Research Article

The Mastery of Extension Field Staff (EFS): Unveiling Their Expertise in Crop Management Practices

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Abstract | The Crop management practices play a crucial role in ensuring successful agricultural outcomes, including yield optimization, disease prevention and sustainable farming. This research aims to investigate the expertise of Extension Field Staff (EFS) in applying diverse crop management practices. The current research study was conducted in four agro-ecological zones of Khyber Pakhtunkhwa, in which one district each was selected. A sample of 147 respondents were selected from the four districts of Khyber Pakhtunkhwa using the Sekaran sampling table whereas proportional allocation technique was also used to obtain the desire sample size from each district. The findings indicated that the majority of the respondents were in the "51-60" age group, with 79.5% holding a diploma as their highest qualification and having more than 21 years of experience in the relevant field. The study identifies limited knowledge and skills, market access and limited resources as major challenges in implementing crop management practices. The results of a regression analysis also stated that age, years of experience and field of specialization significantly influence expertise in crop management, while the impact of education is practically negligible. It is concluded that the expertise of EFS in crop management significantly improves agricultural productivity and promotes sustainable farming techniques by sharing knowledge and providing on-ground assistance to encourage farmers' adoption of advanced crop management practices. To further enhance the impact of EFS in crop management practices, it is recommended that agricultural organizations and governing bodies may invest in continuous training and professional development programs. These initiatives should aim to update EFS on the latest innovations in agricultural technology, sustainable farming methods and climate-resilient practices.

Received | July 31, 2023; **Accepted** | January 26, 2024; **Published** | May 30, 2024
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Citation | Shehzad, K. and I. Haq. 2024. The mastery of extension field staff (EFS): Unveiling their expertise in crop management practices. *Sarhad Journal of Agriculture,* 40(2): 562-569.
DOI | https://dx.doi.org/10.17582/journal.sja/2024/40.2.562.569
Keywords | Crop management practices, Extension field staff, Agro-ecological zones, Khyber Pakhtunkhwa

Introduction

Agriculture is one of the major industries in the whole world as 60% people in the world are depending on it (Dethier and Effenberger, 2012). Developing countries' poverty can be reduced by enhancing agriculture which increase the income and food quality of the world's 80% poor people living

in villages, depending mainly on agricultural sector (FAO, 2019). The economy of Pakistan is heavily dependent upon agriculture like other developing countries. This sector contributes 22.7% in the entire GDP of the country and is a source of livelihood for 43.5 % of the rural population (GoP, 2022).

Effective crop management practices are paramount for agricultural productivity, sustainability, and profitability. Extension Field Staff (EFS) serve as crucial facilitators in this process, acting as vital agents in disseminating knowledge and providing guidance to farmers. Beyond bridging the gap between research and practical application, EFS conduct on-farm demonstrations, workshops and training programs, promoting the adoption of modern techniques and sustainable farming methods (Mustafa, 2018). Their role encompasses not only the dissemination of information but also includes providing timely insights on weather patterns, market trends, and emerging challenges (Muhammad *et al*., 2020). Through collaboration with farmers and experts, EFS contribute to the continuous refinement of crop management practices, ensuring the adoption of resilient varieties and technology-driven solutions to address evolving agricultural needs. Overall, the pivotal role of Extension Field Staff is indispensable in optimizing crop yields, promoting sustainability, and enhancing the profitability of agricultural enterprises. Crop management practices play a critical role in agricultural productivity, sustainability and profitability (Ali *et al*., 2019). Effective crop management requires a deep understanding of various techniques and strategies to optimize crop growth, prevent diseases and pests, manage soil fertility, and implement sustainable irrigation practices (Haq *et al*., 2021). Extension Field Staff (EFS) are vital agents in disseminating knowledge and providing guidance to farmers, helping them adopt and implement these crop management practices effectively (Agyei *et al*., 2021).

The extension serves not only as a bridge but also enhances the efficiency and effectiveness of both farmers and research. It facilitates the smooth transfer of agricultural technologies among farmers, contributing to improved practices and knowledge dissemination (Ali *et al*., 2012). The expertise of EFS personnel is crucial in ensuring the successful implementation of crop management practices at the ground level. Their knowledge, skills and experiences directly influence the adoption and effectiveness of these practices among farmers (Mossie and Belete, 2015). By unveiling the knowledge of EFS in diverse crop management practices there is need to identify the areas of strength and those areas which require further development, ultimately enhancing the effectiveness of agricultural extension services and improving overall farm productivity (Ashraf *et al*., 2009).

The importance of understanding the expertise of Extension Field Staff (EFS) personnel in various crop management practices, such as pest and disease management, soil fertility management, irrigation practices, and crop rotation. However, it lacks specific details on the depth of knowledge in each area, the quantifiable metrics for assessing their proficiency and examples of successful sustainable and profitable crop management strategies they have facilitated (Muhammad *et al*., 2023). Additionally, the duration and continuity of knowledge transfer programs, the specific challenges faced by farmers, and the integration of new agricultural technologies by EFS personnel remain unaddressed (Padgitt *et al*., 2001). A more comprehensive discussion could benefit from providing clarity on these aspects, enabling a more thorough evaluation of the effectiveness of knowledge transfer and extension programs in equipping EFS personnel to support farmers in implementing sustainable practices (Alemu *et al*., 2018).

Objectives of the study

1. Identify the key skills and knowledge areas required for effective crop management as exhibited by EFS.
2. Assess the level of expertise demonstrated by EFS in implementing various crop management techniques.
3. Explore the successful strategies employed by EFS in overcoming challenges and optimizing crop yields.

Materials and Methods

The present study was conducted in four different agro-ecological zones of Khyber Pakhtunkhwa to evaluate the expertise of EFS in crop management practices. By employing the Sekaran sampling table, a sample of 147 Extension Field Staff (EFS) were selected using proportional allocation technique across the four districts i.e. Abbottabad, Swabi, Dir

Upper and D. I. Khan. Considering a confidence level of 95% and a margin of error of 5%, a sample size of 147 respondents was determined. The proportional allocation technique was then applied to ensure that the sample represents the population adequately across the four districts. The data were collected from the EFS through a well-developed and pre-tested interview schedule. Furthermore, the data were analyzed using SPSS v.20. Descriptive statistics were employed for presenting the results, and regression analysis was also conducted.

Regression analysis

To perform regression analysis between the level of expertise in crop management and other variables such as experience, age, education and field of specialization. Regression analysis allows to examine how one or more independent variables relate to a dependent variable.

The multiple regression model for this analysis can be expressed as:

$$Y1 = \beta_0 + \beta_1 * X_1 + \beta_2 * X_2 + \beta_3 + \beta_4 * X_3 + \varepsilon$$

Where: Y_1 is the level of expertise in crop management (dependent variable); X_1 is the age (first independent variable); X_2 is the education level (second independent variable); X_3 is the years of experience (third independent variable). X_4 is the field of specialization (Fourth independent variable). β_0, β_1, β_2, β_3 and β_4 are the regression coefficients to be estimated. ε is the error term, representing the unexplained variability in Y_1.

Results and Discussion

In Table 1, the data presents the age distribution of the respondents as it is categorized into three groups i.e. Up to 30, 31-50, and 51-60 years. Out of the total respondents, 21% of the respondents fall into the age category Up to 30 years, indicating that a significant portion of the participants are relatively young. The 31-50 age group constitutes the largest part with 47% of the respondents, suggesting a considerable number of mid-career professionals. Meanwhile, the 51-60 age group represents 32% of the total respondents, indicating that there is a substantial representation of more experienced individuals in the study area. The results are similar to those of Alotaibi *et al.* (2021) who stated that most (46%) of the EFS respondents had age 31-50 years while 22% of them had above 51 years of age.

Table 1: *Demographic characteristics of extension field staff.*

Factors	Frequency	Percentage
Age (Years)		
Up to 30	31	21
31-50	69	47
51 – 60	47	32
Education		
Diploma	117	79.5
Associate degree	14	9.6
Bachelor's degree	6	4.2
Master's degree	8	5.4
Doctorate/Ph.D.	2	1.3
Experience		
< 10 Years	14	9.6
11-20 Years	57	38.7
21 years and above	76	51.7
Field of specialization		
Diploma in agriculture	131	89.1
Agricultural extension	8	5.4
Horticulture	3	2.1
Soil and environmental sciences	2	1.3
Plant breading and genetics	3	2.1

Education

This factor provides insights into the educational qualifications of the respondents. It is divided into five categories: Diploma, Associate Degree, Bachelor's Degree, Master's Degree, and Doctorate/Ph.D. The majority of respondents, 79.5%, have a Diploma as their highest qualification, indicating a significant proportion of participants have completed diploma-level education in the relevant field. The next most common qualification is an Associate Degree, with 9.6% of respondents, while Bachelor's and Master's Degrees represent 4.2% and 5.4% of respondents, respectively. The smallest group is those holding a Doctorate or Ph.D., comprising only 1.3% of the total respondents, suggesting a limited number of highly educated individuals in the study area Table 1.

Experience

This factor highlights the work experience of the respondents, categorized into three groups: < 10 Years, 11-20 Years, and 21 years and above. The data reveals that 9.6% of respondents have less than 10 years of

experience, indicating a relatively small proportion of entry-level professionals. A larger segment, 38.7%, falls within the 11-20 Years category, suggesting a considerable number of mid-career professionals mentioned in Table 1. Interestingly, the majority of respondents, 51.7%, possess 21 years or more of experience, indicating a significant representation of seasoned experts in the field. The results are similar to those of Ovharhe *et al*. (2020) who reported that majority (37%) of the respondents had 10-20 years of relevant experience.

Field of specialization

Furthermore, in Table 1, the factor sheds light on the specific areas of expertise of the respondents. It is divided into five categories: Diploma in Agriculture, Agricultural Extension, Horticulture, Soil and Environmental Sciences, and Plant Breeding and Genetics. The results with respect to field of specialization state that majority (89.1%) of the respondents had diploma in agriculture, this shows that EFS is mostly concerned with agricultural expertise and skills. Moreover, 5.4% had specialization in agricultural extension while 2.1% each of the respondents were specialized in horticulture and plant breeding and genetics. A few (1.3%) of them had specialization of soil and environmental sciences. From the results it is concluded that majority of the respondents are professionals with a background in agriculture, while only a few have chosen to focus on more specialized aspects of the agricultural sector. The results are similar to those of Ragasa *et al*. (2016) who reported that majority of the staff had diploma as their main specialization.

The data in Table 2 presents a comprehensive results of different management practices which includes their z-scores, mean value, standard deviations, and rank orders. From the findings it is revealed that soil fertility management appears as the top-performing practice with a z-score of 581, indicating a significantly higher mean score than the overall average of all practices. This reflects its highly rated status compared to others. With a mean score of 3.9, respondents have consistently given it a favorable rating. The low standard deviation of 1.369 indicates a high level of agreement among respondents on its effectiveness, leading to its top rank among all practices. Following closely in second place is irrigation and water management, with a Z-score of 570 and a mean score of 3.8, suggesting positive evaluations on average. Nutrient management ranks third among all practices, with a Z-score of 563 and a relatively high mean score of 3.79, indicating favorable ratings with little variability among respondents. The subsequent practices, namely harvest and post-harvest management, Integrated Pest Management (IPM), Disease Management, insect management and weed management practice, all receive positive evaluations with varying degrees of standard deviations, implying different levels of variability in respondents' opinions on their effectiveness. Crop-specific management practices and crop rotation and diversification rank ninth and tenth, respectively, reflecting moderate evaluations and variability in opinions among respondents for these practices.

Adapting crop management techniques to different crop type and varying environmental conditions involves considering the specific requirements and challenges of each crop and understanding the local environmental factors. Figure 1 presents the percentage distribution of various crop management techniques adapted by EFS respondents. The crop

Table 2: *Crop management techniques employed by EFS in the study area.*

Management practices	Z score	Mean	Standard deviation	Rank order
Soil fertility management	581	3.9	1.369	I
Irrigation and water management	570	3.8	1.083	II
Nutrient management	563	3.79	1.435	III
Harvest and post-harvest management	511	3.48	1.576	IV
Integrated pest management (IPM)	533	3.6	1.529	V
Disease management	510	3.46	1.589	VI
Insect management	499	3.39	1.633	VII
Weed management	476	3.2	1.646	VIII
Crop-specific management practices	437	2.97	1.674	IX
Crop rotation and diversification	416	2.8	1.617	X

Table 3: *Identified skills and knowledge areas of the extension field staff.*

Strengths	Areas for improvement
Interdisciplinary Knowledge	Emerging technologies
Strong foundation in agronomy, soil science etc.	Stay updated with precision agriculture and digital tools
Understanding of complex interactions in agriculture	Familiarity with remote sensing and data-driven methods
Data analysis and research skills	Climate change adaptation
Proficiency in data analysis and statistics	Address impacts of climate change on agriculture
Ability to collect and interpret data	Develop resilient cropping systems and practices
Practical field experience	Communication and extension
Hands-on experience in real-world settings	Enhance communication skills for knowledge transfer
Ability to troubleshoot and adapt approaches	Effective extension to promote sustainable practices
	Continuous learning and collaboration
	Stay updated with research and innovations
	Foster collaboration for knowledge sharing

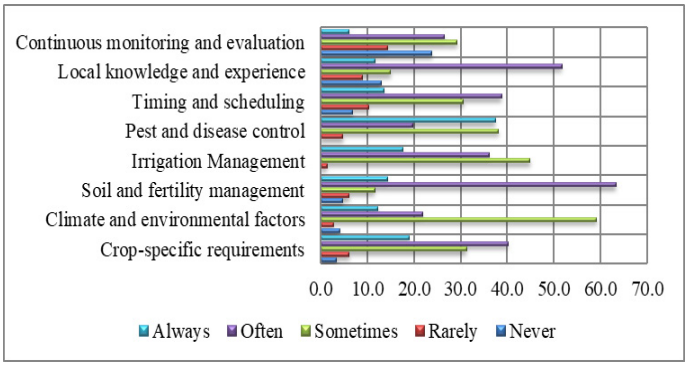

Figure 1: *Adapting crop management techniques.*

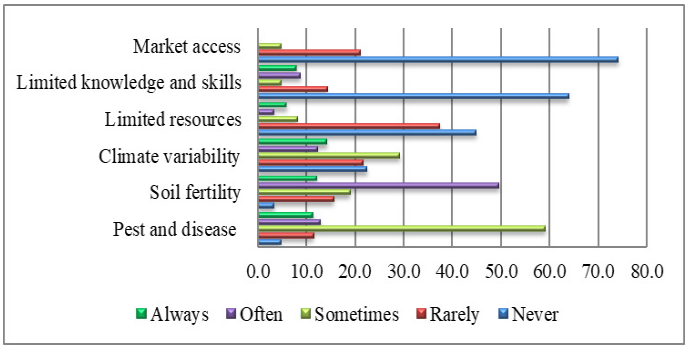

Figure 2: *Challenges faced by extension field staff in implementing crop management practices.*

management practices encompass diverse aspects such as crop-specific requirements, climate and environmental factors, soil and fertility management, irrigation management, pest and disease control, timing and scheduling, local knowledge and experience and continuous monitoring and evaluation. From the data, it is evident that some techniques are consistently considered in farming practices, with significant portions of respondents indicating they often or always take them into account. Notably, soil and fertility management, pest and disease control, and climate and environmental factors are given high priority, with more than half of the respondents expressing regular consideration. On the other hand, irrigation management and crop-specific requirements are frequently acknowledged as relevant aspects. These results highlight the significance of addressing the factors in agricultural planning and emphasize the importance of continuous monitoring and evaluation, as well as the utilization of local knowledge and experience, to optimize farming practices and ensure sustainable and productive agricultural outcomes.

Implementing crop management practices can involve a range of challenges i.e. pest and disease, soil fertility, climate variability, limited resources, limited knowledge and skills and market access. By understanding these challenges and developing appropriate strategies to address them, Extension Field Staff (EFS) can support farmers in implementing effective crop management practices and achieve better crop yields and can improve livelihoods. Figure 2 describe the percentage distribution of factors affecting the implementation of crop management practices. The percentages indicate the proportion of respondents who identified each challenge from never - always affecting their agricultural activities. From the data, it is evident that the most significant challenges faced by Extension Field Staff while implementing crop management practices are limited knowledge and skills, market access and Limited resources, with high percentages indicating they are often or always problematic. Climate variability and soil fertility also pose considerable challenges with responses ranging across the different levels of frequency. On the other hand, pest and disease are seen as a significant issue but tend to vary in its occurrence. This data provides

valuable insights into the key difficulties experienced by EFS, which can help policymakers, researchers and agricultural stakeholders address these challenges effectively and improve agricultural practices and productivity.

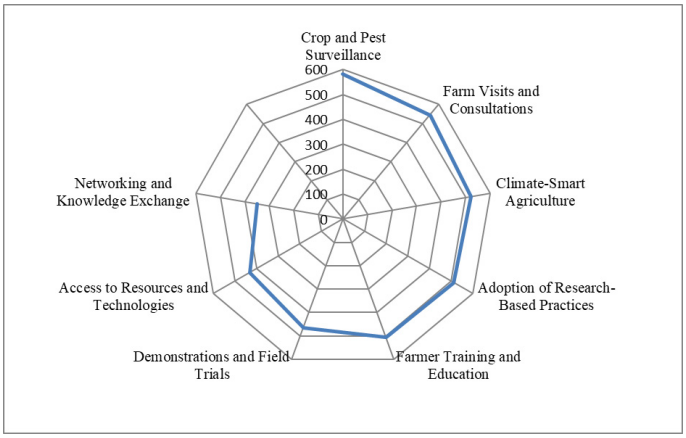

Figure 3: *Strategies made by EFS for overcoming the challenges.*

Figure 3 presents a comparison of different strategies for overcoming challenges, with each strategy ranked based on its Z-score. These scores help to evaluate the effectiveness and significance of each strategy in the given context. Crop and pest surveillance emerges as the top-performing strategy with a remarkably high Z-score of 582, reflecting its crucial role in overcoming challenges. Farm visits and consultations rank second, boasting a Z-score of 544 demonstrating their effectiveness, though with slightly more variability in opinions. Climate-smart agriculture ranked third with a Z-score of 521, indicating favorable recognition despite a slightly lower rating than the top two strategies. Adoption of research-based practices and farmer training and education follow in fourth and fifth place, respectively, showcasing their value in addressing challenges. Demonstrations and field trials, as well as access to resources and technologies, rank sixth and seventh, while networking and knowledge exchange settle in eighth place. Overall, these strategies play significant roles in addressing challenges, each with its specific level of effectiveness and recognition among respondents.

In Table 3 the results show that, EFS professionals possess a valuable blend of interdisciplinary knowledge and expertise in data analysis, complemented by hands-on experience in the field, which bolsters their proficiency in implementing sustainable agricultural practices. Their comprehensive understanding of agronomy, soil science, plant pathology, and environmental science equips them to grasp the intricate interactions within agricultural systems, facilitating effective plant health management, soil fertility, and environmental conservation. Moreover, their adeptness in data analysis enables them to make well-founded recommendations for pest and disease control, irrigation practices, and crop rotation, thereby fostering sustainable agricultural outcomes.

To further enhance their expertise, EFS personnel should actively embrace emerging agricultural technologies and digital tools, ensuring they stay up-to-date with precision agriculture techniques, remote sensing applications, and data-driven decision-making methods. Additionally, they should deepen their focus on climate change adaptation strategies, gaining insights into the climate-related impacts on pests, diseases, soil fertility, and water availability. Developing resilient cropping systems and practices becomes imperative in mitigating the challenges posed by climate change, contributing to sustainable agriculture amidst shifting climatic conditions.

Effective communication and extension skills are also areas where EFS personnel can improve. As pivotal knowledge facilitators, they can enhance their impact by skillfully conveying scientific information, recommendations, and best practices to diverse audiences, including farmers and stakeholders. Lastly, fostering a culture of continuous learning and collaboration within their community will enable EFS professionals to remain at the forefront of research and innovation, actively contributing to ongoing advancements in sustainable agricultural practices. By concentrating on these areas, EFS personnel can further strengthen their expertise and play a pivotal role in advancing sustainable agricultural development for the future.

Table 4: *Regression analysis of the demographic characteristics and level of expertise in crop management.*

Xi	Std. Error (b*)	Coefficient	p-value	95% confidence interval	
				Lower	Upper
Age	0.065	0.132	0.000***	-0.018	0.202
Education	0.00	0.203	0.001**	0.00	0.00
Years of experience	0.04	-0.312	0.012*	0.01	0.005
Field of specialization	0.003	0.260	0.004	0.003	0.016

*R^2= 0.638 Dependent Variable (Xi) = Predictor Variable ***, ** and *= Significant at 0.05*

Table 4 presents the results of a regression analysis

examining the relationship between demographic characteristics and the level of expertise in crop management (*Xi*). The analysis includes four independent variables: Age, Education, Years of Experience and Field of Specialization. The coefficient for Age is positive (0.065), indicating that as individuals get older, their level of expertise in crop management tends to increase. Education, however, has a coefficient very close to zero (0.00), implying that changes in education do not significantly impact the level of expertise. Years of Experience also show a positive coefficient (0.04), indicating that as individuals gain more experience, their level of expertise tends to increase. The field of specialization has a positive coefficient as well (0.003), suggesting that individuals with specialized knowledge in certain fields tend to have a slightly higher level of expertise. The R-squared value of 0.638 indicates that approximately 63.8% of the variability in the level of expertise can be explained by these demographic characteristics. In summary, age, years of experience and field of specialization significantly influence the level of expertise in crop management, while Education's impact is practically negligible.

Conclusions and Recommendations

From the results it is concluded that the Extension Field Staff (EFS) plays a crucial role in the successful implementation of crop management techniques. Their interdisciplinary expertise, proficiency in data analysis and practical field experience enable them to comprehend intricate agricultural systems and provide well-founded solutions. By effectively managing plant health, soil fertility and environmental factors, EFS personnel make significant contributions to sustainable agricultural outcomes. Furthermore, adaptive and embracing emerging agricultural technologies are vital for EFS personnel to stay well-informed of improvements. Continuous learning and promoting collaboration are vital in keeping EFS personnel well-informed and nurturing an innovative community.

To enhance the knowledge and proficiency of EFS in crop management techniques, it is strongly recommended to introduce a comprehensive system of frequent training sessions and workshops. This continuous learning approach is pivotal in empowering individuals to remain abreast of the latest developments in agriculture, enabling them to adopt cutting-edge practices in the field. Implement a feedback-based performance evaluation system for EFS personnel that will be crucial to ensure that their skills remain current and responsive to the evolving demands of farmers. This structured evaluation mechanism will not only serve as a barometer of their effectiveness but also as a catalyst for ongoing improvement. These recommendations will greatly boost the proficiency of EFS staff in crop management, leading to substantial benefits for farmers and agricultural communities. With enhanced knowledge and skills, EFS workers can offer informed and innovative guidance, contributing to overall improvements in agricultural practices and outcomes. Establishing a dynamic training and evaluation framework will be crucial for cultivating a sustainable and progressive agricultural ecosystem.

Acknowledgements

With profound gratitude, we acknowledge the invaluable contributions of the Extension Field Staff members and agricultural communities whose expertise and collaboration were indispensable in conducting this study on crop management practices.

Novelty Statement

This research aims to investigate the expertise of Extension Field Staff (EFS) in applying diverse crop management practices. The EFS have the better knowledge about different ICM practices, however, needs improvement in climate change adaptation and dissemination of new ICM practices to the farming community.

Author's Contribution

Kashif Shehzad: Principal author, who did research, analysis and wrote this manuscript.
Dr. Ikramul Haq: Supervised and provided guidance in the whole PhD.

Conflict of interest
The authors have declared no conflict of interest.

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