

FARMER PERSPECTIVES AND USAGE PATTERNS OF INSECTICIDES IN CHILLI CULTIVATION IN BHABHAR REGION OF UTTARAKHAND

Abstract

A comprehensive field survey was conducted across six blocks of Udham Singh Nagar district in Uttarakhand to assess chilli cultivation practices, pest incidence, and farmer knowledge regarding pest management and pesticide safety. The study revealed that most farmers were marginal cultivators, with 66 per cent growing chilli on less than 0.5 acres. Thrips and other insect pests, including root grubs, tobacco caterpillars, and pod borers, posed significant threats, with 56.29 per cent of farmers reporting damage from non-thrips insects. Leaf curling assessments showed no immune chilli varieties, and over 41 per cent of crops were classified as susceptible to thrips, especially in areas with intensive cultivation and pesticide use. Thrips primarily affected growing shoots and older leaves, while fruit and stem damage were less prevalent. Most farmers relied on formal sources such as university experts and agricultural departments for plant protection advice, although regional disparities existed. Chemical mixing was widely practiced (75.14%), and 72.28 per cent of farmers applied two or more pesticide sprays per crop, often at 5- to 10-day intervals. While 83.14 per cent of farmers used protective clothing during spraying, 15.43 per cent still prepared spray solutions with bare hands, and only half were aware of CIBRC guidelines. These findings highlight the urgent need for integrated pest management, development of resistant varieties, safety education, and enhanced regulatory outreach to ensure sustainable and safe chilli cultivation in the region.

Key words: thrips, varieties, pesticides, plant protection source, protective clothing, CIBRC

INTRODUCTION

Chilli (*Capsicum annum* L.) is a member of the Solanaceae family and is an economically important crop cultivated as both spice and vegetable, especially throughout tropical and subtropical areas. The fruit serves in various culinary cultures, being consumed as fresh green chilli or dried red chilli. They are used in diets through raw consumption in salads, prepared as cooked vegetables, preserved by pickling, or utilization as flavour enhancers in

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numerous culinary preparations (Zanwar *et al.*, 2022). Given its extensive applications across food, pharmaceutical, and cosmetic sectors, chilli holds a considerable economic importance. India dominates global chilli production with 2.78 million tonnes from 8.52 lakh hectares in 2023-24 (Horticulture Statistics Division, 2024), primarily from Andhra Pradesh, Telangana, Madhya Pradesh, Karnataka, and Odisha (Spice Board India, 2023). While Uttarakhand contributes modestly with 10.88 thousand tonnes of capsicum in 2024-25 following a peak of 16.54 thousand tonnes in 2022 (CEIC Data, 2024; DA&FW, 2024). This underscores India's global leadership in chilli production and Uttarakhand's role in preserving unique cultivars for sustainable agroecosystems.

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Insect pests cause significant chilli yield losses, with 25-26 pests species affecting various parts of the chilli plant (Girish, 2012). Key pests include sucking insects like thrips (*Scirtothrips dorsalis*), white mites (*Polyphagotarsonemus latus*), and aphids (*Aphis gossypii*; *Myzus persicae*). Important foliage feeders include tobacco caterpillar (*Spodoptera litura*) and pod borer (*Helicoverpa armigera*). Chilli thrips (*S. dorsalis*), order Thysanoptera poses the greatest threat (Ali *et al.*, 2006; Priyadarshini *et al.*, 2019), potentially causing yield losses exceeding (75%) under favorable conditions (Sarkar *et al.*, 2015; Ballal *et al.*, 2022), making it the most economically damaging pest in chilli cultivation.

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Chilli's soft, succulent tissues make it vulnerable to pests and diseases, worsened by selective breeding that reduced genetic diversity while accelerating growth (Weerakkody and Mawalagedera, 2020). Growing global population demands increased food production through sustainable strategies, especially with declining yields and shrinking farmlands. This has driven industrial farming practices involving widespread use of agricultural chemicals including fertilizers, insecticides, nutrients, and growth enhancers in crop systems. Pesticides are vital for crop protection against pests, fungi, weeds, and rodents, making them indispensable in commercial agriculture, especially for vegetables like chilli. However, excessive and indiscriminate use of pesticide by farmers has created serious environmental and health risks, highlighting the need for better strategies for sustainable pest management approaches (Weerakkody and Mawalagedera, 2020). India has registered 287 pesticides for crop protection as of March 2024. During 2023-24, the country used 67,964.97 metric tonnes of chemical pesticides, with Uttarakhand contributing 147.08 metric tonnes (0.22%) (DPPQS, 2025). National pesticide application rates increased from 0.29 kg/ha in 2021-22 to 0.40 kg/ha in 2023-24 (Janaki Rani *et al.*, 2025; Reddy *et al.*, 2024). Jammu and Kashmir leads in

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pesticide intensity at 2.097 kg/ha, followed by Punjab at 1.3 kg/ha, while Uttarakhand ranks 12th with moderate usage of 0.3 kg/ha (Reddy *et al.*, 2024), indicating regional variations in pesticide dependency across Indian states.

Pesticide usage patterns and farmers' attitudes toward chemical pest control are influenced by multiple interconnected factors including demographics, geography, weather, ecology, and government regulations (Ali *et al.*, 2020). Additionally, crop cultivation techniques, management practices, and crop types significantly affect both pesticide application decisions and overall farmer perceptions regarding chemical pest control methods (Van Hoi *et al.*, 2009). With this background, the present study was undertaken to understand the status of farmers' perspectives and usage patterns of insecticides against chilli thrips across various regions of Uttarakhand.

MATERIALS AND METHODS

Using the roving survey method, data on pesticide usage patterns among farmers in from random villages of major chilli growing areas across various blocks of Udham Singh Nagar district of Uttarakhand state was gathered. Details regarding pesticide usage patterns by chilli growers were obtained through direct interactions with farmers using a structured schedule or questionnaire. Information was collected from a representative sample of farmers regarding the pesticides applied to chilli crops during the previous or current season/year.

The primary aim of the survey was to examine the patterns of insecticide use and perspectives among farmers for managing thrips in chilli cultivation. This was achieved through a comprehensive questionnaire that addressed various aspects of pesticide application. Information was collected via one-on-one personal interviews with the farmers, covering topics such as land holdings, pest and disease occurrence, alternative chemical use, method of application, frequency of sprays, safety precautions, adherence to pre-harvest intervals, and various other aspects at their farm levels. The collected data were compiled across different categories and analysed to assess pesticide usage trends in the chilli cropping systems of major chilli growing regions of Uttarakhand.

RESULTS AND DISCUSSION

The survey conducted over six different blocks of Udham Singh Nagar district of Uttarakhand showed varied results according to the data collected and analysed. The results are represented according of different criteria.

FARMERS KNOWLEDGE ABOUT INSECT PESTS IN CHILLI CLTIVATION.

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The survey results on various cultivation practices and farmers knowledge about insect pests in chilli in various blocks of Udham Singh Nagar are presented in **Table 1**.

Area under chilli cultivation:

A survey on chilli cultivation in various blocks of Udham Singh Nagar revealed that most farmers were marginal cultivators, growing chilli on less than 0.5 acres. In Rudrapur, about 92 per cent of farmers cultivated chilli on under 0.5 acres, compared to only 20 per cent in Kashipur. In contrast, 58 per cent of Kashipur farmers had 0.5 to 1 acre under chilli, while only 6 per cent in Rudrapur fell in this category. Gadarpur had the highest proportion (24%) of farmers cultivating chilli on more than 1 acre, whereas Rudrapur had the lowest in this category. Overall, across all blocks, 66 per cent of farmers grew chilli on less than 0.5 acres, 21.71 per cent on 0.5 to 1 acre, and only 12.31 per cent on more than 1 acre. These findings highlight significant regional differences in land holdings dedicated to chilli cultivation. Similar results were discovered by **Hazari and Kalita (2022)**, who reported that most of the respondents were small and marginal farmers and that all of them were from farming families. Additionally, **Swami *et al.* (2022)** revealed that 41.50 per cent of chilli growers had less than 0.5 acres of growing land, while 31 per cent had between 0.5 and 1 hectares. With an average cultivation area of roughly 0.86 ha per farmer, 27.30 per cent of chilli producers supplied more than 1.0 ha.

Damage Percentage:

The survey assessed insect damage in chilli cultivation across different blocks, categorizing pest infestations into thrips and other insects. Results showed varying damage patterns across surveyed areas. Thrips damage was not severe overall in the region. In Gadarpur, 72 per cent of farmers reported thrips as the primary pest damaging their crops, while only 24 per cent of Khatima farmers experienced thrips damage. This stark regional variation highlights the localized nature of thrips infestations. Other insects, including root grubs,

Table 1. Cultivation and farmers knowledge about insect pests in chilli

	Farmers' Response							Overall
	Jaspur	Kashipur	Bajpur	Gadarpur	Rudrapur	Sitarganj	Khatima	
Area (acre)								
<0.5	35 (70)	10 (20)	32 (64)	29 (58)	46 (92)	44 (88)	35 (70)	231 (66)
0.5 – 1	10 (20)	29 (58)	14 (28)	9 (18)	3 (6)	6 (12)	5 (10)	76 (21.71)
>1	5 (10)	11 (22)	4 (8)	12 (24)	1 (2)	-	10 (20)	43 (12.29)
Damage %								
thrips	20 (40)	28 (56)	19 (38)	36 (72)	23 (46)	15 (30)	12 (24)	153 (43.71)
other insects	30 (60)	22 (44)	31 (62)	14 (28)	27 (54)	35 (70)	38 (76)	197 (56.29)
Curling of leaves (%)								
0 - 0% = immune	-	-	-	-	-	-	-	-
1 - 1-25% = resistant	7 (14)	4 (8)	9 (18)	2 (4)	5 (10)	19 (38)	8 (16)	54 (15.43)
2 - 26-50% = moderately resistant	13 (26)	10 (20)	15 (30)	5 (10)	11 (22)	27 (54)	16 (32)	97 (27.71)
3 - 51-75% = susceptible	24 (48)	21 (42)	25 (50)	25 (50)	23 (46)	2 (4)	26 (52)	146 (41.71)
4 - >75% = Highly susceptible	6 (12)	15 (30)	1 (2)	18 (36)	11 (22)	2 (4)	-	53 (15.14)
Plant part damaged by thrips								
Growing shoot	23 (0)	22 (44)	20 (40)	26 (52)	23 (46)	21 (42)	18 (36)	139 (39.71)
older leaves	18 (0)	17 (34)	19 (38)	20 (40)	18 (36)	20 (40)	21 (42)	100 (28.57)
fruit	7 (0)	8 (16)	10 (20)	3 (6)	9 (18)	8 (16)	10 (20)	75 (21.43)
stem	2 (0)	3 (6)	1 (2)	1 (2)	-	1 (2)	1 (2)	36 (10.29)

N = 50, Data represented in parenthesis is the percentage of farmer respondents of respective categories during the survey

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tobacco caterpillars, and pod borers, showed contrasting distribution patterns. Khatima experienced significantly higher damage from these pests, with 92 per cent of farmers affected, compared to only 28 per cent in Gadarpur. This inverse relationship between thrips and other insect damage across locations suggests different environmental conditions or management practices influence pest prevalence. Regional analysis revealed that thrips affected 43.71 per cent of farmers overall, while other insects impacted 56.29 per cent of the farming community. The data indicates that non-thrips species were more prevalent than thrips across the surveyed areas. The findings demonstrate that root grubs, tobacco caterpillars, and pod borers collectively posed a greater threat to chilli cultivation than thrips in the study region. More than half of farmers experienced damage from these alternative pest species, suggesting the need for integrated pest management strategies targeting multiple insect threats rather than focusing solely on thrips control in chilli production systems. Frantz and Mellinger (2009) also found that thrips caused economic harm to vegetable crops, particularly peppers, *Capsicum annum*. L. Alam *et al.* (2022) also showed that sucking pests, primarily thrips, *Scirtothrips dorsalis*, caused the most damage to chilli crops, resulting in a 70 to 80 per cent production loss.

Curling Percentage of Leaves:

Chilli varieties were assessed for thrips damage response and categorized as immune, resistant, moderately resistant, susceptible, and highly susceptible based on leaf curling percentages. No varieties showed immunity to thrips infestation across the surveyed areas. Regional variations in variety resistance were significant. Sitarganj demonstrated superior resistance patterns with 38 per cent resistant varieties compared to only 4 per cent in Gadarpur. Moderately resistant varieties were predominantly cultivated in Sitarganj (54%) versus 10% in Gadarpur. Susceptibility patterns varied considerably across blocks. Khatima showed high susceptibility with 52 per cent of varieties affected, while only 4 per cent of Sitarganj varieties were susceptible. Gadarpur exhibited the highest vulnerability, with 36 per cent of varieties being highly susceptible to thrips, whereas Khatima recorded no highly susceptible varieties. Overall analysis revealed that 41.71 per cent of cultivated varieties across all blocks were susceptible to thrips. This increased susceptibility was attributed to intensive cultivation practices and excessive insecticide application, which enhanced thrips' tolerance capacity and consequently increased host plant vulnerability. The findings suggest that current pest management strategies may be inadvertently contributing to reduced plant resistance against thrips infestations.

Part of plant damaged:

Survey data from seven regional locations revealed distinct thrips damage patterns across different plant parts. Growing shoots were the primary target, affecting 139 farmers (39.71%),

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with consistent damage rates of 36-52 per cent across all locations. This pattern reflects thrips' preference for soft, developing tissues. Older leaves ranked second, impacting 100 farmers (28.57%) with uniform damage distribution (34-42%) across regions. This consistency suggests thrips attack mature foliage when populations are high or preferred feeding sites become limited. Fruit damage affected 75 farmers (21.43%), showing significant regional variation. Khatima reported minimal damage (6%) while Gadarpur experienced the highest incidence (20%). These differences likely reflect varying crop varieties, growth stages, or local thrips population dynamics. Stem damage was minimal, affecting only 36 farmers (10.29%). Most locations showed low percentages (2-6%), with Rudrapur reporting no stem damage. This pattern aligns with thrips feeding behavior, as stems are tougher and less palatable than other plant tissues. Regional variations were notable, with Gadarpur displaying the most diverse damage pattern across multiple plant parts, while other locations showed typical distributions favouring growing shoots and older leaves. These differences may result from regional farming practices, crop varieties, or environmental factors influencing thrips behavior. Effective thrips management should prioritize protecting young foliage and growing shoots while considering broader impacts on mature leaves and developing fruits.

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KNOWLEDGE ABOUT PLANT PROTECTION PRACTICES

The survey results on knowledge about plant protection practices among chilli farmers in various blocks of Udham Singh Nagar are presented in **Table 2**.

Source of Plant Protection Advice

Survey data from seven blocks in Udham Singh Nagar district showed university experts as the primary plant protection advice source for 191 farmers (54.57%), followed by department personnel (68 farmers, 19.43%), pesticide shops (59 farmers, 16.86%), and fellow farmers (32 farmers, 9.14%). Regional variations were pronounced. Rudrapur demonstrated highest university expert reliance at 78 per cent (39 farmers), followed by Kashipur at 70 per cent (35 farmers). Gadarpur showed contrasting patterns with only 20 per cent (10 farmers) consulting university experts, instead relying heavily on pesticide shops at 46 per cent (23 farmers) and department personnel at 22 per cent (11 farmers). Khatima exhibited highest dependence on department personnel at 30 per cent (15 farmers). Rudrapur farmers showed zero reliance on fellow farmers. Overall, 74 per cent of farmers depend on formal institutional sources, indicating effective agricultural extension service penetration. However, Gadarpur's divergent pattern suggests potential gaps in university extension services or distinct local practices requiring investigation to optimize advisory service delivery across the district. **Rastogi and Hasan (2014)** also found that farmers preferred personal local communication practices requiring investigation to optimize

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Table 2. Knowledge about plant protection practices

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	Farmers' Response							Overall
	Jaspur	Kashipur	Bajpur	Gadarpur	Rudrapur	Sitarganj	Khatima	
Plant protection advice								
University expert	25 (50)	35 (70)	32 (64)	10 (20)	39 (78)	23 (46)	27 (54)	191 (54.57)
Dept. personnel	10 (20)	5 (10)	8 (16)	11 (22)	10 (20)	9 (18)	15 (30)	68 (19.43)
pesticide shop	6 (12)	6 (12)	7 (14)	23 (46)	1 (2)	10 (20)	6 (12)	59 (16.86)
fellow farmers	9 (18)	4 (8)	3 (6)	6 (12)	-	8 (16)	2 (4)	32 (9.14)
Mixing of chemicals								
Yes	37 (74)	41 (82)	36 (72)	44 (88)	40 (80)	34 (68)	31 (62)	263 (75.14)
No	13 (26)	9 (18)	14 (28)	6 (12)	10 (20)	16 (32)	19 (38)	87 (24.86)
Total number of sprays per crop								
0	-	-	-	-	-	-	-	-
1	14 (28)	8 (16)	14 (28)	9 (18)	13 (26)	20 (40)	19 (38)	97 (27.71)
2	15 (30)	15 (30)	16 (32)	10 (20)	13 (26)	15 (30)	13 (26)	97 (27.71)
>2	21 (42)	27 (54)	20 (40)	31 (62)	24 (48)	15 (30)	18 (36)	156 (44.57)
Interval between two sprays								
5 days	32 (64)	38 (76)	31 (62)	40 (80)	35 (70)	31 (62)	29 (58)	236 (67.43)
10 days	12 (24)	9 (18)	13 (26)	8 (16)	8 (16)	13 (26)	14 (28)	77 (22.00)
15 days	6 (12)	3 (6)	6 (12)	2 (4)	7 (14)	6 (12)	6 (12)	36 (10.29)
> 15 days	-	-	-	-	-	-	1 (2)	1 (0.29)

N = 50, Data represented in parenthesis is the percentage of farmer respondents of respective categories during the survey

advisory service delivery across the district. It was also found that farmers preferred personal local communication channels to obtain information about agricultural techniques, followed by local agricultural input suppliers and university experts.

Mixing of Chemicals

The results on farmers' responses regarding mixing of chemicals across seven blocks in Udham Singh Nagar district shows that a significant majority of 263 farmers (75.14%) engage in chemical mixing practices, while 87 farmers (24.86%) do not mix chemicals. Regional analysis reveals that Gadarpur has the highest proportion of farmers mixing chemicals at 88% (44 farmers), followed closely by Kashipur at 82 per cent (41 farmers) and Rudrapur at 80 per cent (40 farmers), while Khatima shows the lowest adoption of chemical mixing at 62 per cent (31 farmers), followed by Sitarganj at 68 per cent (34 farmers) and Bajpur at 72 per cent (36 farmers). The overall pattern indicates widespread adoption of chemical mixing practices across the region, with three-quarters of farmers employing this approach, though notable regional variations suggest differing local agricultural practices, knowledge levels, or extension service influence in chemical application methods. Sachan *et al.* (2022) also found similar results that more than two-thirds of farmers (69.7%) mixed only needed pesticides, with a small percentage spreading them to other crops (15.8%) and disposing of them in the field (11.7%). Pandiyan *et al.* (2023) reported that participants had an average of 19.6 years of farming experience, with women being mostly involved in pesticide mixing and other agricultural tasks other than spraying.

Table 3: Frequently used Pesticide in Cucurbit crops in Kumaun region of Uttarakhand

Sl. No.	Pesticide	Trade name	Class of Pesticide	Colour on the Label	Toxicity Class	Used against
1	Imidacloprid	Confidor	Neonicotinoid	◆	II	Sucking insects
2	Chlorpyrifos	Terminator	Organophosphate	◆	II	Soil dwelling insects
3	Cypermethrin	Cymbush	Synthetic Pyrethroids	◆	II	Borers and Foliage feeders
4	Phorate	Thimet	Organophosphate	◆	II	Soil dwelling insects
5	Dimethoate	Rogor	Organophosphate	◆	II	Sucking insects

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Total number of sprays per crop

Survey data from seven blocks in Udham Singh Nagar district revealed varying spray application patterns across farmers. The majority (156 farmers, 44.57%) applied more than two sprays per crop, while equal proportions used either one spray or two sprays (97 farmers each, 27.71%). No farmers reported zero sprays. Regional analysis showed Gadarpur with highest spray intensity at 62% (31 farmers) using more than two sprays, followed by Kashipur at 54 per cent (27 farmers) and Rudrapur at 48 per cent (24 farmers). Sitarganj and Khatima demonstrated more conservative practices with only 30 per cent (15 farmers) and 36 per cent (18 farmers) respectively applying multiple sprays. Single spray application was most common in Sitarganj (40%, 20 farmers) and Khatima (38%, 19 farmers), while Kashipur had the fewest single-spray users at 16 per cent (8 farmers). Two-spray application showed uniform distribution ranging from 20 per cent in Gadarpur to 32 per cent in Bajpur. Overall, 72.28 per cent of farmers applied two or more sprays per crop, indicating intensive chemical practices. Gadarpur and Kashipur showed most intensive applications while Sitarganj and Khatima adopted moderate approaches.

Interval between two sprays

Survey data from seven blocks in Udham Singh Nagar district revealed intensive spray scheduling patterns among farmers. The majority (236 farmers, 67.43%) maintained 5-day intervals between sprays, followed by 77 farmers (22.00%) using 10-day intervals, 36 farmers (10.29%) employing 15-day intervals, and only one farmer (0.29%) in Khatima extending beyond 15 days. Regional analysis showed Gadarpur with highest adherence to 5-day intervals at 80 per cent (40 farmers), followed by Kashipur at 76 per cent (38 farmers) and Rudrapur at 70 per cent (35 farmers). Khatima demonstrated lowest adoption at 58 per cent (29 farmers). For 10-day intervals, Khatima led with 28 per cent (14 farmers), followed by Bajpur and Sitarganj at 26 per cent each (13 farmers), while Gadarpur and Rudrapur showed lowest usage at 16 per cent each (8 farmers). Fifteen-day intervals were least popular, ranging from 4 per cent in Gadarpur to 14 per cent in Rudrapur, with most areas maintaining around 12 per cent. Results indicate overwhelmingly intensive spray schedules, with nearly 90 per cent of farmers applying insecticides at 10-day intervals or less, suggesting high pest pressure, intensive farming practices, or excessive chemical dependency. Gadarpur and Kashipur demonstrated the most intensive frequency patterns.

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KNOWLEDGE ABOUT SAFE USAGE OF INSECTICIDES

The survey results on knowledge about safe usage of insecticides among chilli farmers in various blocks of Udham Singh Nagar are presented in **Table 4**.

Safety period from last spray and harvest

Survey data from seven blocks in Udham Singh Nagar district revealed concerning patterns in **pre-harvest safety periods**. The majority of farmers (149, 42.57%) maintained 7-day safety periods, followed closely by 135 farmers (38.57%) using 10-day periods. Smaller proportions observed 15-day periods (32 farmers, 9.14%) and 3-day periods (34 farmers, 9.71%), with no farmers extending beyond 15 days. Regional analysis showed Gadarpur with highest 7-day safety period adoption at 52 per cent (26 farmers), followed by Kashipur at 48% (24 farmers) and Rudrapur at 46 per cent (23 farmers). Sitarganj demonstrated lowest adoption at 32 per cent (16 farmers). For 10-day periods, Sitarganj and Khatima led with 48 per cent (24 farmers) and 46 per cent (23 farmers) respectively, while Gadarpur showed lowest usage at 26 per cent (13 farmers). The concerning 3-day safety period was highest in Gadarpur at 18 per cent (9 farmers) and Kashipur at 16 per cent (8 farmers), compared to only 4 per cent (2 farmers each) in Sitarganj and Khatima. Fifteen-day periods showed low adoption, ranging from 4 per cent in Gadarpur to 16 per cent in Sitarganj. Overall, over 80 per cent of farmers-maintained safety periods of 10 days or less, with nearly half observing only 7-day intervals, suggesting potential food safety concerns and inadequate adherence to recommended pre-harvest intervals, particularly in Gadarpur and **Kashipur**.

Preparation of Spray Solution

Survey data from seven blocks in Udham Singh Nagar district revealed varying spray solution preparation practices. Nearly half the farmers (168, 48.00%) used bamboo sticks, followed by 128 farmers (36.57%) using gloves, while 54 farmers (15.43%) prepared solutions with bare hands. Regional analysis showed Sitarganj with highest bamboo stick usage at 54% (27 farmers), followed by Bajpur, Gadarpur, and Khatima at 50 per cent each (25 farmers), while Kashipur showed lowest usage at 42 per cent (21 farmers). For glove usage, Kashipur and Gadarpur led with 44 per cent (22 farmers) and 40 per cent (20 farmers) respectively, along with Rudrapur at 40 per cent (20 farmers). Jaspur showed lowest adoption at 28 per cent (18 farmers). The concerning bare-hand practice was most prevalent in Jaspur and Khatima at 18 per cent each (9 farmers), followed by Bajpur, Sitarganj, and Rudrapur at 16 per cent each (8 farmers). Gadarpur showed lowest rate at 10 per cent (5 farmers). While 84.57 per cent employed protection during preparation, 15.43 per cent still engaged in unsafe direct contact practices, highlighting the need for enhanced safety awareness and training programs. **Sai et**

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al. (2019) also reported that 118 males and 53 females participated in the study, with a median age of 40 years. Approximately 61 per cent of farmers were aware of the adverse consequences of pesticides. However, 22 per cent were mixing insecticides with their bare hands. **Rakesh *et al.* (2017)** also revealed that 39 percent of the 98 farmers interviewed mixed the chemicals with their bare hands, one-third disposed of empty agrochemical sacs or tins in the open, and 43% reused containers/sacks to keep supplies at home. The habit of storing, mixing, and applying agrochemicals without personal protective equipment, as well as the unsafe disposal of pesticide containers, appears to be widespread in the study communities.

Use of protective clothing during protection

Survey data from seven Uttarakhand locations revealed that 291 farmers (83.14%) used protective clothing during spraying, while 59 farmers (16.86%) did not employ safety measures. Regional analysis showed Gadarpur with highest protective clothing adoption at 92 per cent (46 farmers), followed by Kashipur at 88 per cent (44 farmers) and Rudrapur at 86 per cent (43 farmers). Sitarganj demonstrated lowest usage at 76 per cent (38 farmers), followed by Khatima at 78 per cent (39 farmers) and Bajpur at 80 per cent (40 farmers). Correspondingly, Sitarganj had highest non-compliance at 24 per cent (12 farmers), followed by Khatima at 22 per cent (11 farmers) and Bajpur at 20 per cent (10 farmers). Gadarpur showed best safety compliance with only 8 per cent (4 farmers) not using protective gear. The pattern indicates strong safety awareness, with over four-fifths recognizing protective clothing importance. However, location variations suggest Sitarganj and Khatima need enhanced safety training, while Gadarpur and Kashipur demonstrate exemplary safety consciousness serving as potential models for other areas. Similar findings were reported by **Sai *et al.* (2019)** where 26 per cent of pesticide sprayers did not use protective clothes and approximately 67 per cent were irresponsibly disposing of pesticide residue in open fields. **Banerjee *et al.* (2014)** also investigated the personal protection measures adopted by farmers during spraying and discovered that covering the nose and mouth with a handkerchief and bathing after spraying was the most common practice (27%). **Rakesh *et al.* (2017)** also found that just 28 per cent of the 98 farmers interviewed employed appropriate personal protection equipment when applying agrochemicals.

Knowledge about CIBRC guidelines

Survey data from seven Uttarakhand locations revealed nearly equal distribution in CIBRC (Central Insecticides Board and Registration Committee) guideline awareness, with 173 farmers (49.43%) having knowledge while 177 farmers (50.57%) lacked awareness. Regional analysis showed Rudrapur with highest awareness at 60 per cent (30 farmers),

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Table 4. Knowledge about safe usage of insecticides

	Farmers' Response							Overall
	Jaspur	Kashipur	Bajpur	Gadarpur	Rudrapur	Sitarganj	Khatima	
Safety period from last spray and harvest								
3 days	4 (8)	8 (16)	3 (6)	9 (18)	6 (12)	2 (4)	2 (4)	34 (9.71)
7 days	21 (42)	24 (48)	20 (40)	26 (52)	23 (46)	16 (32)	19 (38)	149 (42.57)
10 days	20 (40)	15 (30)	23 (46)	13 (26)	17 (34)	24 (48)	23 (46)	135 (38.57)
15 days	5 (10)	3 (6)	4 (8)	2 (4)	4 (8)	8 (16)	6 (12)	32 (9.14)
> 15 days	-	-	-	-	-	-	-	-
Preparation of spray solution								
Bare hands	9 (18)	7 (14)	8 (16)	5 (10)	8 (16)	8 (16)	9 (18)	54 (15.43)
With gloves	18 (28)	22 (44)	17 (34)	20 (40)	20 (40)	15 (30)	16 (32)	128 (36.57)
With bamboo sticks	23 (46)	21 (42)	25 (50)	25 (50)	22 (44)	27 (54)	25 (50)	168 (48.00)
Use of protective clothes during spraying								
Yes	41 (82)	44 (88)	40 (80)	46 (92)	43 (86)	38 (76)	39 (78)	291 (83.14)
No	9 (18)	6 (12)	10 (20)	4 (8)	7 (14)	12 (24)	11 (22)	59 (16.86)
Knowledge about CIBRC guidelines								
Yes	24 (48)	29 (58)	23 (46)	26 (52)	30 (60)	21 (42)	20 (40)	173 (49.43)
No	26 (52)	21 (42)	27 (54)	24 (48)	20 (40)	29 (58)	30 (60)	177 (50.57)

N=50, Data represented in parenthesis is the percentage of farmer respondents of respective categories during the survey

followed by Kashipur at 58 per cent (29 farmers) and Gadarpur at 52 per cent (26 farmers). Khatima demonstrated lowest awareness at 40 per cent (20 farmers), followed by Sitarganj at 42 per cent (21 farmers) and Bajpur at 46 per cent (23 farmers). Correspondingly, Khatima had highest unawareness at 60 per cent (30 farmers), followed by Sitarganj at 58 per cent (29 farmers) and Bajpur at 54 per cent (27 farmers). Rudrapur showed best regulatory awareness with only 40 per cent (20 farmers) lacking knowledge. Similar findings were also reported by **Mohanty *et al.* (2013)** who observed that approximately 42 per cent of agricultural workers in Puducherry, South India were knowledgeable about pesticides. Results indicate critical knowledge gaps in regulatory awareness, with approximately half lacking familiarity with official pesticide usage guidelines. This suggests urgent need for comprehensive extension programs and regulatory education initiatives, particularly in Khatima, Sitarganj, and Bajpur where awareness levels fall significantly below regional average, while Rudrapur and Kashipur could serve as dissemination models.

Conclusion

The comprehensive survey conducted across six blocks of Udham Singh Nagar district in Uttarakhand reveals significant insights into chilli cultivation practices, pest management strategies, and farmer knowledge systems. The findings emphasize the critical need for comprehensive interventions including development of resistant varieties, promotion of integrated pest management practices, enhanced safety training programs, and strengthened regulatory awareness initiatives. Future research should focus on evaluating the effectiveness of sustainable pest management alternatives and developing region-specific integrated approaches that balance productivity, environmental sustainability, and farmer safety in chilli cultivation systems.

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