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LEVEL OF KNOWLEDGE IN THE MAIN DOMAINS OF AGRICULTURAL PRACTICES AMONG PEPPER FARMERS IN ZAKHO CITY

H. S. Murad

Department of Agricultural Extension and Rural Development, College of Agricultural Engineering Sciences, University of Dohuk, Iraq

***Correspondence to:** Dr. Hashim Saeed Murad, Department of Agricultural Extension and Rural Development, College of Agricultural Engineering Sciences, Dohuk University, Iraq.
Email: hashim.saeed@uod.ac

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Abstract

This research evaluated the level of knowledge among farmers on major agricultural practices domains in pepper growing and listing their relative importance in terms of service operations. A questionnaire was used to collect data on personal and other information from the research population of pepper farmers in Zakho city. The reliability coefficient was calculated through Cronbach's alpha and the data analyzed using several statistical methods, including frequencies, arithmetic mean, standard deviation, and the F and T tests. The results showed that most (49.4%) of the respondents were from the middle category, and that knowledge on the procedures for preparing the land for cultivation ranked highest among the farmers while the lowest was on pest and weed control. A significant correlation was noted between their knowledge on the main agricultural practices for pepper plants and the variables involved (age, sources of agricultural information), while no differences were seen in regard to educational level, main profession, source of income, type of ownership, and previous training. The research also includes several conclusions and recommendations.

Keywords: Knowledge level, Pepper farmers, Agricultural extension.

مستوى معارف المزارعين بالممارسات الزراعية لمحصول الفلفل في مدينة زاخو

هاشم سعيد مراد

قسم الارشاد الزراعي والتنمية الريفية، كلية علوم الهندسة الزراعية، جامعة دهوك

***المراسلة الى:** هاشم سعيد مراد، قسم الارشاد الزراعي والتنمية الريفية، كلية علوم الهندسة الزراعية، جامعة دهوك، العراق.

البريد الالكتروني: hashim.saeed@uod.ac

الخلاصة

استهدف البحث التعرف على مستوى معارف المزارعين بالممارسات الزراعية لمحصول الفلفل في مدينة زاخو وترتيب المجالات حسب أهميتها النسبية، ايجاد التباين في مستوى معرفة المزارعين بالممارسات الزراعية للفلفل حسب خصائصهم الشخصية الاتية (السن، المستوى التعليمي، المهنة الرئيسية، مصدر الدخل، نوع الملكية، مصادر المعلومات، التدريب السابق، عدد افراد الاسرة، الاستعداد للتغيير، كمية الانتاج بالطن، المهنة الرئيسية، التخصص في زراعة الفلفل، نوع العمل، نوع الآلات الزراعية، مساهمة الفلفل في الدخل، النشاطات الارشادية). وكذلك التعرف على مستوى معارفهم في مجالات (تهيئة الارض للزراعة، عمليات خدمة المحصول، عمليات ري المحصول، عملية تسميد المحصول، ومكافحة الآفات والادغال لنباتات الفلفل).

وشمل البحث جميع مزارعي محصول الفلفل في المنطقة المستهدفة والبالغ عددهم 100 مبحوثاً، وتم اختيار عينة عشوائية لاختيار الثبات. وقد تم إعداد استمارة استبيان خاصة لجمع بيانات هذه الدراسة، ولتحليل البيانات استخدم برنامج SPSS وباستخدام عدة وسائل إحصائية منها: التكرارات، والمتوسط الحسابي، والانحراف المعياري، التباين، F and T test وتحليل الانحدار المتعدد. وجُمعت البيانات بواسطة استمارة التي تضمنت خمسة مجالات لقياس مستوى معرفة المزارعين بالممارسات الزراعية الرئيسية لفلفل واشتمل كل مجال على عدد من الفقرات، وتم استخراج الصدق الظاهري للاستبيان وحساب معامل ثباتهِ بطريقة الفاكرونباخ التي بلغت 0.74. وأوضحت النتائج ان نسبة (49.4%) هي من الفئة المتوسطة. كما واظهرت النتائج أن أعلى مجال من مستوى معرفة المزارعين بالممارسات الزراعية الرئيسية لمحصول الفلفل هو مجال (اجراءات تهيئة الارض للزراعة) وأقل مجال لفلفل هو مجال (مكافحة الآفات والادغال لنباتات الفلفل). وكما انهُ توجد فروقات بين مستوى معرفة المزارعين بالممارسات الزراعية الرئيسية لنبات الفلفل وبين متغير (العمر، مصادر المعلومات الزراعية بينما لا توجد فروقات بين مستوى معرفة المزارعين وبين متغير المستوى التعليمي، المهنة الرئيسية، مصدر الدخل، نوع الملكية، التدريب السابق) كما اشتمل البحث على عدد من استنتاجات وتوصيات.

كلمات مفتاحية: المستوى المعرفي، مزارعي الفلفل، الارشاد الزراعي.

Introduction

Agriculture is a major pillar contributing to the development of countries due to its important position in their national economies and its direct impact on food security, rural development and in achieving economic, social and civilizational transformation (4).

The level of farmers' knowledge on pepper plant service operations in the city of Zakho is crucial for the success of their farming activities. Farmers in Zakho can benefit from a range of agricultural practices and techniques to improve their pepper plant service operations. Agricultural extension programs can play a significant role in enhancing their knowledge of these practices and techniques (22). Based on search results, such programs can provide farmers with technical advice and information on various aspects of pepper plant management, such as pest control, irrigation, soil management, and harvesting techniques (19). They can also help farmers form organizations to represent their interests and facilitate collective action. Moreover, they can improve farmers' motivation and self-confidence by providing them with the knowledge, skills, and support needed to improve their production systems (13). These programs can act as catalysts for technology adoption by farmers, speeding up the adoption rate and helping to control change within the agricultural system (9).

In the context of pepper plant service operations in Zakho, agricultural extension programs can provide farmers with the knowledge and skills they need to improve their pepper plant service operations, leading to increased productivity, better livelihoods, and more sustainable agricultural practices. Increasing agricultural productivity and production and achieving food security is a central goal that receives much attention at all levels in the world (8). These goals can be achieved through vertical expansion by achieving higher productivity rates from the production unit or horizontal expansion by opening new areas for agriculture, in addition to crop intensification, which makes the time factor an important element in agricultural production calculations (3).

Countries of the world, including Iraq, endeavor to increase productivity and agricultural production. They adopt various methods and means to develop the sector, including the applying modern agricultural technologies which are an important element in vertical development that focuses on the optimal utilization of the unit of cultivated area to maximize agricultural production. (6) Thus, modern agricultural technologies play an important role in developing food security conditions by increasing productivity, reducing production costs, and improving quality. Modern technologies include the use of chemical fertilizers and pesticides, agricultural mechanization, improved seeds, the use of biotechnology in the field of animal and plant genetic improvement, and the use of modern technologies in the field of diagnosing plant and animal diseases and developing methods of combating them (7).

In this regard, agricultural extension services can contribute in various areas of rural development. They can educate and inform farmers in developing their capabilities, improve their skills, and change their attitudes and way of thinking to fully benefit from scientific and technical progress in agriculture, thus raising their living standards and advancing their local communities (1 and 12).

Vegetable cultivation has witnessed an expansion in its area at the global level, covering much land and being widely distributed (10). However, vegetable production in Iraq is low compared to its neighboring countries. This due to several factors, most notably the level of farmers' knowledge, attitudes, and skills in vegetable cultivation, and the failure of pepper farmers to employ modern scientific techniques. It is important for farmers to be aware of agricultural recommendations and information and to apply them accordingly (2 and 11).

Addressing the knowledge issues involved in pepper plant service operations in Zakho requires focusing on certain crucial aspects. These include limited access to inputs, lack of value chain structure in traditional farming systems, and the use of chemical fertilizers instead of traditional practices like rotation, inter-cultivation, and manure preparation. Also, it should address the impact of knowledge gaps on crop yield, such as the effect of deficit irrigation and quality in sweet pepper cultivars (14). Strategies should also be implemented to enhance farmers' knowledge, such as evaluating existing practices, and exploring new ones to maintain soil fertility and avoid soil erosion. By focusing on these aspects, it may be possible to identify specific research problems related to farmers' knowledge in pepper plant service operations in Zakho and devise effective strategies to address them.

Peppers are plants that belong to the Solanaceae family, which also includes tomatoes, potatoes, and eggplant. Black pepper comes from an unrelated plant. Peppers are grown worldwide in the tropical parts of Asia and Central and South America (5), and can be mild or hot, and their tastes and color vary depending on their maturity. When ripe, they range in color from yellow to deep red and purple. Mild peppers are usually large, and bell or sweet peppers are mild peppers that are bell-shaped, wrinkled, and puffy. They are often used in salads and cooked dishes, and are rich in vitamins A and C (15 and 17).

Therefore, agricultural extension agencies are responsible, as one of the most important change agencies, for playing an effective role in bringing about the desired behavioral changes in the knowledge of pepper farmers through agricultural recommendations and information (16). Many studies have indicated the low and weak efficiency of agricultural extension in the process of transferring and communicating scientific agricultural recommendations, education, and urging farmers to adopt and apply them. Given the importance of the pepper crop for the region in general, this research seeks to determine the knowledge level among pepper farmers, as well as the correlation between the knowledge and some of the variables included in the study (18). The results of this study may contribute to drawing up an effective strategy for spreading innovative agricultural ideas among farmers in the targeted region.

Agricultural extension can serve as a transformative tool in peacebuilding by fostering trust, cooperation, and sustainable livelihoods in conflict-affected areas. The integration of science and local knowledge is essential to adapt extension services to fragile contexts (20). Entrepreneurship education in refugee camps is not only about economic empowerment but also about restoring human dignity and agency. It plays a pivotal role in rebuilding lives through skill evolvement and long-term livelihood solutions (21).

Inter-cropping enhances pest management by elevating crop diversity, which disrupts pest habitats and diminishes out-breaks. This agroecological practice can minimize the need for synthetic pesticides and support sustainable farming systems (23). The Expanded Food and Nutrition Education Program (EFNEP) has significantly contributed to improving nutrition behaviors and food safety practices among low-income families. It emphasizes hands-on learning to enhance knowledge retention and behavioral change (24).

Organic agriculture continues to grow globally, with increasing land area and market value, reflecting a strong consumer demand for sustainable products. The sector also plays a crucial role in biodiversity conservation and soil health (25). The trend toward organic farming intensified in 2023, with more countries integrating organic principles into national policies. Global statistics reflect a growing alignment with environmental and health-conscious agricultural practices (26). Agricultural extension remains a cornerstone for transferring innovations to rural communities, ensuring farmers are informed and empowered. It bridges the knowledge gap and supports the adaptation of climate-smart and sustainable farming techniques (27).

Specifically, this research aimed to answer these questions:

1. What is the level of knowledge of farmers about pepper crops?
2. What are the differences between farmers' knowledge of essential pepper crop service operations and the productivity and sustainability of pepper cultivation?
3. How do farmers' perceptions of technological advancements in pepper cultivation impact their adoption of modern farming practices?
4. What are the key challenges faced by pepper farmers in implementing sustainable agricultural practices in their plants?
5. How does access to agricultural extension services influence farmers' knowledge and practices in pepper plant management?

These questions can delve deeper into various aspects of pepper cultivation and farmers' knowledge, and provide insights into factors that affect productivity, sustainability, and success in pepper farming.

Research Objectives:

1. To identify the level of farmers' knowledge of the most important domains of agricultural practices for the pepper crop in general.
2. To arrange the domains of the farmers' level of knowledge of the service operations according to the arithmetic mean of knowledge level.
3. To determine the differences in the level of farmer's knowledge of service operations for the pepper crop based on certain personal characteristics (age, educational level, occupation, income source, type of ownership, previous training, sources of information, number of family members, willingness to change, production quantity in tons, main profession, specializing in pepper cultivation, type of agricultural machinery, contribution of pepper to income, and extension activities participation).

To determine the multiple linear regression between the cognitive levels and the independent variables (age, number of family members, sources of information, extension activities, and willingness to change).

Materials and Methods

Research Population: Zakho was selected for this study due to its position as a major vegetable cultivation area especially for peppers. The research covered all 100 pepper farmers in the city, comprising 13 for the pre-test and 87 for the research sample.

Research Tools: A scale was prepared to evaluate the knowledge of Zakho farmers on the main scientific recommendations for the production of pepper crops after reviewing the agricultural extension literature and vegetable crops. The scale was then reviewed by a panel of specialists in agricultural extension and pepper cultivation.

A questionnaire was developed covering the farmers' age, educational level, occupation, income source, type of ownership, previous training, sources of information, number of family members, readiness to change, production quantity in tons, main profession, specializing in pepper cultivation, type of agricultural machinery, contribution of pepper to income, extension activities participation. Five domains were examined, namely preparing the land for agriculture, service and pepper cultivation operations, irrigation operations, fertilization processes, and pest and weed control for pepper crops.

To measure the level of farmers' knowledge of the main agricultural practices for pepper plants, numerical values were obtained from the responses to the 44 test paragraphs, which included their basic knowledge in pepper cultivation. The five domains mentioned above comprised 7, 7, 7, 8, and 15 paragraphs each, and the farmers' level of knowledge was classified into low, medium, and high categories.

The research included all 100 pepper farmers in the targeted area, of which 13 were selected as random samples to determine reliability, while the actual research samples comprised 87 farmers.

The reliability coefficient of 0.74 was calculated using Cronbach's alpha while the validity coefficient was 8.94.

Data Collection: A questionnaire was administered through personal interviews to collect data for the research objectives. The questionnaire sought information on the social, educational, and economic characteristics of the farmers, the sources of information, and the five domains to measure their knowledge of the main agricultural practices for pepper plants. The data was collected over 50 days beginning June 2024.

Results and Discussion

First: Level of farmers' knowledge of the most important agricultural practices for the pepper crop in general: The results showed that the highest value for the respondents was 32 degrees, and the lowest 18 degrees. The arithmetic mean was 24.02 while the standard deviation was 3.383, according to the knowledge scale of low, medium, and high. The theoretical range method was based on the highest and lowest degrees of 44 and 18, respectively (Table 1).

Table 1: Distribution of respondent categories according to level of knowledge of pepper crops in general.

	Knowledge Level	N	%	Mean
1	Low (18-20)	33	37.9	20.36
2	Medium (21-27)	43	49.5	25.42
3	High (28-32)	11	12.6	29.55
	Total	87	100	

Mean = 24.02; SD = 3.383.

The table shows that 37.9% of the respondents were within the low category (18-20), 49.4% in the medium category (21-27), and 12.6% in the high category (28-32). This shows that the farmers' knowledge of the most important pepper domain service operations was at a medium level and tending to decline. According to this result, farmers need information on pepper orchard services.

Second: Arranging the domains of the farmers' knowledge level of the service operations according to the arithmetic mean: Table 2 shows that the domain of Irrigation Operations occupied the top position with an arithmetic mean of 4.10, according to the knowledge on service operations for pepper. This may be due to respondents being aware that agricultural land preparation procedures are among the critical areas of service operations for pepper. The domain for pesticides and weed control occupied the last place with an arithmetic mean of 7.51. This could be due to respondents being aware that this domain has little effect on the level of knowledge on service operations for pepper.

Table 2: Distribution of domains based on the means of the respondents ' knowledge level.

Domains	Minimum Value	Maximum Value	Mean	Standard Score	Percentage	Ranking
Irrigation operations for pepper	2	7	4.10	7	58.57	1
Preparing the land for agriculture	2	6	4.02	7	57.42	2
Fertilization processes for pepper	1	7	4.48	8	56.0	3
Service and pepper cultivation operations	1	7	3.90	7	55.71	4
Pest and weed control for pepper plants	3	12	7.51	15	50.06	5

It is clear from the table above that the level of knowledge of the farmers surveyed is high in the domains of irrigation operations, preparing the land for agriculture, and fertilization as the arithmetic mean was less than 4.10.

Third: Determining the differences in level of farmer's knowledge of service operation for the pepper crop according to personal characteristics: Table 3 shows the

personal and functional characteristics of the farmers involved in pepper cultivation in Zakho.

Table 3: Distribution of farmers' knowledge according to personal and functional characteristics.

No.	Variables	Categories	Frequency	%	$\bar{X}$	F and t-test	Sig
1	Age	17-27 years	16	18.4	24.02	2.83	0.030*
		28-38 years	17	19.5			
		39-49 years	27	31.1			
		50-60 years	18	20.7			
		61-more years	9	10.3			
		Total	87	100			
2	Educational Level	Illiterate	24	27.6		0.710	0.642 N.S.
		Read and Write	28	32.2			
		Primary	20	23.0			
		Intermedia	8	9.2			
		Higher School	3	3.4			
		Higher Diploma	2	2.3			
		Collage	2	2.3			
		Total	87	100			
3	Occupation	Agriculture	75	86.2		2.07	0.133 N.S.
		Private Work	9	10.3			
		Official Work	3	3.4			
		Total	87	100			
4	Income Source	Agriculture	81	93.1		2.06 t-test	0.052 N.S.
		Agriculture-Non	6	6.9			
		Total	87	100			
5	Type of Ownership	Ownership	39	44.8		1.77	0.159 N.S.
		Contract with Government	18	20.7			
		Rent	24	27.6			
		Share	6	6.9			
		Total	87	100			
6	Previous Training	Yes	2	3		5.47	0.000**
		No	85	97			
		Total	87	100			
7	Sources of Information	Always 13-19	28	32.2	26.57	15.86	0.000**
		Sometimes 20-26	36	41.4	22.94		
		Non 27-36	23	26.4	22.61		
		Total	87	100	24.02		
8	Number of Family Members	1-5	32	36.8	6	0.369	0.693N.S
		6-10	44	50.6			
		11 more	11	12.6			
		Total	87	100			
9	Willingness to Change	4-8 Non agree	2	2.3		0.280	0.756 N.S.
		9-13 Neutral	19	21.8			
		Agree 14-18	66	75.9			
		Total	87	100			

10	Production Quantity in Tons	Less 5		35	40.2	6	12.08	0.000**
		6-10		40	46.0			
		11 More		12	13.8			
		Total		87	100			
11	Main Profession	Agriculture		75	86.2		2.07	0.133 N.S.
		Freelance		9	10.3			
		Employee		3	3.4			
		Total		87	100			
12	Specializing in Pepper Cultivation	Specialized		3	3.45		0.334 t-test	0.739 N.S.
		Non-specialist Growing other Crops		84	96.55			
		Total		87	100			
13	Work Type	Work in the Field		70	80.46		- 0.686	0.49 N.S.
		Daily Wage Workers		17	19.54			
		Total		87	100			
14	Type of Agricultural Machinery	Puller		7	8.1		1.89	1.57 N.S.
		Cargo Truck		23	26.4			
		Others		57	65.5			
		Total		87	100			
15	Contribution of Pepper to Income	100%		4	4.6		4.17	0.008**
		80%		6	6.9			
		50%		45	51.7			
		25%		32	36.8			
16	Extension Activities Participation	Visit an Agricultural Extension	No	44	50.57		2.77	0.007**
			Yes	43	49.43			
		Attending Extension Seminars	No	51	58.62		2.22	0.029*
			Yes	36	41.38			
		Attending Extension Panels	No	57	65.52		1.45	0.146 N.S.
			Yes	30	34.48			
		Read Extension Magazines	No	68	78.16		- 0.425	0.672 N.S.
			Yes	19	21.81			
		Listening to TV and radio programs	No	46	52.87		5.02	0.000**
			Yes	41	47.13			
Total					100			

1. Age: To test the statistical hypothesis that there was no significant variance in the knowledge level of pepper farmers according to age, the analysis of variance was used, and its value reached 0.030*, which is significant at the 0.05 probability level. It means that there are significant differences between the two variables, thus the null hypothesis is rejected. The reason may be that all pepper farmers do not need information about pepper crop production, regardless of their age.

2. Educational level: The farmers were classified according to their educational level into seven categories as shown in the table above. The results show that 59.8% of the respondents were illiterate being only able to read and write, 23.0% were primary school graduates, 9.2% were intermediate school graduates, 3.4% secondary school graduates, and 4.6% institute and college graduates.

When testing the statistical hypothesis that there are no significant differences between the knowledge level of pepper farmers according to educational level, no significant differences were found between the two variables, as the F-test value reached 0.642, which is not significant at the 0.05 probability level. Therefore, the null hypothesis is accepted and the alternative hypothesis rejected. The reason for this may be that the vast majority of the farmers surveyed (72.4%) belong to the primary school category or less, meaning that they are not at the educational level that enables them to benefit from available extension methods and means. This requires the extension apparatus in the region to focus on practical clarification methods in conveying their messages and scientific recommendations in pepper cultivation and production.

3. Occupation: The farmers were categorized into three occupational groups i.e., those who practiced agriculture as their main occupation (86% of respondents), as a secondary profession and self-employed (10.3%), and those who had government jobs in the sector (3.4%). The hypothesis testing for differences in the knowledge level of the farmers according to occupation found no significant relationship between the two variables as the t-test was 0.133. This could be attributed to the fact that the agricultural profession does not affect knowledge levels, whether primary or secondary.

4. Income source: This involved farmers depending entirely on agriculture for their income (93.1%) and those also having other income sources (6.9%). The statistical test that there were no significant differences in the farmers' knowledge levels based on income source found no significant relationship between the two variables, as t-test registered 0.052. This could be because income source has no bearing on the level of application to agricultural operations.

5. Ownership type: This involved four categories of agricultural land ownership, namely owners (44.8%), those with government contracts to use the land (20.7%), those on land leases (27.6%), and participants (6.9%). The hypothesis testing knowledge levels according to land ownership type showed no significant relationship between the two variables, as possession was not affected by pepper cultivation.

6. Previous training: This involved two categories of farmers i.e., those who did not participate in training courses (97%) and those who did (3%). The hypothesis testing their knowledge levels and participation in training courses found no differences between the two variables, at a correlation coefficient of 0.000**. This could be because most of the courses held in the region did not relate specifically to pepper cultivation.

7. Information sources: Farmers were classified according to their level of contact with information sources on pepper cultivation into three categories. These included farmers having numerical values ranging between 13-19 degrees (32.2%), between 20-26 degrees (41.4%), and between 27-36 degrees (26.4%). This means that the majority of respondents belonged to the categories of low and medium contact with information sources. Table 4 shows the sources of agricultural information according to degree of use by respondents in descending order, as follows: agricultural offices (2.632), neighbors and friends (2.423), distinguished farmers (2.333), agricultural television programs (2.068), agricultural radio programs (2.045), extension center (1.802), extension bulletins (1.701), extension magazines (1.482), agriculture directorate

(1.459), agricultural department (1.379), scientific research centers (1.264), wall posters (1.218), and colleges and institutes of agriculture (1.183).

The statistical hypothesis test on knowledge levels of the pepper farmers and the extent of their use of information sources found significant differences between the two factors at the 0.05 probability level, where the F-test value reached 0.000**. Therefore, the null hypothesis is rejected and the alternative hypothesis is accepted. The reason may be that the more they use information sources, the greater the opportunity to learn about new developments in pepper cultivation.

Table 4: Distribution of farmers according to degree of use of agricultural information sources.

No	Information Sources	Mean	Uses %	Standard Deviation	Rank
1	Agricultural offices	2.632	73.563	0.666	1
2	Outstanding farmers	2.433	64.368	0.741	2
3	Neighbors and friends	2.423	57.471	0.923	3
4	Agricultural TV programs	2.068	49.425	0.961	4
5	Agricultural radio programs	2.045	48.276	0.963	5
6	Agricultural extension centers	1.802	33.333	0.918	6
7	Extension leaflets	1.701	25.287	0.850	7
8	Extension magazines	1.482	18.391	0.775	8
9	Directorate of Agriculture	1.459	17.241	0.789	9
10	Agricultural department	1.379	14.943	0.735	10
11	Scientific research centers	1.264	8.046	0.599	11
12	Wall stickers	1.218	6.897	0.558	12
13	Agri. colleges and institutes	1.183	5.747	0.517	13

8. Number of family members: This involved three categories: farmers with 1 to 5 family members (36.8%), those with 6-10 members (50.6%), and those with 11 or more members (12.6%). The statistical hypothesis test on the relationship between knowledge levels of the farmers and number of family members) showed no significant differences at the 0.01 probability level, where the t-test value was 0.693; thus the null hypothesis can be rejected and the alternative hypothesis accepted, indicating that yhe number of family members does not affect pepper production.

9. Willingness to change: The highest numerical value for openness and readiness for change was 18 and the lowest was 4. The three categories for this variable were low, average, and high willingness to open and change, with respondents representing 2.3%, 21.8%, and 75.9% of the total, respectively. Thus, respondents with a high tendency towards openness and readiness represented three-quarters of the sample. The t-test value of the differences in the level of knowledge and readiness for change variables was 0.756, which was not significant. Thus, the statistical hypothesis can be accepted. The reason for the lack of significance is that the respondents were willing to change which does not affect the application of scientific recommendations.

10. Production quantity (tons): This variable involved three categories i.e., farmers whose annual production was 5 tons or less (40.2%), 6-10 tons (46%), and 11 tons and above (13.8%). The statistical hypothesis test on the relationship between knowledge level of the pepper farmers and annual production revealed a significant difference between the two variables at the 0.01 probability level, where the t-test was 0.000**.

Thus, the null hypothesis can be rejected and the alternative hypothesis accepted, indicating that higher annual production yields better returns and incomes.

11. Main profession: Here, the farmers were categorized as only practicing agriculture (86.2% of total respondents), self-employed agricultural professionals (10.3%), and employee agricultural professionals (3.4%). The statistical hypothesis tested on the relationship between farmers' knowledge levels and main profession showed no differences between the variables, where the t-test was 0.133, thus accepting the null hypothesis. This could be ascribed to the majority of farmers practicing agriculture only.

12. Specialization in pepper cultivation: As shown in Table 3, respondents specializing in pepper cultivation accounted for 3.45% of the total compared to 96.55% who did not. The statistical hypothesis test on the relationship between knowledge levels and agricultural specialization revealed no differences among the farmers surveyed, i.e., they did not specialize in nor relied predominantly on pepper cultivation.

13. Work type: The farmers for this factor were those who either worked their own fields (88.5%) or those who worked for wages (11.5%). The statistical hypothesis test on the link between knowledge levels and their field of work showed a significant difference in the two variables at the 0.01 probability level and t-test value of 0.49, thus rejecting the null hypothesis and accepting the alternative hypothesis, indicating no relationship between their field of work and increased production.

14. Agricultural machinery ownership: In terms of machinery ownership, 7 or 8.1% of the respondents owned a tractor, 23 (26.4%) owned a transport vehicle, and 57 (65.5%) owned other machines (Table 3). The statistical hypothesis test on the knowledge level of the farmers and their ownership of agricultural machines saw no significant differences between the variables at the 0.01 probability level at the t-test value of 1.57 ns, so the null hypothesis is accepted and the alternative hypothesis is rejected. This is because the agricultural machines were not specialized for pepper cultivation.

15. Contribution of pepper to income: The respondents for this factor were those who earned all their income from pepper (4.6%), those with most of their income from pepper (6.9%), those with half their incomes from pepper (51.7%), and those for whom pepper represented only a small proportion of their incomes (36.8%), as shown in Table 3. It is clear that the highest category were respondents who earned half their incomes from pepper. The t-test used to find the differences in the level of knowledge of respondents and their annual income was valued at 0.008**, indicating a positive relationship between the two variables. To find the significance of the relationship, the t-test was used, which had a value of 4.17. When compared with the (t) tabular, it was found to be significant at the 0.01 level. Thus, the statistical hypothesis is rejected and the alternative hypothesis accepted. The reason for this is that higher incomes encourage respondents to explore modern methods and new techniques for increasing production.

16. Extension activities: Respondents for this were grouped into those who were exposed to extension activities in pepper cultivation and services (32.42%) and those who were not (67.58%), as shown in Table 3. As seen, more than two-thirds of the respondents were not exposed to guidance activities. The t-test used to find the

differences in the level of knowledge and guidance activities returned a value of 0.341, indicating the existence of a positive relationship between the two variables. The t-test was used, and its value was 4.849. When compared with the (t) table, it was found to be significant at the 0.01 level, thus rejecting the statistical hypothesis. With more respondents exposed to those activities, the cognitive levels increased together with their experience on the more important operations in pepper production.

Table 5: Distribution of farmers according to extension activity involvement.

No	Extension activities	Yes	No
1	Visit an agricultural extension	43	44
2	Attending extension seminars	36	51
3	Attending extension meetings	30	57
4	Read extension magazines	19	68
5	Listening to TV and radio programs	41	46
6	Participation in special training courses in serving pepper domains	2	85
	Total	171	351

Fourth: Determining the multiple linear regression between cognitive levels and the independent variables: Table 6 shows the results of the multiple linear regression analysis between cognitive levels and the independent variables (age, number of family members, sources of information, extension activities, and willingness to change). There was a significant correlation between the two factors, with the Pearson correlation coefficient at 0.51, the coefficient of determination (R2) at 0.26 and the value of the adjusted coefficient of determination (Adjusted R2) at 0.214. This meant that the above variables explain 26% of the variance in the cognitive level of the respondents, and that this function is significant at the 0.01 level where the calculated value of F reached 5.68.

Table 6: Multiple linear regression analysis between cognitive levels and the independent variables.

R	R2	Adjusted R2	Change R2	F	Sig. F
0.51	0.26	0.214	2.98	5.68	0.000

Conclusions

The study found pepper farmers' knowledge to be significantly influenced by practical and experiential factors such as age, use of information sources, extension activity exposure, annual production, and income dependency on pepper. These factors positively correlate with higher knowledge levels.

Conversely, the variables of education level, training participation, land ownership, occupation, machinery ownership, and specialization showed no significant impact on knowledge. This suggests that formal education and resources alone are insufficient without relevant and targeted governmental support.

Overall, the findings highlight the importance of accessible, practical extension services and information channels in improving farmers' knowledge. Formal education and equipment play a lesser role unless directly aligned with pepper cultivation needs.

Recommendations:

Based on the results, the following recommendations can be made to improve farmers' knowledge of the most important pepper plant services. These can be in the form of standardized guidelines to increase familiarity of farmers with pepper plant services, as follows:

1. Build farmer-centric extension services: Develop needs-based, contextually appropriate knowledge programs supplementary to farmers' education levels and area conditions. Equip extension agents with soft skills and participatory modes.
2. Leverage on ICT and conventional channels: Leverage mobile apps, social media, and radio for dissemination of timely, simplified information on pepper plant services to address digital literacy deficits.
3. Broaden farmer-to-farmer learning: Develop demonstration plots and peer learning groups to enhance experiential knowledge transfer and scaling of local innovations.
4. Intensify policy and market support: Enhance government policies to provide input subsidies, credit access, and market access expansion to incentivize the adoption of better practices.
5. Encourage knowledge application: Provide performance-based rewards to trainers and incentivize farmers adopting sustainable pepper crop production practices.
6. Conduct continuous monitoring and research: By implementing these recommendations, farmers' knowledge of the most important pepper plant services can be improved, leading to better productivity, profitability, and sustainability in the pepper farming sector.

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The author asserts that the absence of any conflicts of interest during the information-gathering phase was essential to completing this research endeavor.

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