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ORIGINAL ARTICLE

Assessment of Adoption Levels of Chemical Pesticide Use Among Commercial Vegetable Growers in Central part of Uttar Pradesh

Gaurav Kumar[1*], R. K. Doharey[2], N. R. Meena[3], Aman Verma[4], Arvind Kumar[5], Anurag Shankar Singh[6]
[2,3]Ph.D. Scholar, [2]Professor & HOD [3]Assistant Professor,
[1,4,5,6]Department of Extension Education, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, U.P., India
***Corresponding author-** kumgaurav1993@gmail.com

ABSTRACT
This study investigates the adoption of safe pesticide practices among vegetable growers in the central region of Uttar Pradesh, particularly in the districts of Etawah, Kanpur Nagar, Unnao, and Jhansi, during the 2023-2024. 400 vegetable growers from 40 villages across eight community development blocks were surveyed. The study aimed to assess the adoption levels of various practices related to pesticide application, safety measures, pest control, personal protective equipment (PPE), and disposal methods. Results revealed a generally low to moderate adoption rate for many key pesticide safety measures. Many respondents partially adopted practices such as ensuring proper equipment cleanliness, pesticide calibration, and safe pesticide storage. Furthermore, only a small proportion of respondents fully adopted personal protective measures, including wearing gloves, goggles, and boots, with a notable percentage neglecting these practices entirely. The findings highlight the need for targeted educational interventions and the provision of accessible resources to enhance the adoption of safe pesticide use among vegetable growers. Increased awareness, better training, and improved extension services are essential to promoting sustainable farming practices, improving both the health of the growers and the long-term sustainability of the agricultural sector.
Keywords: *Pesticide Safety, Vegetable Growers, Personal Protective Equipment (PPE), Adoption Practices, Sustainable Agriculture.*

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INTRODUCTION

Vegetables play an integral role in agricultural diversification, providing employment opportunities and boosting nutritional security, which in turn enhances the economic conditions of farmers. Rich in essential nutrients such as vitamin C, vitamin K, dietary fiber, and vital minerals like calcium, magnesium, phosphorus, and potassium, vegetables are a cornerstone of a balanced diet [1]. These crops are crucial for public health, contributing to overall nutrition and well-being. According to the Indian Council of Medical Research (ICMR), a daily intake of at least 400 grams of vegetables and fruits, constituting about 8% of daily calorie consumption, is recommended [2].

India, as the second-largest global producer of vegetables, accounts for nearly 14% of the world's vegetable output [3]. The country's horticultural production is projected to reach 355.48 million tonnes in 2022-2023, marking an increase of 8.3 million tonnes (2.39%) from the previous year. The area under horticultural cultivation also grew by 1.41%, with vegetable production rising from 209.14 million tonnes in 2021-2022 to 212.55 million tonnes in 2022-2023. India is a global leader in the production of onions, ginger, and okra, and ranks second in potatoes, cauliflowers, brinjal, and cabbages [4]. In the 2023-24 period, India exported fruits and vegetables valued at Rs. 15,039.27 crores (US $1,814.58 million), with vegetables contributing Rs. 6,861.05 crores (US $828.26 million) to this total [5]. Vegetables have contributed 59-61 percent to India's horticultural crop production over the past five

years. There is a growing focus on high yields and producing better-quality vegetables, as these fetch higher prices. Vegetables are grown in diverse agro-climatic conditions across India, with major crops including onions, potatoes, tomatoes, cabbages, radishes, and cucumbers. India is the world's largest producer of cauliflower, the second-largest producer of onions, and among the top producers of cabbage, peas, potatoes, and tomatoes [6]. The development of high-yielding, disease-resistant varieties and hybrids has boosted vegetable production. However, these varieties often require excessive fertilizer, leading to pest problems. Farmers then turn to chemical pesticides, resulting in pest resurgence, harm to natural enemies, and destruction of beneficial insects [7].

299 insecticides/ pesticides are registered in India as of 01/07/2021 [8]. During 2020-21, Maharashtra had the highest total pesticide consumption, followed by Uttar Pradesh, Punjab, and Haryana [9]. Punjab had the greatest per acre pesticide consumption (0.74 kg), followed by Haryana (0.62 kg) and Maharashtra (0.57 kg) during the year 2016-17 [10]. However, per hectare use of pesticide in India is much lower as compared to other countries like China (13.06 kg/ha), Japan (11.85 kg/ha), Brazil (4.57 kg/ha) and other Latin American countries [12].

There are 293 pesticides registered in India, and it is reported that 104 pesticides are still being produced/used in the country despite being prohibited in two or more nations around the world Goi [8]. Of the total insecticides used for pest management in India, 50% are diverted to cotton pest management Mooventhan *et al*. [11]. the present study was aimed at measuring the extent of use of pesticides in commercial vegetable production and its direct impact on human health.

MATERIAL AND METHODS

The present study was conducted in 2023-24 to scrutinize the socio-economic traits of vegetable growers. Uttar Pradesh state comprises seventy-five districts; there are 21 districts in the central part of Uttar Pradesh. Out of these, four districts were selected by table random sampling. Etawah, Kanpur Nager, Unnao and Jhanshi. District was selected randomly for the study to understand the ground reality of commercial vegetable growers in the use of chemical pesticides in these districts. Data for the study was collected from a sample of 400 vegetable growers. Another consideration for selecting this district was the close familiarity of the investigator with this area, its people, official, nonofficial, and local dialects, which enabled the investigator to carry out the work more efficiently. Eight blocks were selected through a random sampling method. District Etawah comprises eight community development blocks, and two community development blocks, i.e., saifai and Basrehar, were selected randomly. Out of 10 Community Development blocks in Kanpur Nagar, Kakwan, and Shivrajpur blocks were selected randomly. Unnao district has sixteen blocks; out of these two blocks, Safipur and Bangarmau were selected randomly. Jhansi district has eight blocks; two Babina and Chirgaon blocks were selected randomly for the investigation. Considering the above facts, five villages were selected from each block. Thus, it makes up a total of 40 villages. A stratified random sampling method was adopted to select sample units. The data was collected through personal interview method with the help of pre-tested interview schedule. The data gathered were analysed for statistical treatments in the light of objectives. Mean score was obtained by total scores of each item divided by total number of respondents. The correlation coefficient ("r" value) was used to measure the relationship between dependent and independent variables.

Statistical Analysis of Data

The following statistical methods were used in the study for precise and meaningful analysis and interpretation of the data collected: Frequency, Percentage, Athematic Mean, Standard deviation and Correlation.

RESULT

Table 1: Distribution of respondents according to application equipment, drift control, and calibration.

S. No.	Category	Respondents					
		F. A.	%	P.A.	%	N. A.	%
1.	Do you take steps to ensure your application equipment is the correct choice for the job?	43	10. 75	210	52.50	147	36.75
2.	Do you make sure your application equipment is clean and in good working order?	35	08. 75	205	51.25	160	40.00
3.	Do you make sure your application equipment is calibrated?	41	10. 25	207	51.75	156	39.00
4	Do you read the label given on the pesticide container?	37	09. 25	196	49.00	167	41.75
5	Do you wash all equipment after use?	98	24. 50	198	49.50	104	26.00

FA= Fully Adoption, PA= Partial Adoption, NA= No adoption

Table 1 revealed that the adoption of practices related to application equipment, drift control, and calibration among vegetable growers is generally low to moderate. A significant percentage of growers partially adopted the use of the correct application equipment for specific tasks, while a substantial portion did not adopt this practice. Only a small proportion fully adopted this approach. Regarding the cleanliness and maintenance of equipment, most growers partially adopted this practice, while a notable percentage did not, with only a small portion fully adopting it. Equipment calibration showed a similar trend, with a majority partially adopting the practice and a considerable number not adopting it, while a small percentage fully adopted calibration before use. Reading pesticide container labels was partially adopted by many growers, but a significant number did not adopt this practice, and only a small percentage fully adhered to it. Lastly, a large portion of growers partially adopted the practice of washing equipment after use, while a smaller proportion did not wash their equipment, and only a few fully adopted washing practices. These findings highlight a need for greater awareness and resources to improve the adoption of these practices in vegetable farming.

Table 2- Distribution of respondents according to safe transportation, storage, handling, disposal.

S.No.	Category	Respondents					
		F. A.	%	P.A.	%	N. A.	%
1.	When you transport pesticides, do you take steps to do so safely?	87	21.75	205	51.25	108	27.00
2.	When you store pesticides, do you take steps to do so in a safe manner?	42	10.50	195	48.75	163	40.75
3.	When you dispose of excess pesticides and/or containers, do you take steps to do so safely?	35	08.75	198	49.50	167	41.75
4	When you mix and load, do you take steps to do so in a safe manner?	39	09.75	196	49.00	165	41.25

FA= Fully Adoption, PA= Partial Adoption, NA= No adoption

Table 2 illustrated the adoption of safety measures related to the transportation, storage, handling, and disposal of pesticides among vegetable growers. Most growers partially adopted safety measures for pesticide transportation, while a significant portion did not adopt these practices at all, and only a small percentage fully adopted the safety measures. Regarding the safe storage of pesticides, most growers partially followed the proper storage guidelines. In contrast, a considerable portion did not follow them, with only a small proportion fully adopting safe storage practices. Regarding the disposal of excess pesticides or empty containers, most growers partially adopted safety measures, with a significant number not adopting them, and only a few fully adopted safe disposal practices. Lastly, most growers partially adopted safety measures for mixing and loading pesticide solutions. In contrast, many did not adopt them, and only a small percentage fully adhered to safety protocols. These results suggest a need for increased education and support to encourage the full adoption of safety practices in pesticide management.

Table 3- Distribution of respondents according to adoption pests pest control

S. No.	**Category**	**Respondents**					
		F.A.	**%**	**P.A.**	**%**	**N.A.**	**%**
1.	Do you use IPM (integrated pest management)?	10	02.25	130	32.50	260	65.00
2.	Do you use the lowest rate of pesticide possible?	32	08.00	154	38.50	214	53.50
3.	Do you identify the pest before choosing your control measure?	35	08.75	115	28.75	250	62.50

FA= Fully Adoption, PA= Partial Adoption, NA= No adoption

Table 3 revealed the adoption of pest control practices among vegetable growers. The data shows that most vegetable growers did not adopt Integrated Pest Management (IPM) practices, with a smaller portion partially adopting it and very few fully adopting it. Similarly, most growers did not use the lowest possible pesticide rate, although a considerable percentage practiced partial adoption, and a small proportion fully adopted the practice. Regarding pest identification before control measures, most growers did not identify the pest, while some partially adopted pest identification practices, and only a small percentage fully adopted them. The findings highlight significant gaps in the adoption of pest control practices, suggesting that further education and training could improve the adoption of these important measures.

Table 4 - Distribution of respondents according to plant protection practices safety

S. No.	Category	Respondents					
		F.A.	%	P.A.	%	N.A.	%
1.	Do you cover your body during pesticide application?	54	13.50	137	34.25	209	52.25
2.	Do you make sure that you are protected from exposure to pesticides?	49	12.25	113	28.25	238	59.50
3.	Do you make sure that you are not exposing others to pesticides?	43	10.75	121	30.25	236	59.00
4	Do you use the right pesticide to do the job with the least toxicity to humans?	39	09.75	119	29.75	242	60.50
5	Do you clean, maintain, and store your Personal Protective equipment properly?	68	17.00	189	47.25	143	35.75
6	Do you keep up your education on pesticide safety?	58	14.50	146	36.50	196	49.00

FA= Fully Adoption, PA= Partial Adoption, NA= No adoption

Table 4 illustrated the adoption of plant protection practices related to safety among vegetable growers. Many vegetable growers did not adopt measures to cover their bodies during pesticide application. At the same time, some practiced partial adoption, and only a small group fully adopted body protection. Similarly, the majority did not ensure protection from pesticide exposure, with some partially adopting safety measures and only a few fully adopting protective practices. Regarding exposure to others, most did not ensure others were protected from pesticide exposure, with some partially adopting this practice, and just a small group fully adopting it. Most growers did not use the least toxic pesticide, while a smaller group partially adopted less toxic pesticides, and only a few fully adopted it. When it comes to maintaining and storing personal protective equipment (PPE), many growers partially adopted proper care, with a portion not maintaining PPE, and only a few fully adopting this practice. Lastly, only a few vegetable growers fully adopted keeping up their education on pesticide safety, with some partially adopting this practice. At the same time, many did not engage in further education on pesticide safety. These findings indicate a significant gap in adopting safety practices and suggest the need for enhanced education and resources to improve safety measures among vegetable growers.

Table 5- Distribution of respondents according to use of personal protective equipment

S. No.	Category	Respondents					
		F.A.	%	P.A.	%	N. A.	%
1.	Wear rubber gloves	32	08.00	86	21.50	282	70.50
2.	Wear Goggles	25	06.25	48	12.00	327	81.75
3.	Wear Boots	23	05.75	35	08.75	342	85.50
4	Wear Nose Mask	50	12.50	104	26.00	246	61.50
5	Wear Caps/Hats/ gamchha	197	49.25	105	26.25	98	24.50

FA= Fully Adoption, PA= Partial Adoption, NA= No adoption

Table 5 illustrated the adoption of personal protective equipment (PPE) among vegetable growers. Most respondents did not wear rubber gloves, with only a small percentage fully adopting the practice. A similar trend is seen with goggles, where most growers did not adopt the practice, and only a few fully adopted it. The use of boots was also minimally adopted, with the vast majority not wearing them during pesticide application. For nose masks, most vegetable growers did not adopt the practice, and only a small fraction fully adopted the use of masks. However, the use of caps, hats, or gamchha was relatively more common, with a significant portion of respondents fully adopting this practice, while others partially adopted it. Overall, the adoption of PPE is low across most categories, indicating a need for increased awareness and better access to protective equipment for vegetable growers.

Table 6 - Distribution of respondents according to disposal of empty pesticide containers.

S. No.	Category	Respondents					
		F.A.	%	P.A.	%	N. A.	%
1.	Burning	32	08.00	76	19.00	301	75.25
2.	Burying	29	07.25	39	09.75	332	83.00
3.	Washing and reusing at home	53	13.25	105	26.25	242	60.50
4	Reuse for storage of other pesticides	55	13.75	145	36.25	200	50.00
5	Throw outside	189	47.25	143	35.75	68	17.00

FA= Fully Adoption, PA= Partial Adoption, NA= No adoption

Table 6 highlighted the disposal practices for empty pesticide containers among vegetable growers. Most respondents did not adopt burning as a disposal method, with only a small percentage fully adopting it.

The practice of burying pesticide containers showed even lower adoption, with most growers not engaging in it, while a small fraction partially adopted this method. Similarly, washing and reusing containers at home was not widely adopted, with the majority not engaging in this practice, although some partially adopted it. Reusing containers for storing other pesticides was also not commonly practiced, with half of the respondents not adopting it and only a small portion fully adopting it. The most commonly reported disposal method was throwing the empty containers outside, which was fully adopted by many respondents. However, a large number of vegetable growers partially adopted this method, while a smaller proportion did not adopt it at all. This indicates a need for better awareness and safer practices for disposing of pesticide containers.

Table 7- Correlation coefficient (r) between different independent variables and adoption.

S. No.	Independent Variable	Correlation Coefficient 'r' value
1.	Age	-0.588**
2.	Education	0.428**
3.	Religion	0.0739^{NS}
4.	Caste	0.224*
5.	Gender	0.001^{NS}
6.	Size of Family	0.052^{NS}
7.	Type of family	0.013^{NS}
8.	Extension contacts	0.516**
9.	Occupation	0.014^{NS}
10.	Land Holding (ha.)	0.593**
11.	Irrigation sources	0.008^{NS}
12.	Social Participation	0.593**
13.	Material possession	0.273*
14.	Annual Income (Lakh)	0.540**

**Significant at 0.05% probability level*
*** Significant at 0.01% probability level*

Table 8 makes it clear that there is a negative yet strong correlation between age. The degree of farmers' adoption of chemical pesticides for commercial vegetable growers was found to be positively connected with education, extension contact, land holding, social participation, and annual income. The degree to which farmers adopted the use of chemical pesticides by commercial vegetable growers was positively connected with factors such as caste and material possession, which were determined to be somewhat significant. Religion, gender, family size, type, occupation, and irrigation were found to have a positive but non-significant correlation with farmers' adoption of chemical pesticides for commercial vegetable growers.

DISCUSSION

The findings from the study on adopting safe pesticide practices among vegetable growers provide valuable insights into the current status of pesticide use and safety measures in the region. A key observation from the data is that the adoption of practices related to pesticide application, equipment maintenance, and safety is generally low to moderate, with a significant number of growers only partially adopting recommended practices.

Regarding application equipment, drift control, and calibration (Table 1), most vegetable growers either did not fully adopt these practices or only partially adopted them. The data reveals that a significant proportion (52.50%) of respondents reported partial adoption in ensuring that their application equipment is the correct choice for the job, while only 10.75% fully adopted this practice. Similarly, for equipment cleanliness and calibration, many growers only partially adhered to these guidelines, with only a small fraction fully adopting them. This suggests that while vegetable growers may understand the importance of using well-maintained equipment for efficient pesticide application, logistical or resource constraints likely hinder full adoption. In particular, the high number of respondents reporting no adoption indicates a gap in awareness or resource availability, suggesting a need for further education and training on the importance of these practices [13].

Regarding safe transportation, storage, handling, and disposal of pesticides (Table 2), the adoption of safety measures was similarly low to moderate. A significant percentage of respondents (51.25%) partially adopted practices for safe pesticide transportation, while a smaller group (21.75%) fully adhered to them. This trend was consistent across the other categories such as storage, disposal, and

mixing of pesticides, where partial adoption rates were notably higher than full adoption. The low adoption rates in these critical areas highlight the need for targeted education and practical training to improve growers' understanding of safe pesticide handling, which is essential for minimizing environmental contamination and health risks.

The results from (Table 3) regarding pest control practices reveal that Integrated Pest Management (IPM) adoption remains very low, with the vast majority of growers not using IPM (65.00%). This finding aligns with other studies [15] that suggest that smallholder farmers face challenges in adopting sustainable pest control practices due to limited resources, knowledge, and reliance on chemical pesticides. This trend was further reflected in the low rates of pesticide rate minimization (53.50%) and pest identification (62.50%), with most growers opting for traditional pesticide application methods without a proper understanding of pest species or the optimal pesticide doses. The partial adoption of IPM practices and pest control measures highlights the need for more in-depth, region-specific education programs on IPM that can equip farmers with the necessary skills and knowledge [14].

Tables 4 and 5 shed light on the adoption of plant protection safety practices. Notably, the adoption of personal protective equipment (PPE) during pesticide application was low, with only a small percentage of growers fully adopting practices such as wearing gloves (8.00%), goggles (6.25%), or boots (5.75%). However, the use of caps, hats, or gamchhas was more commonly practiced, with 49.25% of growers fully adopting this measure. This indicates a partial understanding of the importance of PPE and a significant gap in adopting more comprehensive protective measures. The low adoption of PPE is a cause for concern, as pesticide exposure poses serious health risks to both farmers and their families. Providing affordable access to protective gear and conducting regular safety awareness campaigns could significantly enhance PPE adoption.

Disposal of empty pesticide containers (Table 6) is another area where adoption rates were low. Many growers (75.25%) disposed of empty containers by throwing them outside, a practice that poses significant environmental hazards. Only a small percentage of growers (13.75%) reused containers for pesticide storage, which could increase the risk of pesticide contamination. The most appropriate disposal practices, such as burning or burying pesticide containers, were underused, with only a small proportion fully adopting them. This points to a lack of awareness regarding the environmental and health impacts of improper disposal, suggesting that further education on safe disposal methods is urgently needed.

Lastly, It is evident from the Table 7. that negative but highly correlated (age). education, extension contact, land holding, social participation and annual income were found highly significant and positively correlated with the extent of adoption of farmers regarding use of chemical pesticides commercial vegetable growers. The variables like caste and material possession were found moderately significant and positively correlated the extent of adoption of farmers regarding use of chemical pesticides commercial vegetable growers.

CONCLUSION

The study reveals a low to moderate level of adoption of safe pesticide practices among vegetable growers, with significant gaps in the full implementation of recommended safety measures. The data shows that many growers partially adopt practices related to pesticide application, equipment maintenance, safe transportation, storage, handling, and disposal. A particularly concerning trend is the low adoption of Integrated Pest Management (IPM) and proper pest identification methods, with most growers still relying on traditional pesticide application techniques. Additionally, adopting personal protective equipment (PPE) is alarmingly low, highlighting the need for greater awareness of the health risks associated with pesticide exposure. The findings also suggest that barriers such as limited knowledge, inadequate resources, and lack of training influence adoption levels. To improve pesticide safety practices, targeted educational programs, hands-on training, and accessible resources are essential. Collaboration between government, agricultural organizations, and private sectors can create an environment that supports the full adoption of safe pesticide practices, ultimately reducing health risks and environmental impact while enhancing the sustainability of vegetable farming.

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