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ORIGINAL RESEARCH ARTICLE



## Pesticide use in banana cultivation: Insights into farmers' knowledge and practices in Nawalparasi west, Nepal

Prapti Ghimire<sup>1\*</sup> , Surya Dhungana<sup>2</sup>, Samikshya Pokhrel<sup>1</sup>, Manjita Tiwari<sup>1</sup> and Aashis Subedi<sup>1</sup>

<sup>1</sup>Department of Agriculture, Agriculture and Forestry University, Chitwan, Nepal

<sup>2</sup>Department of Genetics and Plant Breeding, Agriculture and Forestry University, Chitwan, Nepal

\*Corresponding author's E-mail: [praptighimire58@gmail.com](mailto:praptighimire58@gmail.com)

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### ABSTRACT

Banana is one of the most important fruit crops in Nawalparasi West Nepal's serving as a significant production hub. This study was aimed to investigate the knowledge and practices of 100 randomly selected banana farmers regarding pesticide use in two rural municipalities of Nawalparasi West, Nepal. The data was collected through structured survey and were analyzed using MS- Excel and Statistical Package of Social Sciences (SPSS). The study revealed a significant ( $p < 0.05$ ) gap in knowledge with 45% farmers unaware of pesticide labels and only 33% farmers being knowledgeable of Restricted Entry Interval (REI). Despite the widespread reliance on chemical pesticides, only 29% farmers had received training on safe handling practices while 70% farmers had no knowledge on banned pesticides in Nepal. Also, Sigatoka leaf spot and Banana leaf and fruit scarring beetle was highlighted as the major disease and insect affecting banana farming. Among protective measures were insufficient, 82% farmers using only masks but fewer adopting gloves (4%) or aprons (3%) during application of pesticides. Health issues such as burning sensation and skin irritation were commonly reported due to pesticide exposure. Additionally, unsafe storage of pesticide cans and containers were observed, and only 30% farmers storing them in separate storage houses. The study underscores the urgent need for targeted training programs to promote Integrated Pest Management (IPM) and safe pesticide handling practices. Enhancing farmers' awareness through extension activities and policy interventions is critical to mitigate health risks and environmental damage.

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### INTRODUCTION

Banana (*Musa paradisiaca* L.), belonging to the family Musaceae, is one of the most important tropical fruit crops worldwide. Commonly referred to as the "Apple of Paradise," it thrives in warm climates with a temperature range of 15–35°C and relative humidity of 75–85%. Nutritionally, bananas are a rich source of potassium and provide moderate amounts of phosphorus, calcium, and magnesium (Ghimire *et al.*, 2023). A medium-sized banana contains approximately 105 kilocalories, making it both a nutritious and energy-dense fruit (Kothawade, 2019). In Nepal, banana cultivation occupies approximately

5,158 hectares, with an annual production of 116,718 metric tons and an average productivity of 22.63 metric tons per hectare (Ghimire *et al.*, 2023). Recognized as a high-value crop, banana contributes 0.85% to the national GDP (MoALD, 2021). Despite its economic significance, banana production in Nepal faces major challenges from biotic stresses. Farmers frequently incur substantial losses due to pest infestations and plant diseases (Tiwari *et al.*, 2006). Inadequate quarantine and phytosanitary measures have facilitated the introduction and spread of pathogens and pest species (Ramsey *et al.*, 1990). Diseases such as Fusarium wilt, which remains in the soil for several years and affects nearly all cultivars (Pérez-vicente, 2004), as well as

Sigatoka leaf spot and Banana Bunchy Top Virus, are commonly reported (Ghimire & Regmi, 2024). Additionally, over 470 species of mites and insects are known to attack banana crops globally (Bari et al., 2024), with the banana leaf and fruit scarring beetle causing significant damage during the rainy and summer seasons (Bari et al., 2024).

In response to biotic challenges, the use of chemical pesticides has become widespread among farmers. Subsequently, data from the Plant Quarantine and Pesticide Management Center indicate an average annual increase in pesticide imports by 30.48 tons of active ingredients over the past two decades (Khanal et al., 2021). The national average pesticide consumption is estimated at 396 grams a.i./ha, which is slightly lower than the global average of 0.5 kg a.i./ha (Poudel et al., 2020). Despite the increasing reliance on pesticides, misuse and lack of awareness pose serious risks for 61.38%, insecticides 29.19%, herbicides 7.43%, and other categories 2% (Rijal et al., 2018). Pesticide costs represent about 8.28% of total banana production expenses (Ghimire et al., 2019). The primary issues related to pesticide use in Nepal include the repeated use of a limited number of active ingredients, excessive application rates, and inadequate user knowledge regarding pesticide classification and toxicity (Rijal et al., 2018). The situation is exacerbated by the use of outdated, highly toxic, and persistent chemicals, especially in developing countries. Moreover, limited technical awareness and absence of proper safety measures increase farmers' exposure to harmful substances (Rijal et al., 2018).

Farmers often mix pesticides using bare hands, and nearly 80% rely solely on chemical control methods. Alarmingly, 90% of these farmers are unaware of the adverse health and environmental effects associated with pesticide use (GC & Neupane, 2019). Due to this knowledge gap, pesticides are frequently applied 10–15 times more than the recommended level (Tara et al., 2019). Studies have shown that discomfort and inconven-

ience discourage farmers from using personal protective equipment (Thapa et al., 2021). Additionally, around 80% of farmers are unaware of banned pesticides, and 90% are unfamiliar with the classification of the chemicals they use (Kumar et al., 2021). Understanding farmers' knowledge, perception, and practices regarding pesticide use is critical for identifying existing gaps and mitigating health and environmental hazards. Therefore, this study was undertaken to analyze the current status of pesticide use in banana cultivation, identify major pest and disease challenges in the field, document farmers' awareness and health-related experiences linked to pesticide exposure, and to assess storage, hygiene, and disposal practices related to pesticide handling in Nawalparasi West, Nepal.

## MATERIALS AND METHODS

### Description of the study area

The study was conducted in Nawalparasi West, a district situated in the Lumbini Province of Nepal as shown in Figure 1. Geographically, it lies between 27.32° N latitude and 83.40° E longitude. The district is traversed by the East-West Highway and shares its borders with Nawalpur district to the east and Rupandehi district to the west. Parasi serves as the district headquarters. The region records an average banana productivity of 17.02 metric tons per hectare, which exceeds the national average of 16.66 Mt/ha (MoALD, 2022). The production and productivity of banana according to seven provinces in Nepal are given in Table 1. The research focused on banana growers within the Banana Zone of the Prime Minister Agriculture Modernization Project (PMAMP), specifically targeting two rural municipalities: Trivenisusta and Pratappur. Within these municipalities, wards 5, 6, 7, and 8 of Pratappur and wards 3, 4, and 5 of Trivenisusta were selected for data collection, as they are officially registered under PMAMP Rupandehi as part of the designated banana zone.

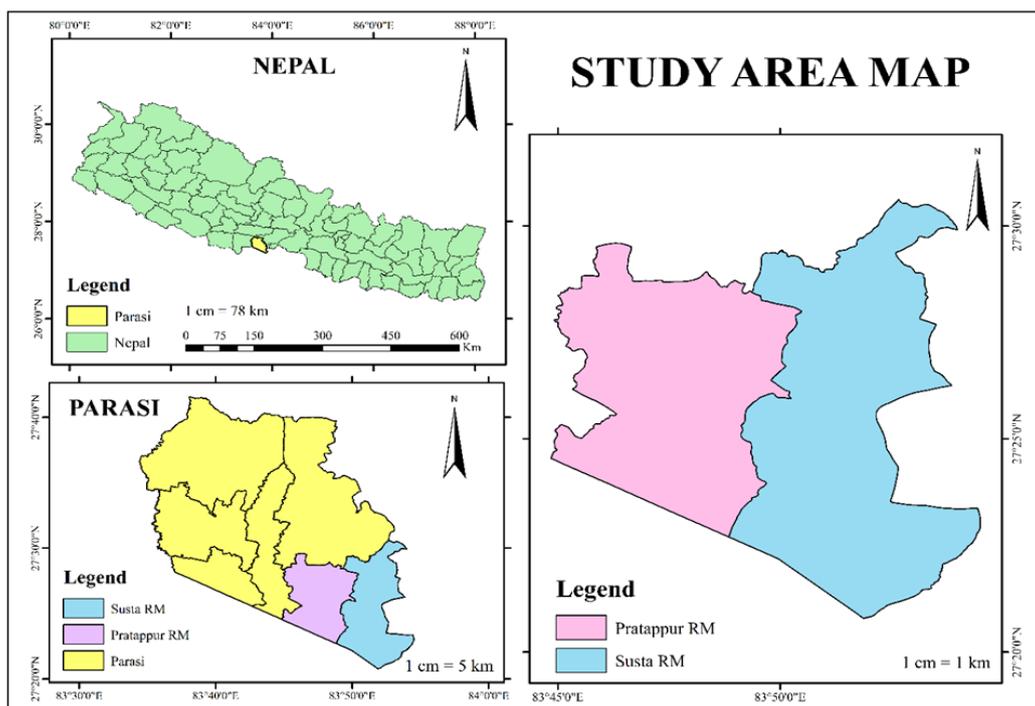


Figure 1. Map of Nawalparasi West, Nepal showing the study area.

**Table 1.** Province wise production and productivity of Banana in Nepal (MoALD, 2022).

Provinces	Production (Mt)	Productivity (Mt/ha)
Koshi	91,257	16.54
Madesh Pradesh	88,745	16.16
Bagmati	65,444	19.01
Gandaki	32,481	15.61
Lumbini	92,231	16.41
Karnali	3,316	10.30
Sudurpaschim	31,197	17.27
Total	404,670	16.66

### Sampling procedure and data collection

The sampling frame included all banana farmers registered under PMAMP in the Trivenisusta and Pratappur rural municipalities. Out of a total of 2,107 registered banana growers, the sample size was determined using the Rao soft sample size calculator with a 10% margin of error. Based on this calculation, 100 farmers were selected through a simple random sampling technique. A structured questionnaire was designed comprising both open-ended and close-ended questions to gather information on pesticide use, application methods, knowledge and awareness, disposal practices, pest and disease incidence, and health and environmental impacts. The questionnaire was informed by an extensive review of literature related to farmers' perceptions and practices regarding pesticide use in agriculture. Prior to final data collection, a pre-survey visit was conducted in key banana-growing regions of Nawalparasi West to assess field conditions and common farming practices. Informal interactions were held with farming families to guide the development of context-relevant questions. The questionnaire was pre-tested with 10 farmers (10% of the sample) to evaluate its clarity, relevance, and reliability. Primary data were collected through face-to-face interviews, field observations, and informal discussions with respondents. Direct observations were also conducted during pesticide application to verify reported practices. Secondary data were obtained from official publications and databases, including PMAMP profiles, agricultural yearbooks, journals, newspapers, the *Krishi Dairy*, the Agriculture Perspective Plan (APP), the Agriculture Development Strategy (ADS), and records from the Ministry of Agriculture and Livestock Development (MoALD).

### Data analysis

Both qualitative and quantitative data were processed and analyzed using Microsoft Excel and the Statistical Package for the Social Sciences (SPSS) version 29. Descriptive statistics were used to summarize the socio-economic characteristics of respondents (e.g., education level, family size, landholding), as well as their knowledge, perceptions, and practices related to pesticide use. For multiple-response questions including pesticide poisoning symptoms and sanitation practices, all answers were included and frequencies were computed based on total response counts. Inferential analysis was performed using the chi-square ( $\chi^2$ ) test to determine associations between socio-demographic variables and pesticide-related practices. Problem

ranking for pest and disease constraints in banana cultivation was conducted using a forced ranking method. This technique, validated in previous studies (Hazels & Sasse, 2008; Rajeev, 2012), was employed to determine the perceived severity of key challenges.

$$I_{imp} = \sum (SiFi / N)$$

Where,

$I_{imp}$  = Index of importance

$S_i$  = Scale value of  $i^{th}$  priority

$F_i$  = Frequency of  $i^{th}$  priority

$N$  = total number of respondents

## RESULTS AND DISCUSSION

### Sociodemographic information

In this study, the farmers' average age in the study area as shown in Table 2, was 44.48 years, and average family size was 7.95, which was significantly ( $p < 0.05$ ) higher than the total national average household size of 4.33, as per Census Statistics (CSN, 2021). This larger household size may be due to extended family structures common in rural Nepal, where multi-generational cohabitation is prevalent. It could also imply more available labor of farm activities, particularly in labour intensive crops like banana. Farming households had an imbalance of gender, with a mean of 4.19 females and 3.75 males per household, indicating a higher proportion of females in farming households. The predominance of female may reflect male outmigration to urban centers or abroad for employment, leaving women more involved in agricultural tasks. In terms of land ownership, the average size of land devoted to banana farming was 1.565 hectares, of which 1.076 hectares was owned and 0.498 hectares was taken on lease. This indicates that a high proportion of land is taken on lease for banana farming, reflecting the prominence of the crop in Nawalparasi West. Educational levels of the respondents were divided into five groups: illiterate, primary (nursery to grade 5), lower secondary (grades 5 to 8), higher secondary (grades 8 to 12), and bachelor's level (post grade 12). Of the respondents, 35% had read up to the primary level, 16% had done higher secondary education, 13% had achieved a bachelor's degree, while just 11% had gone up to the lower secondary level. These figures indicate a low level of formal education among farmers, which might influence their ability to access and interpret agricultural information or adopt new technologies. Religiously, the majority (73%) were Hindu, with 23% Muslims and 4% Buddhists. Agriculture was reported as the main source of income by 82% of the farmers, while 10% were in business and 8% in the service sector. The findings point to the overwhelming position of agriculture in the farmers' livelihood in the region. This is also supported by another research conducted by Ghimire & Regmi (2024), in which it was found that most of the farmers in Nawalparasi West, approximately 90%, relied on agriculture as a significant source of income.

Half of the farmers' share (47%) consisted of 6–10 years of experience in banana cultivation. Similarly, 34% (34) experienced banana farmers have grown banana plants for 1–5 years and 12% (12) have grown bananas for 11–15 years. It is 7% (7) only among farmers, which was related to over 15 years' experience in growing banana plants. This suggests that banana cultivation is a relatively recent agricultural practice in the region for many farmers. Another such study by Ghimire & Regmi (2024) in Nawalparasi West had reported that the farmers with an experience of 4–6 years in banana cultivation were in excess of 45%. With regard to technical competence in the application of pesticides, 29% (29) of farmers had been trained in safe use of pesticides while 71% hadn't received any form of training. This concurs with the findings by Aldosari et al. (2018), who found that 82.1% of farmers hadn't received training in the safe use of pesticides. The lack of awareness and training may lead to unsafe practices and health risks and underscores the urgent need of targeted interventions and farmer training programs in safe handling of pesticides.

### Problem ranking of banana field

The initial field visits and informal discussions with local farmers helped identify particular production constraints to banana growing. Later, farmers were requested to rate the aforementioned constraints on a scale of their perceived severity and impact on banana production. As per the findings, diseases and pest infestations were reported to be the worst notable hurdles. Subsequently, ranked in order were high input costs, lack of access to credit, price instabilities, lodging, and drought. Pertaining to severe concerns, the high inputs' costs comprised of fertilizers, planting materials, organic manures, and labor. Most

farmers appeared to be dissatisfied with the credit facilities provided by government institutions. The disease and pest pressures were more pronounced than any other challenge further supporting Ghimire et al. (2019) findings. Sigatoka leaf spot among infections was recorded as highly prevalent and severe with a 0.883 disease severity index (Table 3). Ranging second, Panama wilt was categorized as a devastating soil-borne plague followed by Bunchy top virus and bacterial wilt which were ranked third and fourth respectively. Regarding insect pests, banana leaf and fruit scarring beetles were reported as the most damaging, with a pest severity index of 0.940 (Table 3). This finding is consistent with the study by Ghimire & Regmi (2024), who reported these beetles as the most significant pest species in banana fields, with an index value of 0.51. The high index reflects the substantial damage inflicted on banana leaves and fruits, adversely affecting marketability. The banana stem and rhizome weevil was ranked the second most important pest followed by banana aphids and scale insects.

### Knowledge among farmers regarding pesticides and their use

All 100 farmers interviewed were using chemical pesticides and were solely dependent on them for pest and disease management. However, 11% of the respondents also reported the use of botanical pesticides, i.e., neem extract, in addition to chemical products. This finding aligns with Rijal et al. (2018), who reported that only 16% of farmers utilized botanical or biological control methods in pest management. As regards the reasons for the use of chemical pesticides, 35% of the farmers cited their fast-acting nature, while 31% ranked ease of use first. In addition, 26% of the farmers believed that chemical pesticides were a necessity due to their easy availability, and 7% found them

**Table 2.** Demographic characteristics of respondent farmers and households in Nawalparasi West, Nepal.

Variables	Minimum	Maximum	Mean ± Standard Deviation
Age of respondent farmers	19	72	44.860±12.390
Family size	2	22	7.950±3.260
Male numbers in the family	1	14	3.730±1.922
Female numbers in the family	1	12	4.190±1.973
<b>Land holding</b>			
Land under banana cultivation (hectare)	5.000	0.300	1.5655±0.987
Own land (hectare)	3.750	0.100	1.076±0.751
Leased land (hectare)	3.000	0.000	0.498±0.562

**Table 3.** Ranking of major problems in banana cultivation in Nawalparasi West, Nepal.

Problems	Index Value	Rank
Disease and pests	0.886	I
High costs of input	0.746	II
Limited credit facilities	0.683	III
Seasonal price fluctuation	0.393	IV
Lodging	0.390	V
Drought	0.386	VI
<b>Diseases</b>		
Sigatoka Leaf Spot	0.883	I
Panama Wilt( Fusarium Wilt)	0.723	II
Banana Bunchy Top	0.475	III
Bacterial Wilt	0.415	IV
<b>Insects</b>		
Banana Leaf and Fruit Scarring Beetle	0.940	I
Banana Stem and Rhizome weevil	0.688	II
Banana Aphid	0.538	III
Scale insects	0.338	IV

relatively inexpensive. Only 1% of the farmers considered efficacy to be the primary reason for the use of chemical pesticides. These preferences indicate a tendency towards short-term convenience over long-term sustainability. As shown in Figure 2, agro-veterinary (agro-vet) suppliers were the primary source of information related to pesticides, and 44% of farmers depended on them. In the same way, 19% of farmers indicated dependence on personal experience or knowledge, and an equal percentage got information from fellow farmers in the neighborhood. Just 18% sought the advice of agricultural technicians for pesticide choice, dosage, or effectiveness, which reflects limited access to professional extension services. These findings are supported by Rijal et al. (2018), who identified that 55% of the farmers relied on agro-vets and 26% on personal experience. Jyoti et al. (2023) also confirmed that agro-vet and pesticide dealers were the primary source of information for 77% of the surveyed people. Alarming, none of the respondents were aware of pesticide residues, pointing to a significant knowledge gap in food safety and environmental risks. Only 34% were aware of the potential impact of pesticide exposure on human health, and only 30% were aware of pesticides prohibited in Nepal. Further, only 29% of the farmers were informed about vendors' license status, highlighting a general lack of regulatory awareness.

In terms of application frequency, 43% of the farmers determined application frequencies based on pest severity. Agro-vet recommendation influenced 32% of the farmers, while 13% determined the frequency based on pesticide availability. Additionally, 12% utilized suggestions from other farmers. These practices highlight the unstructured and often informal methods of decision making in pest control. Statistical analysis also showed the existence of a significant relationship between farmers' age and their practice in handling pesticide quality ( $\chi^2 = 43.418$ ,  $df = 3$ ,  $p < 0.001$ ). The older farmers (>40 years) would more readily rely on peer recommendation and had no concern for pesticide quality, whereas younger farmers (<40 years) would prefer to consult agricultural technicians or conduct their own inquiries before selecting pesticides. This indicates that younger generations may be more receptive to training and modern practices, suggesting a pathway for targeted educational programs. In addition, 70% of the farmers did not let pest or disease infestations reach economic threshold levels prior to spraying pesticides, whereas 30% of them did. This early and possibly unnecessary pesticide use contributes to overuse and resistance buildup. This corroborates Rijal et al. (2018), who reported that 54% of farmers sprayed pesticides as soon as pests were noticed in their farms. Awareness and compliance with the Restricted Entry Interval (REI)—the time to wait before re-entering a pesticide-sprayed area (EHS, 2013)—was discovered to be very low. Only 33% of the farmers were aware of REI information, while 77% had no awareness at all, reflecting a big gap in pesticide safety practices and increases risks of pesticide exposure. Regarding label comprehension, 45% of farmers lacked any knowledge about pesticide labeling. Among the 55 farmers who had knowledge about pesticide color labels, 61.8% applied yellow-label pesticides, 20% applied green-label pesticides, 14.5% applied blue-label, and 4%

reported applying highly hazardous red-label pesticides (Figure 3). This shows that while some farmers are familiar with labeling, many still use moderately to highly hazardous pesticides. The same trend was seen by Kafle et al. (2021), who recognized that 62% of the farmers had no idea about pesticide labeling and color codes. Jyoti et al. (2023) further observed that more than half of the farmers interviewed ignored label color codes while handling pesticides.

### Practices on pesticide use

Among farmers surveyed, 40% (40) preferred the Indian market for purchasing pesticides, and merely 17% (17) of them purchased from the Nepali market. 43% of farmers purchased pesticides from both markets. It is a reflection of the dominance of the Indian market, which would be due to the fact that banana-producing areas of Nawalparasi West are near the border of India. This reliance also raises concern about regulatory oversight, quality control and the possible use of unregistered or banned chemicals. As far as pesticide measurement procedures are concerned, the majority (60%) used a measuring jar in measuring the correct amount of pesticide to put into water. On the other hand, 16% (16) used spoons and cups, 10% (10) used

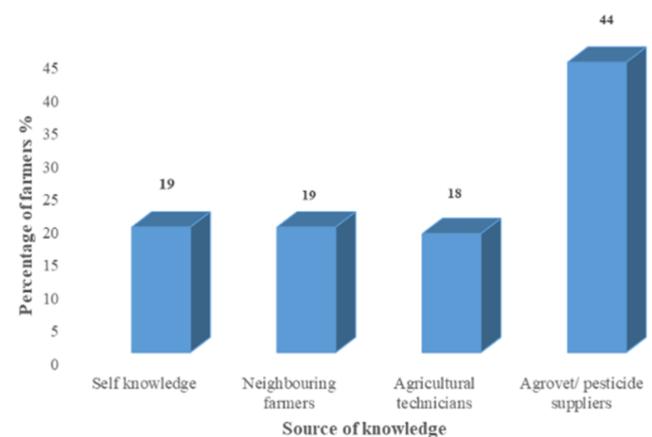


Figure 2. Farmer's source of information on pesticide use in Nawalparasi West, 2024, Nepal.

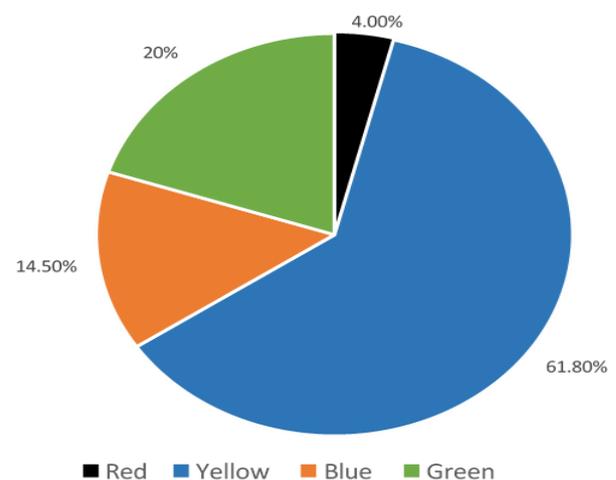


Figure 3. Color code labels of pesticides used by farmers in Nawalparasi West, Nepal.

hands, and 14% (14) estimated by guess without any measurement. These imprecise methods increase the risk of over or under application. Only 32% of farmers ensured reading signs and instructions on containers of pesticides, according to Jyoti *et al.* (2023). Similarly, in the current research, 25% of farmers reported only to have read the instructions, while a majority (75%) applied pesticides without doing so. Mubushar *et al.* (2019) also demonstrated that majority of the respondents (48.2%) ignored the instructions written on pesticide bottles. As for the frequency of pesticide application, nearly half (49%) of the farmers used pesticides 1–5 times during a season, followed by 29% (29) who used them 5–10 times. In addition, 16% (16) used pesticides 10–15 times, while only 6% (6) used them more than 15 times a season. Similarly, other studies carried out by Rijal *et al.* (2018) and Thapa *et al.* (2021) also showed that most farmers used pesticides 1–4 times during a season.

At the level of the initial application phase of pesticides, 48% (48) of the farmers initiated spraying in the early vegetative stage, 23% (23) in the late vegetative stage, 27% (27) in the sapling stage, and as low as 2% (2) at the flowering stage. A greater proportion (60%) used increased pesticides at the fruit setting stage, 33% (33) used pesticides during flowering, and a small percentage of just 7% increased usage in the vegetative stage. These patterns suggest that the use of pesticide are intensified at critical crop development phases, possibly in response to increased pest incidence or market-driven pressure to maintain fruit quality. As far as the timing of pesticide application is concerned, 36% of farmers applied pesticides during morning hours, 20% applied pesticides in the evening, and 19% applied pesticides in the afternoon. Surprisingly, 25% (25) of farmers did not utilize any specific time and applied pesticides at various times of the day. Several safety practices were followed while using pesticides. About 59% of the farmers followed some protective gear. Less than half

(47%) ensured that children did not join them in the field when spraying. Similarly, 47% considered weather conditions before spraying. Only 36% did not smoke or chew tobacco when spraying, and only 29% sprayed backward to minimize exposure.

### Poisoning symptoms, cleanliness and safety gears

Farmers expressed various health symptoms of pesticide poisoning after pesticide spraying in the field. The most common symptom reported was a burning sensation, reported by 61.80% of the farmers. The second was skin irritation, reported by 48.70% of the farmers, followed by dizziness (42.10%) and teary eyes (35.50%). Vomiting was the least reported symptom, reported by only 18.40% of the farmers. These findings are in agreement with the research by Kafle *et al.* (2021), which also established dizziness and skin allergies as the predominant health effects of pesticide exposure among farmers. Such health complaints highlight the acute risks associated with direct exposure during and after pesticide spraying, especially when safety measures are inadequate. As far as the hygiene practice after the use of pesticides is concerned, 64.80% of the farmers reported washing their hands with soap and water, and 47.90% took a bath after spraying, only 42.70% changes into clean clothes- arguably a critical step in minimizing continued exposure to pesticide residues. About the utilization of safety gear when using pesticides, 82% (82) of the farmers reported using masks, the most utilized protective device. Thirty-four percent (34) used safety glasses, 24% (24) used face shields, and 16% (16) used boots. Very few used gloves (4%) and aprons (3%) (Figure 4). These findings demonstrate that while most of the farmers prefer wearing masks to guard themselves against pesticide exposure, the use of other protecting equipment, such as gloves and boots, remains low.

### Mostly used pesticides and their dose

Farmers were reported to have applied various pesticides with multiple trade names and dosages. Propiconazole (fungicide), chlorpyrifos + cypermethrin (insecticide), mancozeb (fungicide), and paraquat (herbicide) were applied most often. The information gathered from the farmers was used to calculate the minimum, maximum, and mean dosages of these chemicals applied in the field and presented in Table 4. Propiconazole was the most widely used fungicide, marketed under brand names such as Ant 505, Cobra 505, Tilt, and Rhino 505. Chlorpyrifos blended with cypermethrin was a prevalent insecticidal formulation, sold extensively under brand names such as Cobra, Chlo Ecta, and Damdaar. Paraquat, a post-emergence herbicide, was applied under various brand names such as Saaf, Safaya, and Parazone.

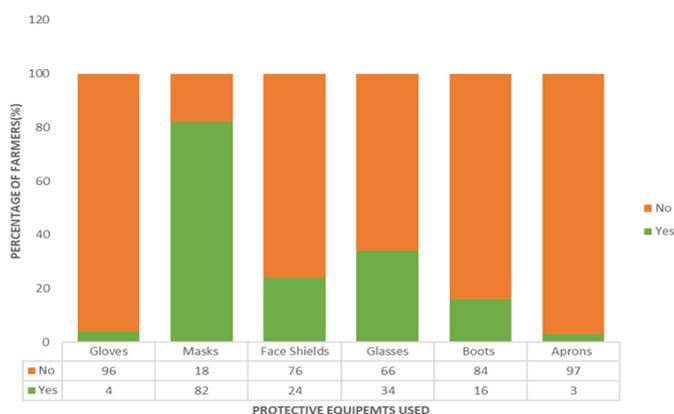


Figure 4. Protective gears adopted by farmers during pesticide use in Nawalparasi West, Nepal.

Table 4. Mostly used pesticides by farmers and their doses in Nawalparasi West, Nepal.

	Minimum dose (ml/l)	Maximum dose (ml/l)	Mean dose (ml/l)	Class
Propiconazole	1.4	7.8	3.161	III
Chloropyrifos+Cypermethrin	2	7	4.680	II
Mancozeb	2	5	3.667	IV
Paraquat	5	9	7.069	II

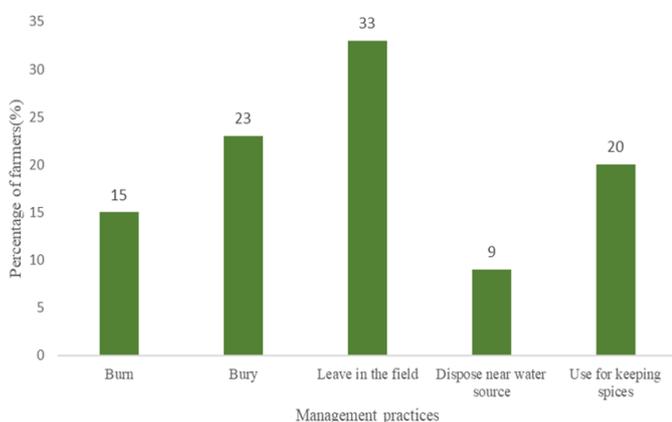
**Table 5.** Association between demographic variables and arrangement of separate storage houses for pesticide.

		Storage house		Chi square value ( $\chi^2$ )	p-value
		Yes	No		
Family type	Joint	23	32	8.129***	0.004
	Nuclear	7	38		
Training	Yes	13	16	4.276**	0.039
	No	17	54		
Education	Upto lower secondary level	16	54	5.669**	0.017
	Above lower secondary level	14	16		

\*\*\* indicates 1% level of significance and \*\* indicates 5% level of significance.

### Awareness on management and disposal of pesticides

A very high proportion of farmers (88%) reported using knapsack sprayers to spray chemicals and pesticides on their farms. Another 8% used hand sprayers, 2% used tractor sprayers, and another 2% used manual methods, such as hands and brooms, to spray pesticides. The dominant use of knapsack sprayers is likely due to their affordability, portability, and suitability for smallholder farms. Regarding pesticide storage practices, 35% of the farmers kept pesticide packets, bottles, and containers at home, 19% in banana fields, and 16% in the kitchen. Only 30% of the 100 farmer respondents possessed a separate pesticide storage facility. This outcome agrees with an associated study presented by Mubushar *et al.* (2019), who reported that almost 54.4% of farmers stored pesticides in a common open store room. Uniquely, joint family farmers, trained farmers, and literate farmers at higher than lower secondary levels had significantly higher chances of having a pesticide storage room separately, at p-values 0.004, 0.039, and 0.017, respectively (Table 5). For the disposal of leftover pesticides, 27% of farmers reported that they stored them for re-application, and 25% applied leftover pesticides to already treated fields. Alarmingly, 28% poured leftover chemicals into surrounding water bodies like rivers and ponds, and 20% treated uncropped areas, including roadsides, hedgerows, buildings, and footpaths indicating a misuse of chemicals that can harm non-target organisms and contribute to environmental degradation. As far as the disposal of pesticide containers is concerned, 33% of the farmers threw away the empty cans and containers in the field, 23% burned them, 15% buried them, and 9% deposited them in water bodies (Figure 5). Further, 20% of farmers admit to possessing empty pesticide containers,



**Figure 5.** Management practices for empty cans and containers of pesticides in Nawalparasi West, Nepal.

which they left in the field to use later, having serious health consequences for human beings and the environment. These findings are supported by a study conducted by Paudel *et al.* (2024), where 68% of farmers dumped pesticide containers randomly in their fields. Similarly, Rijal *et al.* (2018) reported that 60% of Chitwan farmers burnt or buried pesticide containers after use. These revelations indicate a general absence of information regarding Nepalese farmers on the appropriate means of disposing pesticide containers, with most of them storing them based on convenience rather than principles of safety.

### Conclusion

The findings from the study indicated several concerning trends requiring immediate action from policymakers, provincial government, local government, policy makers and farming communities. The research highlights that the banana farmers in the region face significant constraints in the farming, with disease and pest pressure emerging as the most severe challenges with Sigatoka leaf spot and Banana leaf and fruit scarring beetle requiring urgent need for effective pest management strategies. Farmers are heavily dependent on chemical pesticides coupled with inadequate safety knowledge- 71% of farmers lack proper training on pesticide use, 77% are unaware of restricted entry intervals and many engage in dangerous practices like improper storage of cans and containers, no adequate protective gears and unsafe disposal techniques. The situation is worsened by low literacy level and reliance on unqualified pesticide vendors for advice rather than agricultural experts. These findings pointed out the urgent need for multi-dimensional interventions like training farmers in Integrated Pest Management (IPM) and pesticide safety, more intensive extension services and regulated sales of pesticides. Such challenges, if met by collective action, could transform banana farming in the region, improving yields as well as protecting the health of farmers and the environment.

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## DECLARATIONS

### Author contribution statement

Conceptualization: P.G. and S.D.; Methodology: P.G.; Software and validation: P.G. and S.P.; Formal analysis and investigation: P.G.; Resources: P.G.; Data curation: P.G. and A.S.; Writing—original draft preparation: P.G. and A.S.; Writing—review and editing: P.G. and M.T.; Visualization: P.G.; Supervision: S.D.; Project administration: P.G.; Funding acquisition: P.G. All authors have read and agreed to the published version of the manuscript.

**Conflicts of interest:** The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

**Ethics approval:** The study was conducted in strict compliance with the guidelines of Agriculture and Forestry University (AFU), Nepal. Ethical approval was obtained from the Institutional Review Board of Agriculture and Forestry University, Rampur, Chitwan, Nepal. A prior informed consent was provided to all the participants for their involvement in the study.

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## REFERENCES

Aldosari, F., Mubushar, M., & Baig, M. B. (2018). Assessment of Farmers Knowledge on Pesticides and Trainings on Pesticide Waste Management in Central Punjab – Pakistan. *Journal of Experimental Biology and Agricultural Sciences*, 6(1), 168–175. [https://doi.org/10.18006/2018.6\(1\).168.175](https://doi.org/10.18006/2018.6(1).168.175)

Bari, F., Chaudhury, N., & Senapti, S. K. (2024). Susceptibility of different genomic banana cultivars to banana leaf and fruit scar beetle, *Nodostoma subcostatum* (Jacoby). *Acta Botanica Plantae*, 3(1), 7–12. <https://doi.org/10.51470/abp.2024.03.01.07>

CSN, Census Statistics Nepal. (2021). National Population and Housing Census 2021. *Nepal Statistics Office*. <https://microdata.nsonline.gov.np/index.php/>

[catalog/124#:~:text=The%20total%20population%20of%20Nepal,is%200.92%20percent%20in%202021](https://doi.org/10.18006/2018.6(1).168.175)

EHS. (2013). *Restricted Entry Intervals after Pesticide Applications*. October, 1–2. <https://ehs.wsu.edu/ehs-training/factsheets/factsheets-faqrei-field/>

GC, S., & Neupane, J. (2019). Pesticides Use in Nepal and its Effects on Human Health – A Review. *Acta Scientific Agriculture*, 3(11), 114–117. <https://doi.org/10.31080/asag.2019.03.0694>

Ghimire, B., C. Dhakal, S., Marahatta, S., Kafle, N., C. Bastakoti, R., & Sharma, S. (2023). Production Potential of Banana in Nepal: Growth Trend and a Comparative Analysis. *Food & Agribusiness Management*, 4(1), 19–24. <https://doi.org/10.26480/fabm.01.2023.19.24>

Ghimire, S., Koirala, B., Devkota, S., & Basnet, G. (2019). Genetic analysis and inter-relationship of yield attributing traits in *Amaranthus* germplasm. *Proceedings of the International Conference on " Food Security through Agriculture & Allied Sciences "*, 162–165.

Ghimire, S., & Regmi, A. (2024). Assessment of Farm-Level Practices of Disease and Pest Management in the Banana Zone of Nawalparasi West district, Nepal. *Journal La Lifesci*, 5(3), 176–196. <https://doi.org/10.37899/journallalifesci.v5i3.1139>

Hazels, B., & Sasse, C. M. (2008). Forced Ranking: A Review. *Journal of Business and Management*, 14(1), 35–39.

Jyoti, S., Lama, P., Yadav, A., Vaidya, S., & Joshi, S. K. (2023). Knowledge, attitude, and practice of pesticide use among agricultural workers of Lamatar, Lalitpur, Nepal. *International Journal of Occupational Safety and Health*, 13(4), 441–449. <https://doi.org/10.3126/ijosh.v13i4.53257>

Kafle, S., Vaidya, A., Pradhan, B., Jørs, E., & Onta, S. (2021). Factors associated with practice of chemical pesticide use and acute poisoning experienced by farmers in Chitwan district, Nepal. *International Journal of Environmental Research and Public Health*, 18(8). <https://doi.org/10.3390/ijerph18084194>

Khanal, D., Neupane, S. K., Poudel, S., & Shrestha, M. (2021). An Overview of Chemical Pesticide Import in Nepal. *Journal of Agriculture and Environment*, 22, 121–134. <https://doi.org/10.3126/aej.v22i0.46810>

Kothawade, C. V. (2019). Medicinal and Nutritional Importance of Bananas. *South Asian Research Journal of Pharmaceutical Sciences*, 5(03), 48–52. <https://doi.org/10.36346/sarjps.2023.v05i03.002>

Kumar, A., Pugazhendi, S., Kumar, C., Davidson, J., & Rawat, J. (2021). Knowledge and practices regarding pesticide application and handling among farmers in selected community areas of Uttarakhand. *International Journal of Research in Medical Sciences*, 9(4), 1187. <https://doi.org/10.18203/2320-6012.ijrms20211373>

MoALD. (2021). Statistical Information on Nepalese Agriculture 2078/79 (2021/22). *MoALD*, 269. <https://medium.com/@arifwicaksanaa/pengertian-use-case-a7e576e1b6bf>

MoALD. (2022). Statistical Information on Statistical Information on Nepalese Agriculture. 2022.

Mubushar, M., Aldosari, F. O., Baig, M. B., Alotaibi, B. M., & Khan, A. Q. (2019). Assessment of farmers on their knowledge regarding pesticide usage and biosafety. *Saudi Journal of Biological Sciences*, 26(7), 1903–1910. <https://doi.org/10.1016/J.SJBS.2019.03.001>

Paudel, L., Neupane, R., Shrestha, L., Budhathoki, L., & Paudel, K. R. (2024). Knowledge on Chemical Pesticide use among Farmers Exposed to Pesticides in Panchkhal Municipality, Kavrepalanchok, Nepal. *Advances in Public Health*, 2024. <https://doi.org/10.1155/2024/3110674>

Pérez-vicente, L. (2004). *Fusarium wilt (Panama disease) of bananas: An updating review of the current knowledge on the disease and its causal agent*. XVI REUNIÓN INTERNACIONAL ACORBAT 20, Publicación Especial 1. 1–15. [https://www.researchgate.net/publication/240621714\\_Fusarium\\_wilt\\_Panama\\_disease\\_of\\_bananas\\_an\\_updating\\_review\\_of\\_the\\_current\\_knowledge\\_on\\_the\\_disease\\_and\\_its\\_causal\\_agent](https://www.researchgate.net/publication/240621714_Fusarium_wilt_Panama_disease_of_bananas_an_updating_review_of_the_current_knowledge_on_the_disease_and_its_causal_agent)

Poudel, S., Poudel, B., Acharya, B., & Poudel, P. (2020). Pesticide Use and its Impact on Human Health and Environment. *Environment & Ecosystem Science* 4(1), 47–51. <https://doi.org/10.26480/ees.01.2020>

Rajeev, P. N. (2012). Impact of forced ranking evaluation of performance on ethical choices: A study of proximal and distal mediators. *International Journal of Business Governance and Ethics*, 7(1), 37–62. <https://doi.org/10.1504/IJBGE.2012.046104>

Ramsey, M. D., Daniells, J. W., & Anderson, V. J. (1990). Effects of *Sigatoka* leaf spot (*Mycosphaerella musicola* Leach) on fruit yields, field ripening, and green life of bananas in North Queensland. *Australian Journal of Agricultural Research*, 41(2), 305–313.

- Rijal, J. P., Regmi, R., Ghimire, R., Puri, K. D., Gyawaly, S., & Poudel, S. (2018). Farmers' knowledge on pesticide safety and pest management practices: A case study of vegetable growers in Chitwan, Nepal. *Agriculture (Switzerland)*, 8(1), 16. <https://doi.org/10.3390/agriculture8010016>
- Tarar, M. A., Salik, M. H., Riaz, M., Alvi, A. S., Tarar, A. H., Mushtaq, K., Akhtar, S., & Sultan, T. (2019). Effects of pesticides on male farmer's health: A study of muzaffar garh. *Pakistan Journal of Agricultural Sciences*, 56(4), 1021–1030. <https://doi.org/10.21162/PAKJAS/19.9157>
- Thapa, S., Piras, G., Thapa, S., Goswami, A., Bhandari, P., & Dahal, B. (2021). Study on farmers' Pest management strategy, knowledge on pesticide safety and practice of pesticide use at Bhaktapur district, Nepal. *Cogent Food and Agriculture*, 7(1). <https://doi.org/10.1080/23311932.2021.1916168>
- Tiwari, S., Thapa, R. B., Gautam, D. M., & Shrestha, S. K. (2006). Survey of banana stem weevil. *Journal of the Institute of Agriculture and Animal Science*, 27, 127–131.