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Assessing Agricultural Practices and Plant Protection Methods in Rupnagar District, Punjab, India

Sanjay Kumar [a++], Shivani [a*], Pallavi Sharma [a] and Rajeev Kumar [a]

[a] University Institute of Agricultural Sciences, Chandigarh University, Gharuan, Mohali, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The purpose of this research is to analyze plant protection systems and agricultural practices in Punjab, India's Rupnagar District, in order to provide insights into nutrient management, seed rates, crop diversity, mechanization, and their implications.
Conclusion: The study emphasizes the significance of improved mechanization, crop diversity, and sustainable farming techniques in Rupnagar, Punjab, to promote future agricultural development.
Methodology: The study employed a mixed-methods approach, combining field surveys and structured interviews with 120 farmers across six villages in Rupnagar District, Punjab, India. Data on crop types, seed rates, machinery usage, and nutrient management were collected. Random sampling ensured representativeness, providing comprehensive insights into agricultural practices and challenges in the region.
Place and Duration of Study: Villages of Rupnagar district, Punjab (Primary place) and Department of Agriculture sciences, Chandigarh university, Gharuan (Secondary place), between August 2023 and September 2023

[++]Assistant Professor;
**Corresponding author: Email: shivanipandwar15@gmail.com, shivanipandwar154@gmail.com;*

Results: According to the data, the two main crops grown in the research areas were rice and wheat. Among the various degrees of mechanization observed, tractors were the most frequently visible piece of equipment. Seed rate management varied, and some farmers used more seed than was recommended. The data revealed a diversity of nutrient management approaches, as well as a proclivity for urea overuse. These findings offer insight on how complex the farming methods in the area are.

Study Design: A mixed-methods methodology is used in the study design. It combines field surveys, interviews, and data analysis to extensively analyze agricultural practices in Rupnagar District, Punjab, India, including crop diversification, mechanization, and the use of plant protection strategies.

Keywords: Agricultural practices; crop diversity; mechanization; nutrient management; seed rate.

1. INTRODUCTION

Agriculture, often referred to as the backbone of many economies, plays a pivotal role in ensuring food security, economic prosperity, and the overall well-being of nations [1]. Growing population and high consumption rates place previously unheard-of strains on agricultural and natural resources [2]. This agricultural prowess extends well beyond state borders, as India is one of the world's major agricultural hubs, supplying a diverse range of crops to the global market [3]. Furthermore, given that India will have more people by 2027 (based on United Nations population forecasts from 2019), it will be incredibly difficult for Indian agriculture to feed this massive population. This is especially true in light of climate change and the depletion of natural resources such as air, water, and land [4]. Agriculture's profound implications are further underscored when considering its vital role in addressing the increasing challenges of a growing global population [1]. This significance is particularly exemplified in Punjab, a northern state of India. Known as the "Granary of India," agriculture sector of Punjab has been instrumental in providing sustenance to its population and contributing substantially to the nation's grain reserves [5,6]. As of the introduction of modern agricultural technologies such as chemical fertilizers, irrigation systems, and high-yielding wheat seed varieties, the Punjab economy expanded rapidly after green revolution [7]. Also, there have been various plant protection methods used in Punjab. Farmers who have a low tolerance for pest infestations use a lot of fertilizer. Furthermore, the public sector encourages the use of IPM, environmentally friendly pest management approaches, and insecticides [8]. Integrated farming system reduces the cost of production by recycling the residues in the field and also helps to conserve water, soil health and nutrients which decrease their dependence on excessive chemicals [9]. Several reports have highlighted the effect of indiscriminate and excessive use of pesticides not only on human health but also the environment [10]. Agriculture can regularly feed food and other resources to a growing global population is critical to human survival and, by extension, to all human undertakings. Climate change, a high rate of biodiversity loss, land degradation due to compaction, erosion, pollution, and salinization, depletion and pollution of water resources, rising production costs, a steadily declining number of farms, and the poverty and declining rural population that accompany it all pose a threat to agriculture's ability to meet human needs now and in the future [11].

In the ever-evolving landscape of agricultural education, a transformative program known as the Rural Agricultural Work Experience (RAWE) program has taken root in agricultural universities across India [12]. This research aims to characterize the agricultural practices followed by farmers and analyze the data to identify any emerging trends, patterns, or commonalities among different agricultural practices.

2. MATERIALS AND METHODS

The study was conducted in six villages: Mandauli khurad (District Rupnagar), Ratangarh (District Rupnagar), Ramgarh manda (District Rupnagar), Badwali (District Rupnagar), Bhateri (District Fategarh sahib), and Mandauli kalan (District Rupnagar).

Fig. 1.

This survey's data was gathered through field trips and farmer interviews. As surveyors, members visited the selected farms and conducted formal interviews with the participating farmers. Researchers used a standardized questionnaire to collect information on crop types, varieties, acreage, seed rates, suggested seeds, irrigation techniques, seed and fertilizer usage, cultivation techniques, disease management strategies, years of farming experience, and changes in farming practices over time.

Among the principal data collection sources were:

1. Direct Interviews: Researchers asked questions of the farmers face-to-face and noted their answers.
2. On-site observations were conducted by the researchers regarding farming techniques, including the availability of agricultural machinery and the state of the crops.
3. Historical Records: A question concerning years of experience and past modifications to farming methods was posed to farmers.

Random sampling is used in surveys. In random sampling, a portion of the population (farmers in this case) is chosen at random, offering each person an equal chance of being included in the sample. To assure representativeness, this technique is frequently applied [13].

A total of 120 farmers were surveyed and data were collected. From Mandauli khurad, 15 respondents were interviewed, from Ratangarh, 20 respondents were interviewed and from Ramgarh manda, Badwali, Bhateri and Mandauli kalan, 25,15, 25, 25 respondents were interviewed respectively. During the survey conducted, the major crops were Rice, Wheat, Berseem (fodder) and Multi-cut sorghum (fodder) whereas other crops which are grow by less farmers were vegetables and sugarcane.

3. RESULTS AND DISCUSSION

Farmers have begun to use increasing dosages of chemical fertilizers and other agro-chemicals in order to sustain current levels of food grain output, which has impacted the ecology. As a result, farmers must be educated about the importance of sustainable agriculture, the financial benefits of conservation technology and practices to both the state and farmers, and the need for them to demonstrate these techniques on their farms in order to preserve Punjabi agriculture. To compete in the market with rice wheat systems, government policies must be amended to encourage natural resource management and environmental conservation. Maize, pulses, oilseeds, milk, and other products also require assistance, as does the building of supply and value chain systems for these items [6].

There are various research options available to increase crop yields. There are numerous options for rice, Punjab's main crop: improved rice cultivars, optimal pesticide use, the use of laser leveling and furrow irrigated raised beds (FIRB) technologies, the matching of water

availability with land use systems, the adoption of practices free of distortion, integrated crop management, strengthened crop improvement programs, integrated pest and disease management, integrated nutrient management, site-specific nutrient management (SSNM) [14].

3.1 Major Crops Grown

In six communities, local farmers raise a diverse range of crops. According to statistics (Table 1), these groups follow various agricultural patterns. Wheat and rice are the most common crops in Mandauli Khurad, with notable occurrences of multi-cut sorghum, berseem, and mustard. Maize and sugarcane are minor crops. Wheat and rice are the principal crops of Ratangarh, with mustard accounting for a significant percentage and other crops being considered. Ramgarh Manda is known for its emphasis on berseem, wheat, and multi-cut sorghum, rather than sugarcane. Badwali, like Mandauli Khurad, grows a variety of crops, although maize and cauliflower are becoming increasingly popular. These variations reflect the diverse agricultural methods utilized in these societies.

The data depicts crop distribution across multiple villages. Wheat is grown in every village, although the majority also grows multi-cut sorghum and rice as their principal crops. Mustard and sugarcane are not evenly distributed. Maize and cauliflower are rather uncommon. Rice, wheat, and multi-cut sorghum are the principal crops in each village, with varying proportions of other crops.

3.2 Commonly Grown Varieties

In the Rupnagar district, there are six unique villages that farm a varied range of common crop species. Farmers in these villages have adopted a range of crop types to accommodate their distinct preferences and local conditions. Wheat fields, in particular, prosper with WH 711, DBW 17, and PBW 502, while rice varieties such as Pusa 44, HKR-47, and others are popular. For fodder, Berseem varieties BL42 and BL10 are preferred; for multi-cut sorghum, SL44, Punjab Sudax, and Chari 1 are offered. GSC6 and GSC5 are shown in mustard fields, whilst TL 15 (toria), Hyola and Hybrid Shell, Double, 31Y45 are shown in sugarcane and maize fields, respectively. These various varieties reflect the area's extensive agricultural past (Table 2).

3.3 Seed Rate

Farmers in the region's six communities use varying seed rates for different crops (Table 3). Approximately 36% of farmers employ the recommended seed rate for rice cultivation, whereas a sizable 64% use a higher seed rate. Similarly, only 25.6% of farmers grow wheat at recommended rates, whereas a huge 74.4% grow it over recommended levels. In multi-cut sorghum, 31.2% of farmers follow suggested techniques, whereas 68.8% choose higher seed rates. Berseem, mustard, sugarcane, maize, and cauliflower follow suit, reflecting the area's diverse farming techniques and inclinations, as some farmers chose to use greater seed rates than recommended while others stick to official recommendations.

3.4 Machinery and Equipment Owned

The data (Table 4) demonstrates the wide range of agricultural approaches by providing insights into how farmers in various villages use machinery and equipment. In Mandauli Khurad, Ratangarh, Ramgarh Manda, Badwali, Bhateri, and Mandauli Kalan, various farming equipment is employed to differing degrees.

Tractors are a popular choice; Mandauli Khurad comes in second with 60, followed by Ratangarh with 75%. Plows, harrows, and levelers are used by 46.6% to 75% of the population. Cultivators and rotavators, on the other hand, have poor adoption rates ranging from 0% to 16%. Seed drills are the least common in most communities, accounting for less than 5% of the equipment.

3.5 Irrigation Schedule

The information (Table 5) sheds important light on the irrigation methods used by farmers in a number of different communities. Regarding the quantity of irrigations they use, farmers in Mandauli Khurad, Ramgarh Manda, Badwali, Bhateri, and Mandauli Kalan use a variety of strategies. A significant majority of farmers in Mandauli Khurad and Bhateri—86% and 66%, respectively—choose a more frequent strategy, choosing five to six irrigations. However, a sizable portion of farmers in Ratangarh and Ramgarh Manda—35.6% and 67%, respectively—choose to use three to four irrigations.

Table 1. Crops grown by farmers in different villages of Rupnagar district

	Crops grown (% of total farmers)								
Village name	**Rice**	**Wheat**	**Multi-cut sorghum**	**Berseem**	**Mustard**	**Sugarcane**	**Maize**	**Cauli-flower**	**Other crops**
Mandauli Khurad	100	100	93.3	86.7	40	6.7	6.7	13.3	0
Ratangarh	100	100	90	85	75	15	20	0	10
Ramgarh Manda	92	100	96	96	60	0	0	4	0
Badwali	100	100	93.3	86.7	60	20	26.7	6.7	13.4
Bhateri	92	100	96	92	44	4	12	12	0
Mandauli kalan	100	100	92	76	56	0	8	0	0
Total	**97.3**	**100**	**93.4**	**87.06**	**55.8**	**7.61**	**12.2**	**6**	**3.9**

Table 2. Common varieties grown by farmers in Villages of Rupnagar district

Crop name	Varieties grown
Rice	Pusa 44, HKR- 47, PR 113, PR-126, PR-128
Wheat	WH 711, DBW 17, PBW 502
Berseem	BL42, BL10
Multi-cut sorghum	SL44 , Punjab Sudax, Chari 1
Mustard	GSC6, GSC5
Sugarcane	TL 15 (toria), Hyola (sarson)
Maize	Hybrid Shell, Double (Monsanto), 31Y45

Table 3. Seed rate of different crops

Crop name	Recommended Seed rate [%of farmers follow]	Above recommended seed rate [%of farmers follow]
Rice	36	64
Wheat	25.6	74.4
Multi-cut sorghum	31.2	68.8
Berseem	47.2	52.8
Mustard	44	56
Sugarcane	53.6	46.4
Maize	62.4	37.6
Cauliflower	65	35

Table 4. Machineryand equipment owned

	Village name						
Machinary (% of total farmers)	**Mandauli khurad**	**Ratangarh**	**Ramgarh Manda**	**Badwali**	**Bhateri**	**Mandauli kalan**	**Overall (% of total farmers)**
Tractor	60	75	72	53.3	80	76	**69.4**
Ploughs	60	70	64	53.3	68	72	**64.55**
Harrows	53.3	70	68	46.6	64	68	**61.65**
Cultivator	6.7	10	12	0	4	4	**6.1**
Rotavator	6.7	0	0	0	16	12	**5.8**
Leveller	53.3	75	64	53.3	76	76	**66.3**
Seed drills	0	0	0	0	4	0	**0.6**

Table 5. No. of irrigations given to crops

No. of the irrigations (% of total farmers)	Mandauli khurad	Ratangarh	Ramgarh Manda	Badwali	Bhateri	Mandauli kalan	Overall
1-2	0	10	4	0	0	0	**2.3**
3-4	23	35.6	67	43	34	48	**41.8**
5-6	87	54.4	29	57	66	52	**57.6**

3.6 Nutrient Management

3.6.1 Organic manure usage

In Table 6, farm yard manure is most extensively employed in Bhateri (94%) and Badwali (83%), with an overall average of 76.7%. Vermicompost sees noteworthy usage in Ratangarh (12%), contributing to an overall high average of 59.7%. Compost is predominantly used in Mandauli Kalan (21.6%), while the overall average stands at 11.4%. Other organic manure usage is limited, primarily found in Ratangarh (10%), resulting in a minimal overall average of 2%. These trends reflect the varying manure preferences, with Bhateri favoring farm yard manure, while vermicompost is widely adopted across the villages.

Table 6. Organic manure used by farmers in different villages

Manure (% of total farmers use)	Mandauli khurad	Ratangarh	Ramgarh Manda	Badwali	Bhateri	Mandauli kalan	Overall
Farmyard manure	76	62	73	83	94	72	**76.7**
Vermicompost	7	12	21	9	4.3	6.4	**59.7**
Compost	17	16	4	8	1.7	21.6	**11.4**
Other organic manure	0	10	2	0	0	0	**2**

3.6.2 Inorganic fertilizer usage

3.6.2.1 Dose of urea applied

The data (Fig. 2), presented in percentages, paints a clear picture of the various urea application procedures employed by farmers in various places. Although some farmers adhere to the recommended urea levels, others prefer to apply less or more than what is recommended. Mandauli Khurad is remarkable for having 66.7% of farmers exceed the recommended urea levels, while only 20% adhere to the regulations. In Ratangarh, 85% of farmers exceed the prescribed quantity, while 15% strictly adhere to it. This data shows how agricultural practices are dynamic and influenced by a variety of factors such as crop kinds, soil conditions, and local customs. The varying percentages in each of these localities demonstrate the farmers' adaptability and flexibility in tailoring their urea application.

As recommended dosage of urea is around 224-274 kg/hectare (90-110 kg/acre) for majority of crops. However, majority of farmers apply more than the necessary amount of urea which ultimately harm the plant and soil health [15,16,17]. Nitrogen application improves cell size, meristematic activity, and protoplasm production and function, all of which lead to increased crop development [18].

3.6.2.2 Dose of DAP

The data (Fig. 3) illustrates the varied DAP (Diammonium Phosphate) application practices among farmers in different villages, presented in precise percentages. In Mandauli Khurad, 46.7% of farmers align with the recommended DAP application, while 13.3% apply below the recommended rate, and 40% opt for higher levels. Ratangarh shows 45% adhering to the recommendations, 15% using less DAP, and 40% surpassing the suggested application. In contrast, Ramgarh Manda demonstrates 32% following recommendations, 12% below, and 56% exceeding them. This data reflects the dynamic agricultural landscape shaped by local factors, crop types, and traditions, highlighting the adaptability of farmers as they make tailored choices to suit their specific needs and local conditions.

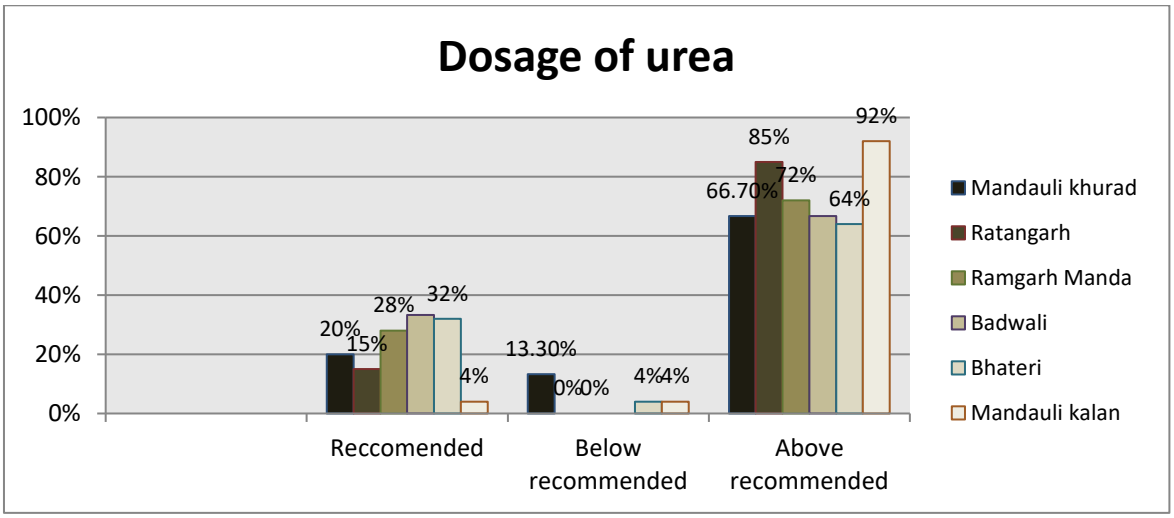

Fig. 2. Dosage of urea

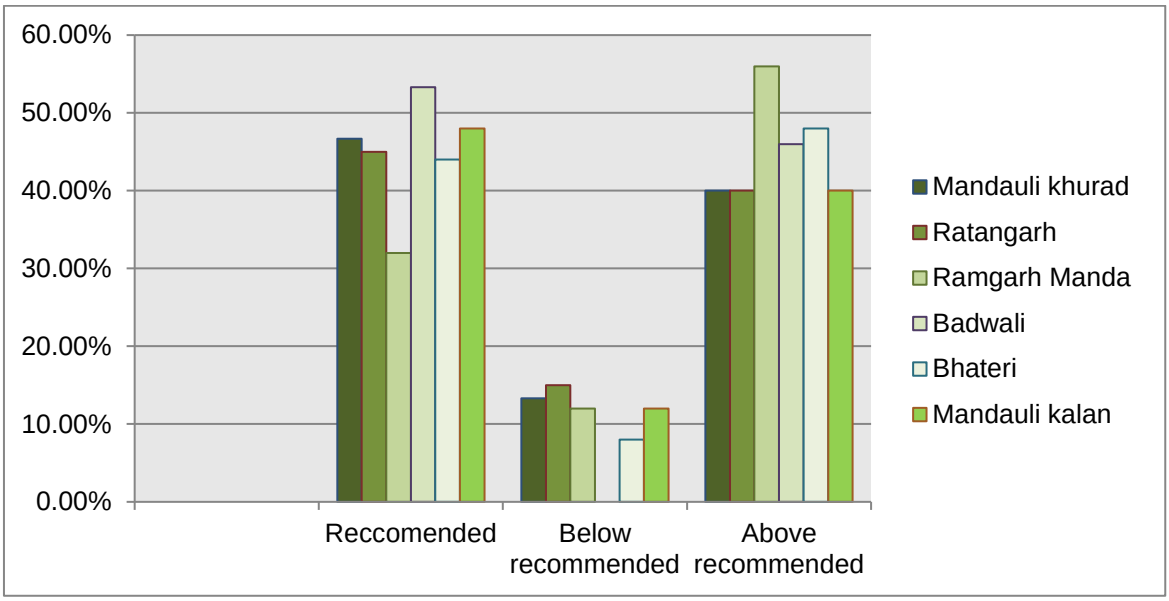

Fig. 3. Dosage of DAP

3.7 Weed Management

In six distinct villages, seasonal differences in the frequency of important weed species have been identified (Table 7) These settlements have a large diversity of common grasses. Crow foot grass (*Dactyloctenium aegyptium*), Goose grass (*Eleusine indica*), Love grass (*Eragrostis tenella*), Sandbur (*Cenchrus catharticus*), and Crab grass (*Digitaria sanguinalis*) take center stage during the Kharif season. Canary grass (*Phalaris minor*), wild oats (*Avena ludoviciana*), and beard grass (*Polypogen monspellensis*) are prevalent throughout the Rabi season.

Controlling weed species is critical to maintaining agricultural productivity in these six settlements. Different herbicides are employed as vital tools to control the great diversity of common grasses (Table 10). Herbicide selection is tailored to the specific weed species and seasonal requirements. In these areas, herbicides such as Bispyribac Sodium 10% SC (80.45%), Pyroxasulfone 85% G (59.28%), Axial- 45 g/l (4.5% w/w) pinoxaden, 5 g/l florasulam (0.5% w/w) and 11.25 g/l (1.1% w/w) cloquintocet-mexyl (24.83%), Pretilachlor- 2-chloro-2′, 6′-diethyl-N-(2-propoxyethyl) acetanilide (18.2%), and Sulfosulfuron 75% WG (10.3%) are commonly used. These herbicides are critical for weed control as well as crop health and productivity. They are employed in a method that allows for responsible and efficient weed management in these agriculturally diverse regions, taking aspects like weed kind, development stage, and environmental considerations into account.

Table 7. Major weeds identified in Rupnagar

Common name	Scientific name	Season	Percentage (% of total farmers encounter)
Canary grass	*Phalaris minor*	Rabi	100
Crow foot grass	*Dactyloctenium aegyptium*	Kharif	100
Goose grass	*Eleusine indica*	Kharif	96
Love grass	*Eragrostis tenella*	Kharif	60
Sandbur	*Cenchrus catharticus*	Kharif	46
Crab grass	*Digitaria sanguinalis*	Kharif	35
Wild Oats	*Avena ludoviciana*	Rabi	20
Beard grass	*Polypogen spp.*	Rabi	10.2

Table 8. Different herbicides use to control weeds

S. No.	Herbicide	Chemical name	Percentage (% of total farmers use)
1.	Nominee gold	Bispyribac Sodium 10% SC	80.45
2.	Avkira	Pyroxasulfone 85% G	59.28
3.	Axial	45 g/l (4.5% w/w) pinoxaden, 5 g/l florasulam (0.5% w/w) and 11.25 g/l (1.1% w/w) cloquintocet-mexyl	24.83
4.	Pretilachlor	2-chloro-2′, 6′-diethyl-N-(2-propoxyethyl) acetanilide	18.2
5.	Leader	Sulfosulfuron 75% WG	10.3

3.8 Pest Management

The incidence of numerous pests varies across the researched areas, affecting agricultural operations (Table 9). Mandauli Khurad has the highest percentage of leaf hoppers and aphids, at 93.3% and 86.7%, respectively, but Ratangarh is not far behind, with 90% and 85%, respectively. The presence of aphids in Ramgarh Manda is 96%. Significant aphid infestations have been observed in Badwali (93.3%) and Bhateri (92%). Mandauli Kalan has a high proportion of leaf hoppers—96%. Stem borers are rare; Mandauli Khurad has the highest incidence rate, at 46.5%. These figures illustrate the importance of effective pest management plans that are tailored to the specific challenges that each region faces.

Pesticide spraying is critical in these agricultural settings for crop protection and pest control. In Table 10., Mandauli Khurad and Badwali lead the way in pest management with a 100% chlorpyriphos usage rate. Ratangarh and Ramgarh Manda both choose Chlorantraniliprole 18.5% w/w, with 95% and 92% of the vote, respectively. Notably, imidacloprid is used in 46.7 percent of Badwali and 50% of Ratangarh. The entire statistics reflect a regional average, with chlorpyriphos at 95.50%, Chlorantraniliprole 18.5% w/w at 90.95%, and imidacloprid at 42.78%. These pesticide use patterns reflect the distinct agricultural requirements and obstacles found in these varied regions.

3.9 Disease Management

The incidence of numerous ailments in the agricultural landscape of Rupnagar's six distinct villages has an impact on crop health and productivity. In Table 11, it is shown that Brown rust, a serious danger, is found in Mandauli khurad (100%) and Ramgarh Manda (88%), with the highest concentrations in Ratangarh (80%) and Badwali (80%). Yellow rust is constantly widespread in every village. Meanwhile, powdery mildew is most prevalent in Ratangarh (65%) and Mandauli khurad (60%). The entire data underscores the importance of disease management in these various agricultural areas by emphasizing the average 86 regional problem of brown rust, as well as the prevalence of yellow rust and powdery mildew.

Disease control is critical for crop health and yield in Rupnagar's six villages (Table 12.) Tebuconazole 50%+ Trifloxystrobin 25%. is the chemical of choice for disease management in these places; it is utilized 100% of the time in Mandauli khurad, Ratangarh, Ramgarh Manda, Badwali, and Bhateri. Mandauli Kalan, on the other hand, has a somewhat lower usage rate of 84%. Another frequent chemical is mancozeb, which is used at rates ranging from 60% to 65% in a number of villages, while propiconazol is used at rates ranging from 4% to 20%. Overall, the statistics show a 97.3% average heavy reliance on Tebuconazole 50%+ Trifloxystrobin 25%., with Mancozeb and Propiconazol also playing key roles in sickness management in these diverse agricultural areas.

3.10 Yield

3.10.1 Yield of wheat

The data reveals the distribution of wheat yield per hectare across six villages, including Mandauli Khurad, Ratangarh, Ramgarh Manda, Badwali, Bhateri, and Mandauli Kalan. It shows that the majority of wheat yields in the "37-50q" and "51-62q" categories are concentrated in most of the villages, with Mandauli Kalan standing out for its high yield in the "51-62q" category. However, in the "More than 62q" category, the yield is relatively low across all villages, with Bhateri having the highest percentage. The overall average wheat yield in all six villages falls into the "51-62q" category (Table 13).

Table 9. Common pests found in villages of Rupnagar

Pest (% of total farmers encounter)	Mandauli khurad	Ratangarh	Ramgarh Manda	Badwali	Bhateri	Mandauli kalan	Overall
Leaf hopper	93.3	90	95	86.7	92	96	92.2
Aphids	86.7	85	96	93.3	92	88	90.2
Stem borer	46.5	45	44	40	44	40	43.25
Other pests	6.7	5	4	0	0	4	3.28

Table 10. Major pesticides used by farmers

Pesticide (%of farmers use)	Mandauli khurad	Ratangarh	Ramgarh Manda	Badwali	Bhateri	Mandauli kalan	Overall (%of farmers use)
Chlorpyriphos	100	90	95	100	96	92	95.50
Chlorantraniliprole 18.5 % w/w	100	95	92	86.7	84	88	90.95
Imidacloprid	40	50	44	46.70	36	40	42.78

Table 11. Major diseases found in Rupnagar district

Disease (% of total farmers encounter)	Mandauli khurad	Ratangarh	Ramgarh Manda	Badwali	Bhateri	Mandauli kalan	Overall
Brown rust	100	80	88	80	84	84	**86.**
Yellow rust	80	80	80	80	80	80	**80**
Powdery mildew	60	65	64	60	36	40	**54.17**

Table 12. Common chemical control in Rupnagar district of Punjab

Chemical used for diseases management (% of total farmers use)	Mandauli khurad	Ratangarh	Ramgarh Manda	Badwali	Bhateri	Mandauli kalan	Overall
				(% of total farmers use)			
Tebuconazole 50%+ Trifloxystrobin 25%.	100	100	100	100	100	84	97.3
Mancozeb	60	65	64	60	36	40	51.2
Propiconazol	13.3	15	20	6.7	4	4	10.5

Table 13. Yield of wheat in different villages of rupnagar

S. No.	Wheat yield (Quintals/hec.) (% of total farmers get)	Mandauli khurad	Ratangarh	Ramgarh Manda	Badwali	Bhateri	Mandauli kalan	Overall
1.	37-50	40	50	44	46.7	36	40	**43**
2.	51-62	53.3	55	48	53.3	52	60	**54**
3.	More than 62	6.7	5	8	0	12	0	**3.6**

Table 14. Yield of rice in different villages

S. No.	Rice yield (quintals/hec.) (% of total farmers get)	Mandauli khurad	Ratangarh	Ramgarh Manda	Badwali	Bhateri	Mandauli kalan	Overall
1.	37-50	53.3	50	52	46.7	48	56	**51**
2.	51-62	46.7	50	48	53.3	52	44	**49**

3.10.2 Yield of rice

In the "37-50" quintals/hec. Category (Table 14), Mandauli Khurad, Ramgarh Manda, and Mandauli Kalan have the highest percentages of yield, while in the "51-62" category, Ratangarh, Bhateri, and Ramgarh Manda lead. The overall average rice yield leans towards the "37-50" category, with a slight majority at 51% for that range.

4. CONCLUSION

In conclusion, our research provided light on crucial farming methods and challenges in Rupnagar District of Punjab. The findings highlighted the many crop types that are cultivated, the diverse seed rates, and the relevance of mechanization. Farmers employed sophisticated nutrient management techniques customized to their unique agroecological conditions. The study's mixed-methods design ensured good data and allowed for a thorough comprehension. Pest control and water scarcity were identified as critical issues. Among the recommendations are personalized extension services, technology dissemination, and neighborhood-based water conservation projects. Addressing these concerns is crucial in order to develop sustainable agriculture in the area, emphasizing the importance of context-specific solutions. Future research should concentrate on the socioeconomic issues that influence farming.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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