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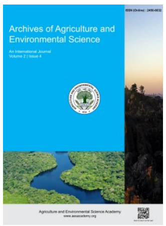

ORIGINAL RESEARCH ARTICLE

CrossMark

Knowledge and application of Good Agricultural Practices (GAP) among cucumber (*Cucumis sativus* L.) growers in Bharatpur metropolitan city, Nepal

Barsha Sapkota[*] and **Bhawana Khadka**

Agriculture and Forestry University, Rampur, Chitwan, Nepal
[*]Corresponding author's E-mail: sapkotaanjali30@gmail.com

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ABSTRACT

A study was conducted to determine the Good Agricultural Practices (GAPs) adopted by cucumber (*Cucumis sativus* L.) growers in Ward 27 of Bharatpur Metropolitan City, Chitwan, Nepal. For the collection of data, 60 cucumber growers were interviewed through a semi-structured questionnaire. Farmers were categorized as GAP aware farmers and GAP unaware farmers. The data was analyzed using descriptive statistical tools, such as t-test and binary logit regression analysis. The results revealed that only 25% of the farmers were aware of GAP. Although, majority of farmers were not aware of GAP, i.e., 75%, yet they managed to apply various good agricultural practices on their farms. 70% of farmers planted the recommended variety, 70% practiced mulching, and 60% applied the recommended dose of fertilizers (RDF). Likewise, almost all (93.33%) integrated organic nutrients alongside chemical fertilizers, whereas 81.7% applied irrigation water free from harmful contaminants. The results revealed that 65% farmers used PPE while handling chemical fertilizers and 61.7% adopted IPM. Very few, 29% of respondents kept the record, which was determined to be the least adopted among other practices. From the result of the binary logit regression analysis, none of the independent factors were found to be statistically affecting GAP awareness. Poor access to government services, followed by inadequate access to GAP input, were found to be the major problems related to GAP adoption. Limited knowledge and training, and limited market incentives were other major problems faced by farmers.

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INTRODUCTION

The significance of food safety has escalated over time due to its influence on consumer health and the expansion of both domestic and international food product trade. With swiftly evolving global landscape and diverse factors like population growth, scientific progress, technological innovations, shifts in agricultural methods, and transformations in lifestyles around the globe, it is imperative to explore and tackle the rising likelihood of food safety incidents (FAO, 2016). GAPs can be viewed as efforts to increase agricultural sustainability in a variety of ways, such as safeguarding natural resources and the environment, boosting food security through better production methods, and improving food quality and safety. The idea behind good agricultural practices is to apply existing knowledge to the sustainable use of natural resources to produce safe, healthy food and non-food agricultural products in a humane way while attaining social stability and economic viability (FAO, 2004). From primary production to consumption, food contamination can happen at any point in the food chain. Therefore, measures to guarantee food safety must be put in place at every stage of the food chain (FAO, 2016). Good Agricultural Practices is defined by the Food and Agriculture Organization of the United Nations(FAO) as "Collection of principles to apply for on-farm production and post-production processes, resulting in safe and healthy food and non-food agricultural products, while taking into account economic, social and environmental sustainability" (FAO, 2016). Agricultural products are transported from farm to table through a number of processes, including production, harvesting, post-harvest treatments, packing, shipping, storage, and marketing. GAP is the set of protocols and standards utilized at various stages of the agricultural value chain (Sareen, 2016). Good agricultural practices, or GAPs, are essential for producing safe food and reducing health risks (Mim & Islam, 2022). The FAO has created a training manual and scheme on Good Agricultural Practices (GAP) for fruits and vegetables. The requirements are divided into five modules: produce quality, environmental management, food safety, and worker health, safety, and welfare. The four pillars of GAP, namely food safety and quality, economic viability, environmental sustainability, and social acceptability are included in most private and public sector standards. In many nations, public authorities and/or the commercial sector have created their own set of GAP standards. While some nations, like Thailand, are making certain standards and practices mandatory, others are making them optional. The implementation of GAP is an assurance to the world that fresh fruits and vegetables being produced in the country are safe for human consumption, that production is done with high regard for the environment, and ensuring the health, safety, and welfare of workers (FAO, 2016).

Evidence of the European Union rejecting Nepalese products has surfaced. Poor farming methods and a lack of recognized produce certification have led to this situation. The Government of Nepal approved the Nepal GAP Implementation Directives on October 15, 2018, in response to the growing demand for certified safe products. However, various factors have been affecting Nepali farmers' understanding of GAP (Joshi *et al.*, 2019). Adopting Good Agricultural Practices (GAP) in Nepal has the potential to greatly benefit consumers, farmers, and agricultural workers. GAP helps farmers use natural resources and inputs more effectively while enhancing soil fertility, preserving biodiversity, and enhancing resilience to agricultural externalities (Kharel *et al.*, 2023). As a major initiative to increase productivity, the implementation of Good Agricultural Practices (GAP) has been highlighted in Nepal's Agriculture Development Strategy (ADS) (2015–2035) (MoAD, 2015). However, the adoption of GAP is restricted to a very small number of regions in Nepal because of the absence of government initiatives and the lack of understanding and awareness of GAP (Baral *et al.*, 2021).

Bharatpur is a city in south-central Nepal. It is the third most populous city after Kathmandu and Pokhara, with 369,377 inhabitants in 2021. Bharatpur is a city that has a lot of productive land for agriculture. Most of the villagers are farmers engaged in farming of cereal crops, oilseed crops, and vegetables. Varieties of vegetables are grown owing to their seasonality. Cucumber, a short-duration crop, is widely grown in this area. Cultivation of cucumber has played an important role in generating remuneration and alleviating poverty. However, despite the efforts of farmers, production isn't achieved as expected. Farmers aren't aware of the adoption of good agricultural practices, and the production and post-production process isn't farmer and environmentally friendly. This research regarding the adoption of GAP in cucumber and the factors affecting it will be an important study that will shed light on the prevalent agricultural practices and provide awareness regarding GAP. It will also provide insight into the GAP among the farmers.

MATERIALS AND METHODS

Description of the study area

The area of the study was ward no 27 of Bharatpur Metropolitan City, Chitwan which was purposively assigned for LEE internship by Agriculture and Forestry University, Rampur Chitwan. Bharatpur is a city in south central Nepal situated in Bagmati province and has 29 wards. It is located at the center of the Mahendra (east-west) highway and Kathmandu-Birgung (North south) road corridor and is traditionally based on agriculture.

Sample and sampling technique

A total of 60 samples were selected from the study area. Sampling frame was prepared from the data obtained from ward office and Agriculture Knowledge Centre (AKC), Chitwan. Similarly, sampling was done using simple random sampling technique. Sample size was estimated using Cochran formula (Cochran, 1997) for smaller population:

$$n = \frac{n_o}{1 + \frac{(n_o - 1)}{N}}$$

$$n_o = \frac{Z^2 pq}{e^2}$$

Where, e is the desired level of precision (i.e. the margin of error); p is the (estimated) proportion of the population that has the attribute in question; q is 1 – p; n0 is Cochran's sample size recommendation, N is the population size, and n is the new, adjusted sample size; A well-structured questionnaire was used for interviewing cucumber farmers; The questionnaire made was simple focusing on the adoption of GAP among cucumber growers.

Research design

Data collection was done through personal interviews. Based on the interview schedule and checklist, questions were asked to the respondents in order to gain the aimed information. Key informant interviews (KII) and focus group discussions (FGD) were carried out primarily to triangulate data and information obtained from scheduled interviews and secondarily to obtain additional qualitative information.

Data analysis

All the collected data was carefully refined before analysis. It was then coded and entered in the Statistical Package for Social Sciences (SPSS) and Excel sheet. Following this, the data was analyzed to draw meaningful inferences using SPSS (version 30) and MS Excel software. The data was analyzed by using tools like descriptive statistics, mean comparison, regression analysis, chi-square, etc.

Factors affecting awareness of GAP among cucumber growers

For the analysis of factors affecting awareness of GAP among cucumber growers, binary logit regression model was used. Awareness of GAP was taken as a dependent variable with a value of 1 (if the farmer is GAP aware) and 0 (if the farmer is GAP unaware). The independent variables were taken as the gender of the household head (HH), the age of HH, the education of HH, total farming experience, and total farm size. This model was used because various literature on this topic were found using this model. The binary logit model predicts the logit of the dependent variable (awareness of GAP) from independent variables. The likelihood of farmers being aware of GAP is predicted by odds (y=1); that is, the ratio of the probability that Y equals to 1 to the probability that Y not equals to 1:

$$OddY=P(Y_i=1)/(1-P(Y_i=1))$$

$$\ln[P(Y_i=1)/(1-P(Y_i=1))] = \log Odds = Logit(Y)$$

$$Logit(Y)= ß0 + ß1X1 + ß2X2 + ß3X3 + ... + \varepsilon.$$

Where y=Dependent variable (GAP awareness) with 1=aware and o=otherwise; ß0 = intercept and ß1-ß4 = coefficient of determination, X= Independent variables, and ε = random error term

Problem ranking and indexing

Firstly, the problems related to the adoption of GAP were evaluated through group discussions and interactive methods. Then the problems mentioned in the questionnaire were asked to the respondents, and the ranking of problems was done based on severity and extremities of problems faced by them. The forced ranking method was used for problem ranking and indexing. It was evaluated using the formula:

$$I_{prob}= \Sigma (S_i f_i/N)$$

Iprob= Index value for intensity of problems

Σ = Summation

Si = Scale value at ist intensity

fi =Frequency of ist intensity

N = Total number of respondents

RESULTS AND DISCUSSION

Socio-economic and demographic information of the respondents

For continuous variables: Regarding the age of the household head (HH), the average age of GAP-aware HH was found to be 40.53 years, which is slightly lower than the average age of GAP-unaware HH, which was 44.49 years (Tables 1). It contradicts the result of Sedhai *et al.* (2022) where the average age of GAP-aware respondents was 49.74 years, while the average age of GAP unaware respondents was 45.26 years. Similarly, the number of economically active members in GAP-aware households was found to be 2.87, and in GAP unaware households was 2.18. Sedhai *et al.* (2022) reported that the average number of economically active members was 4.15 and 3.69 for GAP-aware and unaware respondents, respectively. Likewise, the average family size of GAP aware and GAP unaware households was

Table 1. Distribution of socio-economic and demographic characteristics (continuous variable) of the sampled household with the farmer's category.

Variables	Overall	Farmer's Category		Mean difference	t-value
		GAP Aware (n = 15)	GAP Unaware (n = 45)		
Age of HH (yrs.)	43.50(8.33)	40.53(10.27)	44.49(7.45)	-3.96	-1.38ns (p=0.185)
Economically active members	2.35(0.97)	2.87(1.19)	2.18(0.83)	0.69	2.4** (p=0.016)
Family size	5.03(1.17)	5.13(1.73)	5.00(1.79)	0.13	0.25 ns (p=0.80)
Total land size (ha)	0.80(1.73)	1.52(3.31)	0.56(0.56)	0.96	1.12 ns (p=0.28)
Total area of cucumber cultivation (ha)	0.16(0.19)	0.24(0.33)	0.13(0.11)	0.11	1.31 ns (p=0.21)
Farming experience (yrs.)	4.52(3.14)	5.53(4.99)	4.18(2.19)	1.36	1.02 ns (p=0.324)

Note: Figures in the parentheses indicate standard deviation; p values are the result of t-test, ** indicates 5% level of significance

Table 2. Distribution of socio-demographic characteristics of sampled households (categorical variables).

Variables	Frequency	Percent
Gender of respondent		
Male	26	43.3
Female	34	56.7
Ethnicity of respondent		
Brahmin	29	48.3
Chhetri	15	25
Janajati	13	21.7
Others	3	5

5.13 and 5, respectively, which is consistent with the findings of Chhetri & Ghimire (2023), who reported the average family size for GAP aware, and GAP unaware households was 6.24 and 5.13, respectively. Likewise, the average land size was found to be 1.52 hectare (ha) and 0.56 ha for GAP aware and GAP unaware farmers, respectively, which is in accordance with the findings of Sedhai *et al*. (2022), in which farm size was larger in GAP aware farmers. Although GAP-aware farmers have a larger average land size, the difference is not statistically significant. In the case of the area of cucumber cultivation, the average land size for GAP aware and GAP unaware farmers was 0.24 ha and 0.13 ha, respectively, indicating the area under cucumber cultivation is slightly larger for GAP-aware farmers. However, the difference is not significant, which correlates with the findings of Chhetri & Ghimire (2023). Added to this, the farming experience was found to be 5.53 years and 4.18 years for GAP aware and GAP unaware farmers, respectively, which contradicts the result of Sedhai *et al.* (2022) in which farming experience was lower for GAP aware farmers. Moreover, the number of economically active members was found to be significant at 5% level of significance, indicating households with more economically active members are significantly more likely to be aware of GAP.

For categorical variables: Most of the respondents were female (56.7%), indicating the presence of females in the house during the daytime (Tables 2). It contradicts the result of Chhetri & Ghimire (2023), which reported that most respondents were male. Brahmins form the largest ethnic group, representing 48.3% of the sample. Chhetris are the second-largest group with 15 respondents accounting for 25%, and Janajatis constitute 21.7% of the sample (Tables 1 and 2). The Others category has the least representation, making up 5%. This result is in harmony with the findings of Acharya *et al.* (2024) who reported

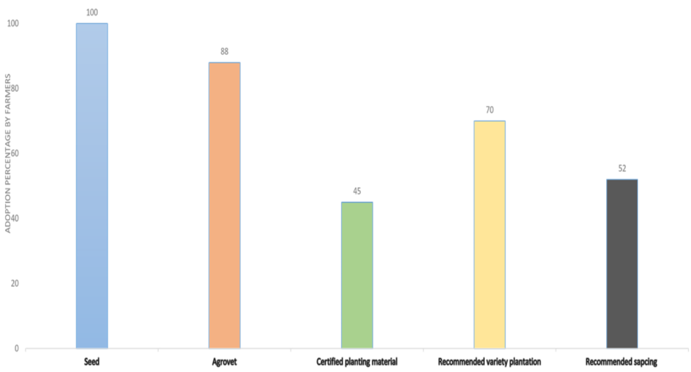

Figure 1. *Planting material and practice related to GAP by cucumber farmers.*

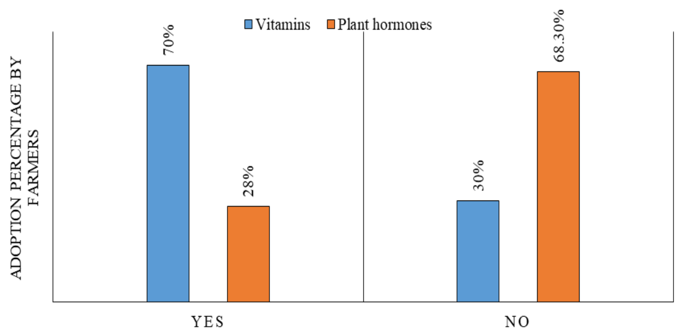

Figure 2. *Application of vitamins and hormones by cucumber farmers.*

Brahmins share the highest proportion (37), followed by Chhetri (18). Male-headed households constitute the majority, accounting for 86.7% while female-headed households are in the minority, only representing 13.3%. This indicates a strong male dominance in household leadership within the study sample, which might reflect traditional societal norms in the area. Regarding the educational attainment of household heads, illiterate household heads represent 25% of the sample. Those with lower secondary education (up to grades 6–8) are 18.3%. Secondary-level education (grades 9–10) is the most common, comprising 28.3%. Likewise, higher secondary education (grades 11–12) is held by 9 respondents, accounting for 15%. However, only 2 respondents (3.3%) have a university-level education (Tables 1 and 2). This shows that many household heads have low to moderate levels of education, with very few having pursued education beyond the higher secondary level.

Production practices adopted by farmers related to GAP

Planting material and practice: The planting material used by all respondents is cucumber seed. The frequency is 60, which accounts for 100% of the valid responses (Figures 1 and 2). Most respondents (88.3%) obtain their planting material from Agrovet, while a smaller proportion (11.7%) obtain it from their own farm. Since the purchased seeds are already treated, no further treatment is done. 45% of the respondents stated that they are aware that the planting material they are using is certified (Table 3). Adhikari &Thapa (2023) reported that 69% used certified planting materials, whereas 31% used uncertified planting materials. In this, 70% of the farmers plant the recommended variety while 52% practice recommended spacing, which aligns with the result of Bajgain *et al.* (2024).

Soil management practices: Out of 60 respondents, 42 people (70%) practice mulching. This indicates that mulching is a widely adopted practice among the respondents, which is like findings of Ojha *et al.* (2024). A little over half of the respondents (60%) apply the recommended dose of fertilizer for cucumbers, indicating a general adherence to guidelines for optimal crop production, which is like the findings of Adhikari & Thapa (2023), where 63% of the respondents applied the recommended dose of fertilizer (RDF). Likewise, 75% of respondents have not tested their land, while only 25% have done so. Rijal *et al.* (2018) reported that 48.5% of the respondents have performed the soil test of their banana orchards in Chitwan. A significant majority of respondents (93.33%) integrate organic sources of nutrients

Table 3. Method of pest management by cucumber farmers.

Methods of pest management	Frequency (%)
Pheromone lure	1(2.7)
Sticky trap	24(64)
Pheromone lure + Sticky trap	6(16.21)
Pheromone lure + Sticky trap + Jholmol	3(8.1)
Sticky trap + Jholmol	3(8.1)
Total	37(100)

with chemical fertilizers, indicating a strong preference for combining both methods to enhance soil fertility and crop health. This result is like the finding of Rijal *et al.* (2018) who reported that 92.2% of the respondents used organic matter in the soil while planting bananabananasmajority of respondents (70%) apply vitamins for better growth, while (68.3%) do not apply plant hormones, indicating that this practice is not commonly adopted among them.

Irrigation practices: The primary source of water for irrigation in the study area is deeply boring, used by 70% of respondents. A smaller percentage relies on streams (18.3%) and municipal/pipe water (11.7%) (Table 4; Figures 3, 4). Rijal *et al.* (2018) reported that most of the farmers irrigate their fields by pumping groundwater and some of them through the canal. 60% of respondents use flooding as their irrigation system, while 40% use drip irrigation. This suggests that flooding, a more traditional method, is still the most widely used. Testing of water before application is not done by any of the farmers, which aligns with the result of Acharya *et al.* (2024). All the farmers reported that the irrigation status is rainfed, which means they do not depend on rainwater for irrigation. This result is like that of Kharel *et al.* (2023), who reported that all the GAP farmers had year-round water facilities for vegetable production.

Pest management practices: Sticky traps are the most used pest management method, adopted by 64% of respondents. The combination of pheromone lure and sticky traps is utilized by a smaller segment (16%), and the combination with Jholmol by 8%. Many respondents (65%) report wearing appropriate personal protective equipment (PPE) while handling pesticides, indicating a reasonable awareness of safety practices (Table 3). Ojha *et al.* (2024) reported that only 20% of respondents use personal protective equipment while spraying fertilizers and pesticides in Palpa. Likewise, all the respondents (100%) purchase their chemicals from licensed suppliers, and 61.7% of farmers responded that they adopt IPM methods, while about 65% apply the prescribed doses. Ojha *et al.* (2024) reported that 42% farmers use IPM in Palpa, Nepal.

Documents and records: Only 29% farmers are found keeping records of farm activities. This result is aligned with the report of Ojha *et al.* (2024), who reported 25% of aware farmers only keep any form of farm and crop records, while 75% of the farmers do not maintain records in Palpa.

Harvesting and post-harvesting practices: Hand harvesting of cucumber was adopted by 100% of respondents, indicating the absence of mechanized harvesting (Figure 5). This result aligns with the result of Ojha *et al.* (2024) in the citrus harvesting method in Palpa. Many respondents harvest biweekly (51.7%), indicating this is the most common frequency. Additionally, 21.7% harvest weekly, while 10% do so daily. A smaller portion (16.7%) falls under the "Others" category, which indicates 3-4 times a day (Figure 5).

Table 4. Binary logit regression output.

Determinants	Standard error	Odd ratio	P value
Gender(1=male,0=female)	1.077	2.488	0.397
Age of HH (Yrs.)	0.046	0.918	0.065
Education of HH(1=Literate,0=Illiterate)	0.758	0.315	0.127
Total land (ha)	0.448	1.033	0.942
Area under cucumber cultivation(ha)	2.807	26.012	0.246
Farming experience (Yrs.)	0.155	1.003	0.987
Summary Statistics			
Number of observation	60		
Log likelihood	58.875		
Pseudo R2	0.198		

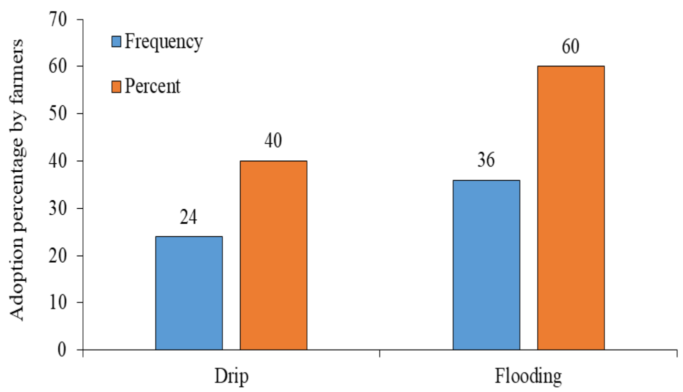

Figure 3. *Method of irrigation adopted by cucumber farmers.*

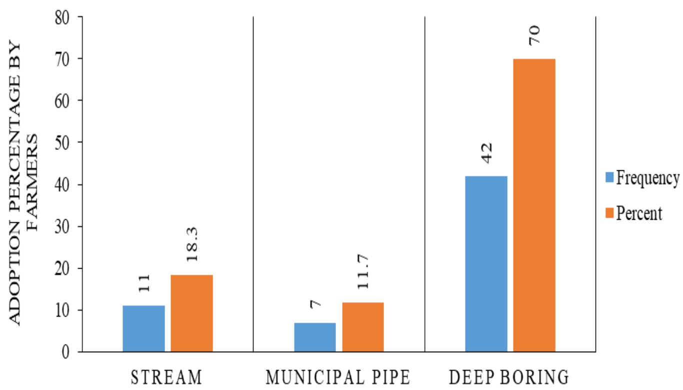

Figure 4. *Sources of irrigation used by the farmers.*

Table 5. Ranking of problems related to GAP adoption.

Problems	Index	Rank
Access to GAP input	0.68	II
Limited knowledge and training	0.63	III
Poor access to government services	1.39	I
Limited market incentives	0.58	IV

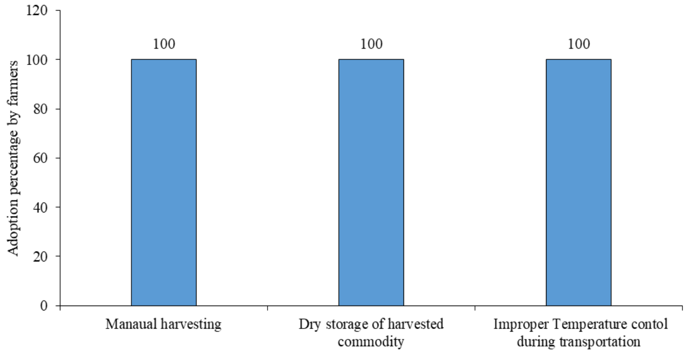

Figure 5. *Harvesting and storage practices of cucumber.*

Farm waste management: Management of degradable farm waste through composting is adopted by 40% of the respondents, while 35% leave it in the field. Additionally, 21.7% feed it to livestock, and a smaller portion (3.3%) uses vermicomposting. Vermicomposting is the least used method among the respondents. Likewise, 51.7% of respondents manage non-degradable farm waste by burning it, making this the most common method. Additionally, 40% collect it for disposal by municipal vans, while a smaller percentage (8.3%) choose to dump the waste. This suggests that burning is the primary practice for dealing with non-degradable waste, although a significant number of respondents also utilize municipal services for proper disposal. According to Ojha *et al.* (2024), 75% of the respondents disposed of the containers they use for chemical control safely, while 25% of respondents were found burning the cans after use in Palpa.

Factors affecting awareness of GAP: None of the independent factors such as the gender of the household head (HH), the age of HH, the education of HH, total farming experience, and total farm size were found statistically affecting the awareness of GAP among cucumber growers. However, the odds ratio of 2.488 of gender indicates that males are 2.49 times more likely to be aware of the gap compared to females. Odds ratio of age of HH indicates that a one-year increase in age decreases the odds of being aware of the gap by 0.918 times but is not statistically significant at the 5% level. An increase in the cucumber cultivation area greatly increases the odds of awareness, 26 times higher. Despite the large odds ratio, the result is not statistically significant.

Ranking of problems

Based on problems mentioned in the questionnaire and asked to farmers, the problems were ranked using the forced ranking method. Among all the mentioned problems decided after pre-testing of the questionnaire, poor access to government services was found to be the most significant barrier faced by stakeholders in adopting GAP with its index value being 1.39 (Table 5). The high index value suggests that participants in the study viewed the lack of sufficient government support, such as subsidies, policies, or technical assistance, as a primary obstacle. Likewise, the second most pressing issue was the limited availability or accessibility of essential inputs for implementing GAP, such as certified seeds, organic fertilizers, and pest control measures. Insufficient knowledge and training in GAP practices are ranked as the third most critical issue having its index value of 0.63. This indicates a need for capacity-building initiatives, such as farmer training programs and workshops, to improve awareness and skill levels. The least prioritized but still important problem was the lack of market-driven incentives, and its index value is 0.58.

Conclusion

Many respondents were unaware of Good Agricultural Practices (GAPs), which accounts for 75%. This is a serious problem prevailing in the study area and calls for efforts to be taken seriously to raise awareness among farmers. Only 25% of farmers being aware is a serious concern for all the stakeholders involved. Despite the low percentage of aware farmers, many of them still managed to apply GAPs in their farms, like the application of certified planting material, recommended dose of fertilizers (RDF), integration of organic nutrients, and integrated pest management (IPM). 70% of the farmers plant the recommended variety according to their location, while 52% practice recommended spacing, 60% apply the recommended dose of fertilizer (RDF) and almost all, i.e., 93.33% integrate organic sources of nutrients with chemical fertilizers. Likewise, 65% wear personal protective equipment (PPE) while handling chemicals, and 61.7% adopt integrated pest management, with 65% applying the prescribed doses of chemicals. All these practices are quite satisfactory and can be taken positively. However, not even a single respondent was found testing irrigation water, and a minority, i.e., 29% only keep records and documents of farm activities. Likewise, a vast majority, i.e., 75% do not test their soil and practice farming without the knowledge of the pH of their land. Overall, none of the independent variables were found to be statistically significant in awareness of GAP among cucumber growers. Respondents concluded that poor access to government services was the major problem related to the adoption of GAP, followed by poor access to GAP input, lack of knowledge and training, and lack of market incentives. These practices by a minimal percentage of farmers emphasize the need for active involvement of government as well as private bodies to make farmers aware of GAP and provide access to various GAP inputs.

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DECLARATIONS

Author contribution statement: Conceptualization: B.S.; Methodology: B.S. and B.K.; Software and validation: B.S., and B.K.; Formal analysis and investigation: B.S.; Resources: B.S.; Data curation: B.S.; Writing—original draft preparation: B.S.; Writing—review and editing: B.S., and B.K.; Visualization: B.K.; Supervision: B.S. and B.K.; Project administration: B.S.; Funding acquisition: B.S. All authors have read and agreed to the published version of the manuscript.

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