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Pesticide Usage Patterns and Farmer Awareness Among Cotton Growers in Rajkot district

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Agriculture is the most important sector of the economy in India as it provides food and livelihood security. The industrialization of agriculture has favoured the use of plenty of agrochemicals including fertilizers, pesticides, micro nutrients and plant growth regulators in the agricultural fields. Pesticides are an integral part of modern agriculture. The use of pesticides in agriculture is obvious for the prevention of crop-damaging pests, fungus, unwanted plants (weeds) and a number of crop-eating animals like rodents etc. The present research was designed to study pesticide usage patterns and assess farmers' awareness about the usage of pesticides. A multi-stage sampling technique was adopted to sample 120 farmers in Rajkot district. The analyses included simple tabular analysis, the frequency and percentage method, as well as calculations of mean and standard deviation. Farmers relied on approximate pesticide dosages and dealer recommendations, highlighting the need for improved education on safety and integrated pest management. While most were aware of environmental impacts, they predominantly used chemical solutions, with some interest in biopesticides. Knowledge gaps regarding recommended pesticide types and decontamination methods, along with misconceptions about higher doses improving yields, underscore the necessity for targeted educational initiatives.

(***Key words:*** *Awareness, Cotton, Pesticides, Simple tabular analysis)*

India's agricultural sector has rapidly modernized, but the heavy use of chemical inputs especially pesticides has created environmental and health concerns, particularly in cotton farming where misuse and limited knowledge remain major issues (Reddy *et al.*, 2024). Research across India shows that many farmers still rely on dealers for advice, use incorrect dosages, and lack awareness of safer or sustainable options, leading to low adoption of IPM and biopesticides (Satya Sai *et al.*, 2019). The agricultural sector plays a vital role in global food production, yet only 25% of total agricultural land is cultivated organically, with the majority relying on pesticide use (Sabran and Abas, 2021). Cotton, often referred to as "white gold," is a key commercial fiber crop in India and significantly influences the economy and textile industry while supporting the livelihoods of millions. Beyond fibre, cotton also provides valuable by-products such as edible oil, cattle feed, and raw material for packaging industries (Rathwa and Bochalya, 2023). It is widely grown across irrigated and rainfed regions of India as a major *Kharif* crop.

Globally, cotton is cultivated in about 60 countries, and in India, major producing districts include Vadodara, Surendranagar, Ahmedabad, Bhavnagar, Bharuch, Kheda, Surat, Rajkot, Junagadh and Kutch (Raviya *et al.*, 2023).

Cotton is one of the most important fibre crops globally and plays a vital role in the textile industry and rural livelihoods. India is among the leading cotton-producing countries in the world, with recent production estimated at around 29–30 million bales annually. The crop significantly contributes to the national economy through employment generation, raw material supply to the textile sector, and export earnings. Millions of farmers and workers are directly or indirectly dependent on cotton cultivation and its value chain. Within India, Gujarat is one of the major cotton-producing states and contributes a substantial share to national production. Cotton is a key cash crop in the state and forms the backbone of farmers' income in several districts. It also supports a strong network of ginning, processing, and textile industries, thereby playing a crucial role in the state's rural economy and industrial growth. However, cotton cultivation in Gujarat is highly

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dependent on agro-chemicals, and excessive use of pesticides and synthetic fertilizers has created serious challenges. Continuous and indiscriminate chemical application has resulted in declining soil fertility, reduced soil health, and the development of pest resistance, particularly in Bt cotton systems. Farmers are compelled to increase the frequency and dosage of pesticide sprays, which raises the cost of cultivation and reduces profitability. Moreover, excessive chemical use has led to environmental concerns such as soil and water contamination, decline of beneficial insects, and health risks to farmers due to repeated exposure. These constraints are increasingly affecting the sustainability and economic viability of cotton farming in the region (Nthebere *et al.*, 2025).

The issue of pesticide usage in cotton becomes particularly relevant in the context of the commercialisation of genetically modified cotton hybrid seeds, *Bacillus thuringiensis*, or Bt cotton varieties since 2002. However, there is an ongoing debate on whether cultivation of Bt cotton has resulted in lower pesticide usage (Krishna and Qaim 2012; Narayanan and Viswanathan 2015a, 2015b). The studies show that although total pesticide usage has significantly reduced (Carpenter 2010; Krishna and Qaim 2012), there has been an increase in pesticide sprays against the outbreak of secondary pests such as jassids and aphids (Nagrare *et al.*, 2009). In spite of the association between the growing cultivation of Bt cotton and pesticide use among cotton farmers, not much is known in terms of the trends and determinants of pesticide usage since the commercialization of Bt cotton.

Pesticides are considered a vital component of modern farming, playing a major role in maintaining high agricultural productivity. However, concerns over pesticides' effects on human health and the environment have grown in recent years. As a result, it is critical that everything possible is done to ensure that pesticides are used correctly in order to provide the greatest benefit while posing the fewest risks to humans and the environment. Careless handling of pesticides usually due to ignorance, lack of information or lack of training can pose a serious health risk for farmers, who are the major pesticide users and are regularly exposed to pesticides in their day-to-day life (Devi *et al.*, 2023).

There is a wide regional variation in the use of pesticides across the states in India. The consumption pattern of different pesticides belonging to different groups varies across the geographic location primarily based on the dealer recommendations, intensity of pests and diseases, influence of peer groups, efficacy of particular insecticides, knowledge level of the farmer, availability of a particular insecticide and socio-economic condition of the farmer (Lingappa *et al.*, 1993). Pesticide consumption pattern in Cotton (93.27 %) was the high pesticide consuming agro product (Yadav and Dutta, 2019).

Mounika *et al.* (2023) observed that maize farmers in Andhra Pradesh lacked knowledge about pesticide recommendations (80%) and classifications (60%), with most relying on dealer advice (73.4%) and often using bottle caps for measurement. Chaudhary (2018) found that 88.5 per cent of farmers in Rajasthan were aware of pesticides, though some avoided them due to organic practices encouraged by Pramparagat Krishi Vikas Yojana, and many relied heavily on dealer recommendations. Jorgensen *et al.* (2019) revealed that European pesticide use varied significantly by farm type, with dairy farms on sandy soils and mixed crops on clay soils showing the lowest usage, while larger farms demonstrated greater pesticide intensity.

Plianbangchang *et al.* (2009) found that farmers in northern Thailand widely misused pesticides, often applying them unsafely without personal protective equipment and relying on advertisements for product selection. Despite a government ban, endosulfan was still in use. Benerjee *et al.* (2014) found that farmers in West Bengal most commonly used Alpha-cypermethrin, followed by methyl parathion and imidacloprid, while neglecting safety practices during pesticide application. Deviprasad *et al.* (2015) found that farmers in Karnataka predominantly used insecticides, followed by fungicides, but lacked knowledge about proper application techniques, safety measures, and environmental impacts. Malgie *et al.* (2015) revealed that farmers in Suriname frequently used toxic pesticides unsustainably, over-applied dosages for quicker results, and neglected safe handling and disposal practices, despite being largely literate. Gaikwad and Jirali (2016) noted that farmers in Dharwad and Belagavi districts used 20-50 pesticides, primarily to control brinjal pests. The most frequently used pesticides included Indoxacarb and Rynaxypyr.

Patel and Lad (2018) found that the majority of tomato farmers in Anand district had low awareness about the correct doses and usage of different fungicides for disease control. Pandey *et al.* (2020) found that most hybrid paddy seed growers in Bihar were influenced by dealer and retailer promotions, which played a significant role in their purchasing decisions.

The research aims to examine how farmers actually use pesticides, how well they understand safety measures, and what prevents them from shifting to more sustainable pest control options. By focusing on local conditions, the study hopes to generate insights that can guide practical training programs and policy efforts, ultimately improve pesticide management while reduce risks to farmers, consumers, and the environment. It also seeks to address existing knowledge gaps by encouraging the use of safer, affordable, and eco-friendly methods of pest management in cotton cultivation.

MATERIALS AND METHODS

Sampling design

The present study was conducted in Rajkot district of Gujarat State to examine pesticide usage patterns and assess farmers' awareness of pesticide usage. Three talukas from Rajkot district were selected for the study. From each selected taluka, 4 villages were chosen randomly and from each village, 10 cotton-growing farmers were selected as respondents, totaling 120 farmers for the study. An interview schedule was developed based on the study's objectives and farmers were personally interviewed to collect information. All responses were systematically recorded and entered into a master Excel database for analysis. The data were compiled, scored, tabulated and analyzed statistically to address the specific objectives of the research.

Statistical analysis

Frequency and percentage method

The frequency and percentage method was used to identify the usage pattern of pesticides in the study area. It was a commonly used method for expressing the relative frequency of survey responses and other data. The percentage frequency distributions were often displayed as bar graphs, pie charts or tables.

The formula used for percentage method is:

$$\text{Percentage} = \frac{X}{Y} * 100$$

Where,

X = Number of respondents falling into each category of pesticide usage practices.

Y =Total number of respondents

Standard deviation and mean

Pesticide awareness was defined as farmers' knowledge of the different pesticides commonly used in cotton cultivation. The overall awareness of pesticides by farmers was assessed on a two-point scale: "Yes" (1) and "No" (0).

Mean

Mean value was used as the basis for fixing the range for the awareness level. Mean was the value arrived at by dividing the sum of observations by the total number of observations. Symbolically, for several observations (Sullivan, 2012).

$$\bar{X} = \frac{\sum x_i}{n}$$

where,

$\bar{X}$ = Mean value

Σx_i = Sum of the values

n = Number of observations

Standard deviation

The standard deviation is the most frequently calculated measure of variability or dispersion in a set of data points. The standard deviation value represents the average distance of a set of scores from the mean or average score. Standard deviation was worked out from the total score obtained by each respondent as per the following formula (Sullivan, 2012).

$$SD = \sqrt{\frac{\sum (x_i - \bar{X})^2}{n-1}}$$

where,

SD = Standard deviation

x_i = Individual score

$\bar{X}$ = Mean score

n = Total number of respondents

The respondents were classified into three categories based on the standard deviation and mean. The maximum obtainable score for awareness was 11, while the minimum score was 0.

Table 1. *Classification of respondents based on awareness levels*

Sl. No.	Category	Range
1	Low	< Mean – S.D.
2	Medium	Mean ± S.D.
3	High	> Mean + S.D.

RESULTS AND DISCUSSION

Socio-economic profile of cotton growers

Socio-economic profile of cotton growers is presented in Table 2. The study revealed that the majority of cotton growers were middle-aged (51.67%), likely because this age group combines experience with the physical capability needed for labor-intensive cotton cultivation. A substantial portion held middle school education (35.83%), possibly reflecting limited educational infrastructure in rural areas and the tendency for youths to enter farming to support family income. Most farmers had considerable farming experience, with 31.67% having 16 to 20 years of experience, which could be due to the generational transfer of farming knowledge and skills essential in cotton agriculture (Padaliya *et al.*, 2023).

Health values were mainly at a medium level (35%), perhaps because farmers face frequent exposure to chemicals but adopt some basic protective measures. Semi-medium land holdings (2.01 to 4.00 ha) were common (35%), as landholdings are often fragmented through inheritance, affecting the scale of cotton production. Many growers earned between ₹1,00,001 to ₹1,50,000 annually (31.67%), which may indicate the relatively moderate profitability of cotton farming under existing market conditions and input costs (Kaur and Sharma, 2025).

Environmental orientation and sustainability levels were mostly at a medium level, with 59.17% and 63.33% respectively, likely due to the gradual adoption of eco-friendly practices such as reduced pesticide use, given their impact on soil health and cotton yield. A medium level of risk orientation (31.67%) was common, as cotton growers may be cautious about adopting new techniques due to high input costs and variable market prices. Economic motivation was also predominantly medium (40%), possibly driven by fluctuating cotton prices and the need for stable income. Scientific orientation was at a medium level for 35% of growers, suggesting a balanced approach where traditional methods are augmented by scientific practices for cotton cultivation. Most farmers displayed medium innovativeness (25%), as cotton growers often selectively implement innovations like high-yielding seed varieties but may be hesitant about unfamiliar technologies. Mass media exposure was medium for 65% of respondents, likely because farmers rely on accessible sources like radio or regional publications for updates on farming practices and market trends. Information sources were utilized at a medium level by 61.67%, reflecting reliance on local agricultural extension services and peer networks for insights into effective cotton farming techniques (Rout *et al.*, 2024).

Pesticide usage pattern

The findings presented in Table 3 provide an in-depth analysis of pesticide usage patterns among 120 cotton farmers in the study area. First, the method of measuring pesticide dosage revealed that a majority (62.5%) relied

Table 2. *Distribution of cotton growers based on their personal characteristics*

Sl. No.	Personal characteristic	Category		Frequency	Percentage
1	Age	Young age (up to 35 years)		23	19.17
		Middle age (36 to 50 years)		62	51.67
		Old age (above 50 years)		34	28.33
2	Education	College/post-graduation		11	9.17
		Higher school (11th & 12th)		14	11.67
		Middle school (9th to 10th standard)		43	35.83
		Primary school (1st to 8th standard)		26	21.67
		Functionally Literate		18	15
		Illiterate		8	6.67
3	Farming experience	Very less (Up to 5 years)		7	5.83
		Less (6 to 10 years)		17	14.17
		Medium (11 to 15 years)		27	22.5
		High (16 to 20 years)		38	31.67
		Very high (Above 21 years)		32	26.67
4	Health value	Very low level (Up to 7.2)		12	10
		Low level (7.3 to 10.4)		15	12.5
		Medium level (10.5 to 13.6)		42	35
		High level (13.7 to 16.8)		28	23.33
		Very high level (16.9 to 20)		22	18.33
5	Land holding	Big size (above 10.00 ha)		9	7.5
		Medium size (4.01 to 10.00 ha)		18	15
		Semi medium size (2.01 to 4.00 ha)		42	35
		Small size (1.01 to 2.00 ha)		32	26.67
		Marginal size (0.01 to 1.00 ha)		19	15.83
6	Annual income	Above ₹ 2,00,000		11	9.17
		₹ 1,50,001 to ₹ 2,00,000		18	15
		₹ 1,00,001 to ₹ 1,50,000		38	31.67
		₹ 50,001 to ₹ 1,00,000		29	24.17
		Up to ₹ 50,000		25	20.83
7	Environmental orientation	Low level (< Mean – S. D.)	(Up to 7.51)	22	18.33
		Medium level (Mean + S. D.)	(7.52 to 10.83)	71	59.17
		High level (> Mean + S. D.)	(Above 10.83)	28	23.33
		Mean = 10.40 S.D. = 1.39			
8	Sustainability	Low level (< Mean – S. D.)	(Up to 8.59)	23	19.17
		Medium level (Mean + S. D.)	(8.60 to 15.47)	76	63.33
		High level (> Mean + S. D.)	(Above 15.47)	21	17.5
		Mean = 14.36 S.D. = 2.85			

9	Risk orientation	Very low		0	0
		Low		21	17.5
		Medium		38	31.67
		High		42	35
		Very high		18	15
10	Economic motivation	Very low		9	7.5
		Low		12	10
		Medium		48	40
		High		37	30.83
		Very high		13	10.83
11	Scientific orientation	Very low		8	6.67
		Low		12	10
		Medium		42	35
		High		45	37.5
		Very high		12	10
12	Innovativeness	Traditional farmer		9	7.5
		Less innovative farmer		28	23.33
		Medium innovative farmer		30	25
		High innovative farmer		42	35
		Very high innovative farmer		10	8.33
13	Mass media exposure	Low (< Mean – S. D.)	Up to 6.95	24	20
		Medium (Mean + S. D.)	6.95 to 16.05	78	65
		High (> Mean + S. D.)	Above 16.05	18	15
		Mean = 11.14 S.D. = 2.70			
14	Source of information	Less (< Mean – S. D.)	Up to 7.33	26	21.67
		Medium (Mean + S. D.)	7.33 to 16.65	74	61.67
		More (> Mean + S. D.)	Above 16.65	20	16.67
		Mean = 11.77 S.D. = 2.89			

on approximate estimation, while 37.5% used a bottle cap. This lack of precision in dosage measurement could lead to inconsistent application rates, affecting both crop health and environmental safety. In terms of mixing, all farmers (100%) reported using a stick, indicating positive safety practices as they avoided direct contact with chemicals. Regarding recommendations, 62.5% consulted dealers, while smaller groups turned to agricultural officers (18.33%) and agricultural scientists (19.17%). This reliance on commercial entities suggests a potential bias in pesticide selection driven by dealer influence rather than scientific recommendations (Alebachew *et al.*, 2023).

The survey also examined waiting periods after pesticide application; 68.33% of farmers adhered to a one-week waiting period before re-entry or harvest, demonstrating a reasonable understanding of safety protocols. However, 22.5% waited four days, and 9.17% only waited two days, indicating a need for better education on safety measures. When it comes to disposal methods for empty containers, 47.5% of farmers sold them, raising concerns about potential reuse, while 41.67% disposed of them in the trash and 10% buried them in soil, reflecting a lack of appropriate disposal practices. For equipment decontamination, the majority (82.5%) used water for washing, suggesting reliance on basic cleaning methods that may not adequately remove pesticide residues.

In examining application frequency, 46.67% of farmers reported applying pesticides every 10 to 15 days, with 30.83% applying weekly, which indicates varying pest pressures and possibly differing adherence to integrated pest management strategies. Protective clothing usage showed that only 25% of farmers always wore protective gear during applications, while 58.33% did so sometimes. This highlights a critical area for intervention as inadequate protective measures can expose farmers to harmful chemicals. The data further revealed that 75% of farmers purchased pesticides from local dealers, demonstrating a reliance on local sources for chemical acquisition, which underscores the importance of ensuring these vendors provide safe and effective products (Gudadur and Dolli, 2024).

Farmers' motivations for pesticide choice were primarily based on previous experience (45.83%) and recommendations (37.5%), suggesting a tendency to rely on past practices rather than critically evaluating product efficacy. In terms of storage, 54.17% utilized designated storage areas, while 33.33% stored pesticides at home and 12.5% in fields, indicating varied levels of adherence to safe storage practices. Decisions for reapplication were often based on crop condition (41.67%), with other factors such as weather forecasts (25%) and dealer advice (33.33%) influencing practices, showcasing the need for more systematic decision-making (Sachan *et al.*, 2022).

The primary pest control method reported was chemical pesticides (66.67%), with only 25% using organic options and 8.33% practicing integrated pest management, which indicates a heavy reliance on chemical solutions. Training on pesticide use was infrequent, with 50% of farmers never attending workshops, suggesting an education gap that could be addressed through outreach initiatives. Many farmers (70.83%) acknowledged that pesticide use negatively impacts soil health, indicating awareness of environmental issues associated with chemical use. Regarding accidental spillage, 54.17% reported washing spills with water, while 29.17% absorbed them with soil, highlighting a need for standardized training on spill response to minimize harm.

Farmers were also aware of pest resistance, with 50% noting resistance buildup over time. The rotation of pesticide types was reported regularly by 35% and occasionally by 65%, indicating a mix of practices that could contribute to resistance issues. A significant majority (79.17%) considered the impact of pesticide use on crop yield, demonstrating a balance between pest control and productivity. In terms of packaging preferences, 58.33% favored larger sizes, likely for cost-effectiveness. Consultation with fellow farmers about pesticide use was rare (54.17%), indicating an opportunity to foster collaborative knowledge-sharing among farmers.

The disposal of expired pesticides revealed that 58.33% disposed of them in soil, while 41.67% returned them to dealers, emphasizing the need for better disposal options. While 66.67% did not reuse pesticide containers, 33.33% reported doing so, highlighting a potential risk for safety. The primary purpose of pesticide application was overwhelmingly pest control (91.67%), with only 8.33% aiming to increase yield, emphasizing the importance of effective pest management. Lastly, a large portion (70.83%) of farmers adjusted pesticide concentration based on pest severity, demonstrating responsiveness to pest pressures. However, only 25% followed a specific pest management plan, indicating a critical area for improvement in adopting integrated pest management practices. Additionally, 41.67% of farmers used biopesticides alongside chemicals, suggesting a willingness to explore alternatives, though the majority still relied on chemical options (Yaseen *et al.*, 2024).

Awareness

Awareness level of farmers about usage of pesticides was find out using mean and standard deviation method. Awareness of farmers about usage of pesticides is

Table 3. *Usage pattern of pesticides by sample farmers in the study area*

Sl. No.	Statements	Options	Frequency	Percent (%)
1	How do you measure the pesticide dosage?	a) Bottle cap	45	37.5
		b) Approximate estimation	75	62.5
2	What tool do you use to mix the pesticide?	a) Stick	120	100
		b) Bare hands	0	0
3	Who do you consult for pesticide recommendations?	a) Agricultural Officer (AO)	22	18.33
		b) Dealer	75	62.5
		c) Agricultural Scientist	23	19.17
4	What is the typical waiting period after pesticide application?	a) 2 days	11	9.17
		b) 4 days	27	22.5
		c) 1 week	82	68.33
5	How do you dispose of empty pesticide containers?	a) Bury in soil	12	10
		b) Sell	57	47.5
		c) Throw into trash	50	41.67
6	What method do you use to decontaminate equipment?	a) Saltwater wash	21	17.5
		b) Water wash	99	82.5
7	How frequently do you apply pesticides?	a) Every 2 days	7	5.83
		b) Every 4 days	15	12.5
		c) Weekly	37	30.83
		d) Every 10-15 days	56	46.67
8	Do you wear protective clothing during pesticide application?	a) Always	30	25
		b) Sometimes	70	58.33
		c) Never	20	16.67
9	Where do you purchase your pesticides?	a) Local dealer	90	75
		b) Online	10	8.33
		c) Cooperative	20	16.67
10	What motivates your choice of pesticide?	a) Recommendation	45	37.5
		b) Previous experience	55	45.83
		c) Cost	20	16.67
11	How do you store unused pesticides?	a) Designated storage area	65	54.17
		b) Home storage	40	33.33
		c) Random storage in fields	15	12.5
12	How do you decide when to reapply pesticides?	a) Crop condition	50	41.67
		b) Weather forecast	30	25
		c) Dealer's advice	40	33.33
13	What method of pest control do you primarily use?	a) Chemical pesticides	80	66.67
		b) Organic pesticides	30	25
		c) Integrated pest management	10	8.33

14	How often do you attend training or workshops on pesticide use?	a) Regularly	10	8.33
		b) Occasionally	50	41.67
		c) Never	60	50
15	Do you think pesticide use has affected soil health over time?	a) Yes	85	70.83
		b) No	20	16.67
		c) Not sure	15	12.5
16	How do you handle accidental spillage of pesticides?	a) Absorb with soil	35	29.17
		b) Wash with water	65	54.17
		c) Leave it	20	16.67
17	What is the primary factor for your choice of pesticide brand?	a) Cost effectiveness	40	33.33
		b) Availability	30	25
		c) Efficacy	50	41.67
18	Do you keep a record of pesticide applications?	a) Yes	30	25
		b) No	90	75
19	Do you inspect your sprayer equipment before use?	a) Always	65	54.17
		b) Sometimes	40	33.33
		c) Never	15	12.5
20	Have you noticed resistance buildup in pests over the years?	a) Yes	60	50
		b) No	30	25
		c) Not sure	30	25
21	How often do you rotate pesticide types?	a) Regularly	42	35
		b) Occasionally	78	65
22	Do you consider crop yield impact before pesticide use?	a) Yes	95	79.17
		b) No	25	20.83
23	Preferred pesticide packaging size	a) Small	50	41.67
		b) Large	70	58.33
24	Frequency of consultation with fellow farmers on pesticide use	a) Often	55	45.83
		b) Rarely	65	54.17
25	How do you dispose of expired pesticides?	a) Return to dealer	50	41.67
		b) Dispose in soil	70	58.33
26	Do you reuse pesticide containers for other purposes?	a) Yes	40	33.33
		b) No	80	66.67
27	Primary purpose of pesticide application	a) Pest control	110	91.67
		b) Increase yield	10	8.33
28	Do you change pesticide concentration based on pest severity?	a) Yes	85	70.83
		b) No	35	29.17
29	Do you follow a specific pest management plan?	a) Yes	30	25
		b) No	90	75
30	Do you use biopesticides along with chemical pesticides?	a) Yes	50	41.67
		b) No	70	58.33

presented in Table 4. 40% farmers were aware of recommended pesticides for different pests, and 60% were not aware about recommended pesticides for different pests, 45.83% of the respondents are aware of pesticide classification based on toxicity, indicating that over half 54.17% may not be fully informed. A high 70.83% of farmers were followed safe methods when handling pesticides, suggesting a positive trend in safety practices, while 29.17% farmers were not aware about this safe method of pesticides. All farmers (100%) observe the health effects of pesticides on sprayers, indicating a universal concern for health implications. 80% farmers were used pesticide mixtures. This suggests a significant reliance on combinations of pesticides for effective pest control while 20% farmers were not aware about any pesticide's mixture methods. A large majority of 79.17% were aware that pesticide residues in food can accumulate in the body, highlighting a general understanding of potential health risks, and 20.83% farmers were not aware about that pesticide residues in food enter into body and accumulate. Over half 58.33% of the farmers were aware of food export rejections due to pesticide residues, indicating a partial understanding of international standards and 41.67% farmers were not aware about that food exports are rejected due to pesticide residues. A majority 73.33% farmers were aware about the quantity of pesticides used is adequate, reflecting a general satisfaction with current usage levels and 32% farmers were not aware about that the quantity of pesticides used as adequate. A majority 75% farmers believed that pesticides are helpful in achieving good crop yields, with a smaller percentage 25% disagreed. 75% farmers aware about that the higher doses of pesticides led to higher yields, indicating a potential misconception about the effectiveness of pesticides and 25% farmers were not aware about that high pesticide dose gives higher yields. 62.5% farmers were aware of pesticide decontamination methods, suggesting a moderate level of knowledge in this area, and 37.50% farmers were not aware about any pesticide decontamination method.

According to the awareness level, farmers were divided into three groups low, medium and high on the basis of mean score 7.6 and standard deviation 1.74. Distribution of the farmers according to their overall awareness level is presented in Table 3 and Fig 1 As

Table 4. *Usage pattern of pesticides by sample farmers in the study area*

Sl. No.	Statements	Yes	%	No	%
1	Are you aware about recommended pesticides against different pests?	48	40	72	60
2	Are you aware about the pesticide classification based on toxicity?	55	45.83	65	54.17
3	Do you follow safe methods while storing / mixing / spraying pesticides?	85	70.83	35	29.17
4	Do you observe pesticide effect on health of spray men during spray?	120	100	0	0
5	Do you use pesticide mixtures?	96	80	24	20
6	Do you know that pesticide residues in food enter into body and accumulate?	95	79.17	25	20.83
7	Are you aware that food exports are rejected due to pesticide residues?	70	58.33	50	41.67
8	Do you think the quantity of pesticides used as adequate?	88	73.33	32	26.67
9	Do you think that pesticides are helpful in getting good yield?	90	75	30	25
10	Do you think high pesticide dose gives higher yields?	90	75	30	25
11	Are you aware about pesticide decontamination method?	75	62.5	45	37.5

per the result, it was clear that 91 (75.83%) farmers had medium level of awareness, 15 (12.5%) farmers had high level of awareness and 14 (11.67%) farmers had low level of awareness about awareness about usage of pesticides. It indicates that majority of farmers had medium level of awareness about usage of pesticides.

CONCLUSION

Agriculture is a vital occupation for rural communities and serves as the backbone of many economies. In India, cotton is the most significant fiber crop, ranking first in area and production while holding the eighth position in productivity. The consumption of pesticides is particularly high in cotton cultivation due to the serious threat posed by pests to crop yields. Cotton farmers heavily rely on approximate dosages and dealer recommendations for pesticide application, resulting in limited adherence to safety protocols. Although there is some awareness of the impacts on soil health and pest resistance, issues such as inconsistent use of protective gear, inadequate disposal methods, and insufficient training underscore the urgent need for improved education on safe pesticide practices. Despite a general understanding of health risks, knowledge gaps persist regarding pesticide types, toxicity, and food safety implications. Targeted educational initiatives and greater adoption of integrated pest management strategies are essential to promote safer

Table 5. *Level of awareness about usage of pesticides among famers*

Awareness level	No. of farmers	Percentage
Low (below < 5.86)	14	11.67
Medium (5.86 to 9.34)	91	75.83
High (above >9.34)	15	12.5
Total	120	100
Mean score		7.6
Standard deviation		1.74

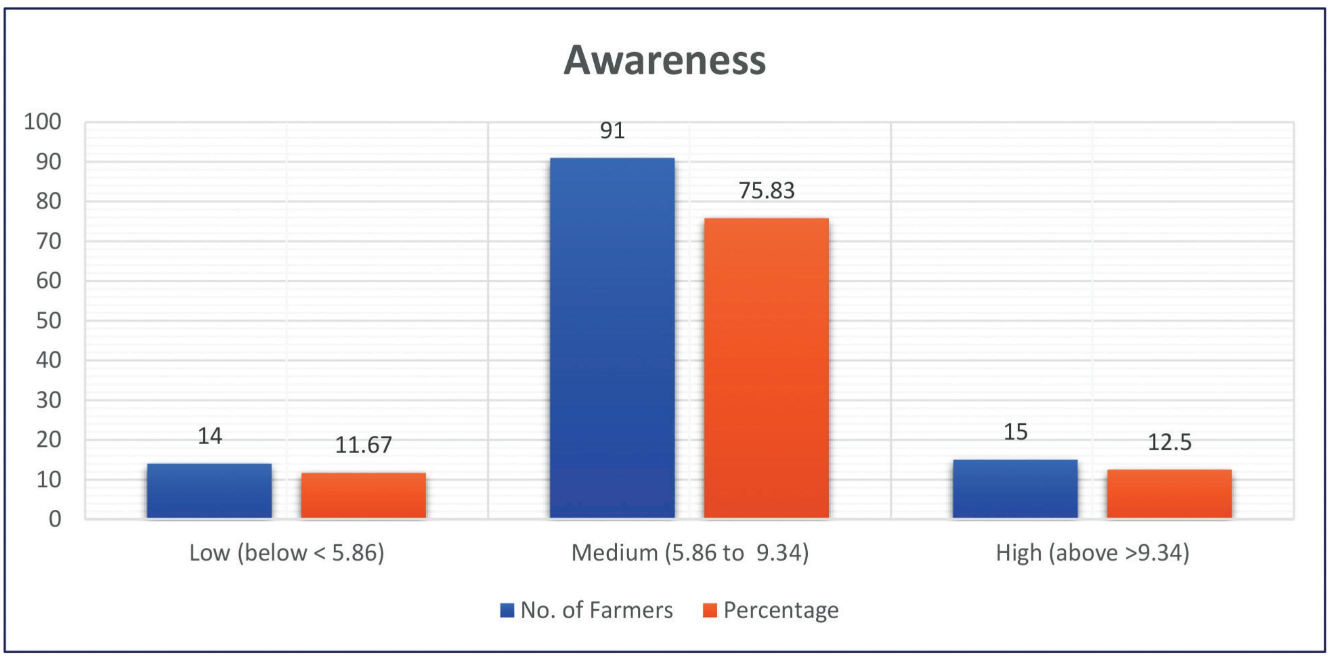

Fig. 1. Awareness level of farmers about usage of pesticides

and more compliant pesticide use among farmers. These findings will assist scientists and extension personnel in understanding the current situation and developing suitable measures to guide cotton growers in responsible pesticide practices.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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