of wheat crop
- To document the awareness and adoption of UAF fertilizer model among the farmers in the selected villages of Faisalabad
- To suggest measures for improving the soil fertility, soil health and productivity of crops in the light of UAF fertilizer model

METHODOLOGY

A research paradigm guides a researcher in considering, analysing and interpreting a situation (Creswell 2009; Morgan 2007). The current research was carried in three villages viz; 81 JB Pansira, 109 JB Jarawala and 411 GB Tandailiawala of Faisalabad district where the farmers’ were guided through Agricultural Service Providers (ASPs) about the use of UAF fertilizer model. The respondents were divided into two categories i.e., adopters (who adopted the model) and non-adopters (who did not adopt the model). The study was based on primary data collected from 60 wheat growers through structured questionnaire by direct interview method. Further, twenty respondents including 10 adopters and 10 non adopters from each village were interviewed. A random sampling technique was used to select the sample size. Initially the list of growers acquainted with UAF model was prepared and then out of that list adopters and non-adopters farmers were interviewed randomly. The final distribution of sample size is given in (Table 1).

Table 1. Distribution of sampled respondents

Farmers' Categories	Villages of Faisalabad district			All
	81 JB	109 JB	411 GB	
Adopters (No.)	10 (50)*	10 (50)	10 (50)	30 (50)
Non adopters (No.)	10 (50)	10 (50)	10 (50)	30 (50)
All	20 (100)	20 (100)	20 (100)	60 (100)

* Figures in the parenthesis show percentages

The data collected was edited, entered and analyzed using SPSS software. The data was analyzed using descriptive statistics involving percentages, averages, mean values and cross-tabulation.

RESULTS AND DISCUSSION

This section describes the results of the survey in detail.

Farmers' personal and Farm related characteristics

Farmers' personal and farm related characteristics are important from the point of view of adoption of technologies (Mahmood, 2017). The survey results revealed that average education of respondents on overall basis was about 09 years. The education level of farmers was quite high as it was expected due to high literacy rate (61%) in rural areas of Faisalabad district (GoP, 2017). There was no much difference in education level across farm size categories. The respondents were quite experienced and had about 19 years of farming experience on overall basis. The survey results revealed that a very high percentage of the respondents (84%) on overall basis did not undergo analysis of their soil despite of facility available at district level. However, it is emphasized that soil analysis is critical for accurate fertilizer application and for increased crop income (Government of Punjab, 2017). The details of respondents' personal and farm related characteristics are given in (Table 2).

Table 2. Personal and farm related characteristics of sampled respondents

Items	Farmers' Categories		All
	Adopters	Non-Adopters	
Age (Years)	48.4	41.5	46.9
Education (Years)	09	9.5	9.1
Farming Experience(Years)	18.6	22	19.3
Operational Area (Acres)	25.4	16	23.8
Wheat area sown as per UAF model (Acres)	6.3	-	6.3
Source of Irrigation	%		
Canal	-	16.7	3.7
Canal + Tube well	85.7	83.3	85.2
Tube well	14.3	-	11.1
Undergone Soil Analysis by himself	%		
Yes	20	-	16
No	80	100	84

Economic evaluation of fertilizer use- ASPs Plot Vs. conventional

ASPs on an average recommended 1.4 bags of urea and 0.9 bag of DAP for the desired yield of wheat while farmers' previous practice was on an average 1.3 bags of urea and 1.1 bags of DAP per acre based on their indigenous knowledge. So, Through ASPs farmers were using less fertilizer and saved 0.1 bag per acre on overall basis. This had led to a saving of Rs. 714 per acre. All the above and further narration is given in (Table 3).

Table 3. Economic evaluation of fertilizer's use - conventional VS ASP's Plot

Fertilizers	ASP-recommended doses (Bags/ac)	Unit Price (Rs.)	Total cost (Rs/ac)	Conventional doses (Bags/ac)	Unit Price (Rs.)	Total cost (Rs/ac)
Urea	1.4	1413.3	1978.6	1.3	1411.1	1834.4
DAP	0.9	2740	2466	1.1	3022.2	3324.4
Total	2.3	-	4444.6	2.4	-	5158.8
Quantity saved through balanced use of fertilizers= 0.1 bag/acre				Amount saved through balanced use of fertilizers = Rs/ac 714.2		

Economic gains from the balanced use of fertilizer

Economic gains from use of balanced fertilizer through UAF fertilizer prediction model is given in (Table 4). The adopters got higher yield of about 2.8 mds per acre as compared to non-adopters. Similarly, adopters managed save income Rs. 3480.4 per acre through balanced use of fertilizers. Overall income gain from balanced use of fertilizer and higher yield was Rs. 4194.6 per acre. It was also to be kept in mind that wheat yield was less this year due to climatic conditions and less availability of canal water. Patil *et al.*, 2020 also found similar results regarding the prediction of the doses of fertilizers for the desired yield using machine learning algorithms. Earlier, Chilingaryan *et al.* (2018) also endorsed the above facts in his research and concluded that the fast developments in sensing technologies and machine learning techniques provides cost-effective and complete answers for improved crop estimation and decision making.

Table 4. Income gain from balanced use of fertilizers

Items	Adopter	Non-adopter	All
Yield (mds/ac)	33.6	30.8	33
Price (Rs/md)	1218.8	1216.6	1218.3
Total income (Rs./ac)	40951.6	37471.2	40203.9
Income gain from balanced use of fertilizer Rs/acre= 3480.4			-

Overall income gain from the use of UAF fertilizer prediction model Rs/acre= 714.2+3480.4= 4194.6

Farmers' response about technology related characteristics

Farmers were also asked about their awareness about technology before project campaign and after project campaign. Their response was given in the following Figure 1 and 2. About 96% of the farmers were not aware of the technology before project campaign. The project campaign in selected villages had increased awareness

level of farmers. About 29% farmers were fully aware of technology while 42% were partially aware of technology. About 91% of farmers recognized that technology was suitable and economically beneficial for that area as depicted in Figure 3. This technology involves the use of internet and it was found that 17% of the farmers' or their family members can use internet as given in Figure 4.

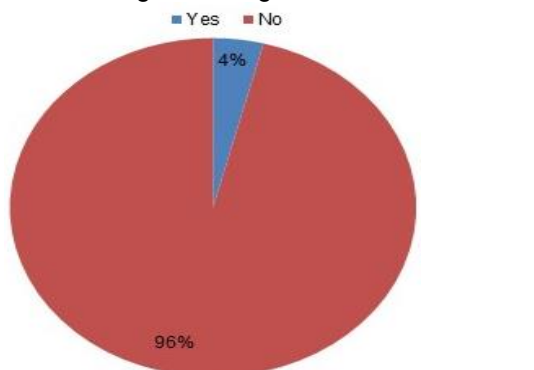


Figure 1. Awareness about technology before project campaign

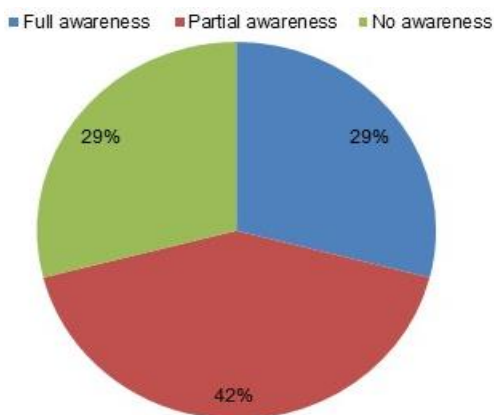


Figure 2. Awareness about technology before project campaign



Figure 3. Usefulness of technology for the area

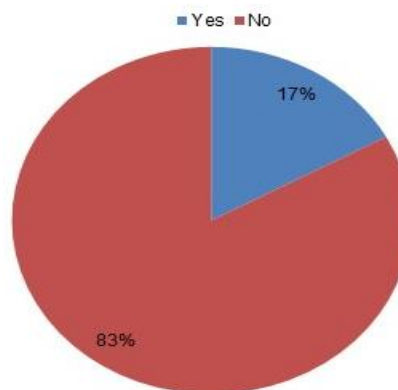


Figure 4. Internet Use

CONCLUSION AND RECOMMENDATIONS

It is the need of time that the nutrients are to be used in the quantity and proportion in which these are required by specific crop in a specific soil for the specific yield. Recognizing this fact, University of Agriculture, Faisalabad has developed fertilizer prediction models in collaboration with Agriculture Department, Punjab which are available on the website www.fertilizeruaf.pk. Presently, soil health, cost of production and yield of crops are among the important areas of concern for the agriculture sector of the country. All these important aspects which affect the farmers and ultimately agricultural economy are tried to be resolved through UAF fertilizer prediction models.

In short, the farmers were not only able to improve soil health, reduced cost of production in case of wheat crop through balanced use of fertilizers and also got higher yield with application of this model. It was estimated that the overall net income gain from balanced use of fertilizer and higher yield was Rs.4194.6 per acre. It was also to be kept in mind that wheat yield was lower in the area due to unfavorable climatic conditions and shortage of canal irrigation water in the study year.

There was rise in awareness, diffusion and adoption of this very model among the farming community of selected villages after the project campaign. ASPs and progressive farmers may guide the other farmers regarding the use of UAF model after the completion of project. However, the farming community on the whole does need continuous support from university or any other organization in order to use the model successfully and take full advantage of it.

It is worth researching to undertake work in terms of all mediums of dissemination (electronic, print, field demonstration, ICT etc.)

used for UAF Fertilizer model under ICARDA project in Punjab (Pakistan). However, due to limited manpower and shortage of time makes it difficult. Moreover, the future research evaluating all sources of dissemination of fertilizer prediction models application will help to assess the efficiency of this model with more accuracy. Also, future research work related to its awareness and adoption in the field will provide useful insight about the feat of UAF fertilizer prediction models.

AUTHOR'S CONTRIBUTION

M. A. Mahmood: Conceived the idea, collected data and finalized the paper

R. Saeed: Data collection and analysis

A. Bashir: Helped in write up of paper

I. Mahmood: Helped in results and discussion part of paper

W. Akhtar: Proof read the manuscript

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