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Pranjal Saini
University Institute of Agricultural
Sciences, Chandigarh University,
Mohali, Punjab, India

Aryan Singh
University Institute of Agricultural
Sciences, Chandigarh University,
Mohali, Punjab, India

Dr. Gurshaminder Singh
University Institute of Agricultural
Sciences, Chandigarh University,
Mohali, Punjab, India

Dr. Navjot Singh Gill
University Institute of Agricultural
Sciences, Chandigarh University,
Mohali, Punjab, India

Corresponding Author:
Dr. Gurshaminder Singh
University Institute of Agricultural
Sciences, Chandigarh University,
Mohali, Punjab, India

Adaptations of sustainable agronomic practices in Punjab villages

Pranjal Saini, Aryan Singh, Gurshaminder Singh and Navjot Singh Gill

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Abstract

The goal of the present research was to assess how much farmers in selected Punjabi villages employed sustainable agronomic practices. A structured poll was utilized to question 64 farmers from nine villages in order to compile information on crop patterns, types, input use, irrigation, and pest control methods. The findings showed that the rice-wheat cropping system was the best, with 100% of farmers accepting it. There was also some diversity with mustard (79.69%) and forage crops (68.75%). Though most farmers followed recommended agronomic practices like suitable seed rate (60.94%) and crop-specific irrigation scheduling, there was a great reliance on groundwater and traditional flooding methods. Traditional and contemporary nutrient management methods were clearly combined by the extensive use of both organic fertilisers (FYM, chicken manure, green manure) and inorganic fertilisers (urea, DAP, micronutrients). Chemical control techniques were mostly used since pests and diseases, especially aphids and rust, are so common. The yields were different for every crop, with sugarcane and fodder crops being among the most productive ones. Generally speaking, the study highlights the partial adoption of environmentally friendly techniques and notes opportunities for increasing resource utilization effectiveness and promoting ecologically friendly farming practices in Punjab.

Keywords: Sustainable agriculture, agronomic practices, rice–wheat system, Punjab agriculture, nutrient management, irrigation practices, crop diversification, pest management, farmer adoption, crop productivity

Introduction

Introduction to global agriculture-

Providing the essential food, fiber, and resources needed for life, economic growth, and social development, agriculture has been the bedrock of human civilization. Food security, the availability, accessibility, use, and stability of the food supply, has become one of the most pressing concerns of our time as the world's population is predicted to reach almost 10 billion by 2050 (Islam, 2025) ^[2]. The agricultural sector worldwide has experienced notable shifts away from traditional subsistence farming and towards intensive, automated, and technologically driven production techniques. Advances in agronomy, biotechnology, digital agriculture, and precision farming have changed agricultural systems all around the world and significantly increased output (Islam, 2025) ^[2].

Agriculture is intrinsically linked to food security, environmental sustainability, and rural development. However, modern agricultural systems face serious challenges including land degradation, water scarcity, biodiversity loss, greenhouse gas emissions, and climate change, all of which threaten agricultural productivity and resilience. (Lampridi *et al.*, 2019) ^[3].

Apart from its function in food production, global agriculture is vital to the Sustainable Development Goals (SDGs), especially Zero Hunger (SDG 2), Climate Action (SDG 13), and Life on Land (SDG 15), stressing its bigger contribution to both environmental sustainability and socioeconomic development (Mrudula & Keerthi, 2026) ^[4].

Agriculture forms the foundation of the global food supply. It is in charge of creating most of the food we consume, including fruits, vegetables, animal products, and essential crops including rice, wheat, and maize. According to the FAO, agriculture, which hires more than a billion people worldwide, is the largest employer in the world. In addition to its financial

relevance, agriculture is strongly related to the cultural norms, customs, and social institutions of several regions. However, agriculture's capacity to meet the growing need for food is progressively constrained. With a projected global population of around 10 billion by 2050, food output needs to increase by 50% from its present levels (Islam, 2025) ^[2].

Introduction to agriculture in Punjab

Agriculture is the foundation of Punjab's economy, and it has been vital to the state's socioeconomic development, rural livelihoods, and food production systems. Given its rich alluvial soils, extensive irrigation system, and ideal agro-climatic circumstances, the state has long been considered among India's most productive agricultural region (Rafie & Kumar, 2020) ^[5]. Punjab is a strategically important region of the country, based on the output and productivity of the two primary food grain crops: rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.). Punjab's agriculture was primarily subsistence-based before the Green Revolution, marked by low productivity, sustenance farming, and minimal mechanization. By increasing wheat and rice production in Punjab, the Green Revolution helped India solve the reoccurring food shortages of the 1960s. (H. Singh, 2023) ^[6].

Although agriculture in Punjab has been successful, it is now having major issues such as soil degradation, groundwater depletion, nutritional imbalance, stubble burning, loss of biodiversity, and rising expenses for production. These difficulties have caused doubts regarding the environmental sustainability of the state's intensive agriculture (R. Singh *et al.*, 2024) ^[7].

Recent studies underline that changing from an input-intensive cereal monoculture to more diversified, climate-resilient, and sustainable agricultural systems will determine the future of agriculture in Punjab. Understanding the evolution, achievements, and developing problems of Punjab agriculture is therefore crucial for designing future agricultural research and policy measures (Rafie & Kumar, 2020) ^[5].

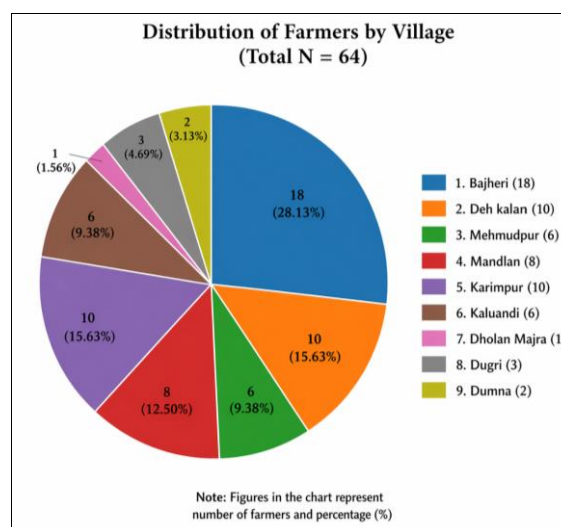
Objectives-

- 1) To assess the extent of adoption of sustainable agronomic practices among farmers in selected villages of Punjab.
- 2) To analyze the socio-economic, institutional, and technical factors influencing farmers' adaptation of sustainable agronomic practices in Punjab villages.
- 3) To evaluate the constraints faced by farmers in adopting sustainable agronomic practices and suggest strategies to enhance their adoption for sustainable agricultural development.

2.2. Materials and Methods

The study was undertaken in the Kharar block of SAS Nagar, Fatehgarh Sahib, and Rupnagar. Ten villages were—BAJHERI, DEH KALAN, MEHMADPUR, MANDLAN, KARIMPURA, KALAUNDI, DUGRI, KOTLI, DHOLAN MAJRA, DUMNA were selected. A total of 64 farmers were interviewed. - Respondents were from the villages- Bajheri, Deh kalan, Mehmoodpur, Mandlan, Karimpur, Kaluandi, Dholan Majra.

S.no.	Village name	Total no. of farmers (N=64)
1.	Bajheri	18
2.	Deh kalan	10
3.	Mehmudpur	6
4.	Mandlan	8
5.	Karimpur	10
6.	Kaluandi	6
7.	Dholan Majra	1
8.	Dugri	3
9.	Dumna	2



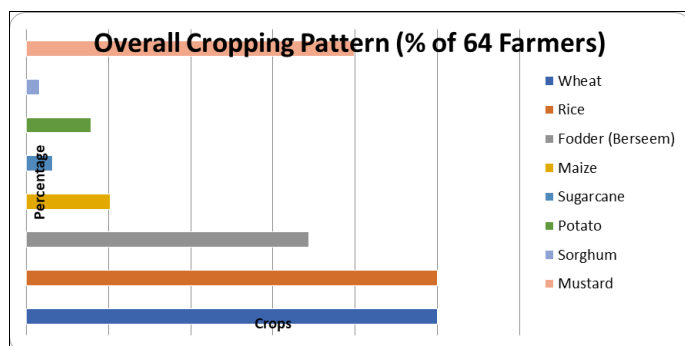
Comprehensive interactions were conducted with farmers to gather information regarding their socio-economic characteristics and the agronomic practices adopted throughout the year. Data were collected through interviews carried out at both farmers' residences and agricultural fields. A well-structured questionnaire was prepared to systematically evaluate each parameter, ensuring comprehensive coverage of all aspects related to farming operations. The information obtained was compiled, classified, and analyzed using appropriate statistical techniques. Various tools such as percentages, bar graphs, pie charts, and other graphical representations were used to present the findings in a clear and systematic manner.

Results and Discussion

Agronomic practices in Punjab have been dominated by the rice–wheat cropping system, which has contributed significantly to agricultural productivity but has also raised concerns related to soil degradation, groundwater depletion, and declining factor productivity (Dhanda *et al.*, 2022) ^[1]. With the help of the survey taken by the farmers in the RAWE programme from the villages of Bajheri, Deh kalan, Mehmadpur, Karimpur, Kaluandi, Dholan Majra in Punjab, information was gathered regarding the crops grown and the practices followed. The findings revealed that rice was the predominant crop during the Kharif season, while wheat dominated in the Rabi season. Some farmers also cultivated Fodder (berseem), Maize, Sugarcane, Potato, Sorghum, Mustard, Few vegetables (for their own usage).

Major Crops grown in the field by the farmers

Sr.no	Crops	Bajheri (n=18)	Deh kalan (n=10)	Mehmadpur (n=6)	Mandlan (n=8)	Kalaundi (n=6)	Karimpur (n=10)	Dholan Majra (n=1)	Dugri (n=3)	Dumna (n=2)	Overall (N=64)
1.	Wheat	18	10	6	8	6	10	1	3	2	100%
2.	Rice	18	10	6	8	6	10	1	3	2	100%
3.	Fodder (Berseem)	12	6	4	5	5	8	1	2	1	68.75%
4.	Maize	4	2	1	2	1	2	0	0	1	20.31%
5.	Sugarcane	2	1	0	0	0	1	0	0	0	6.25%
6.	Potato	3	2	1	0	2	2	0	0	0	15.63%
7.	Sorghum	1	0	0	0	0	1	0	0	0	3.13%
8.	Mustard	15	8	5	6	4	9	1	2	1	79.69%



A review of the statistics on crop patterns shows that wheat and rice were produced by all 64 farmers polled (100%), therefore proving that these two crops make up the main cropping system in the research area. Among other crops, 79.69% of

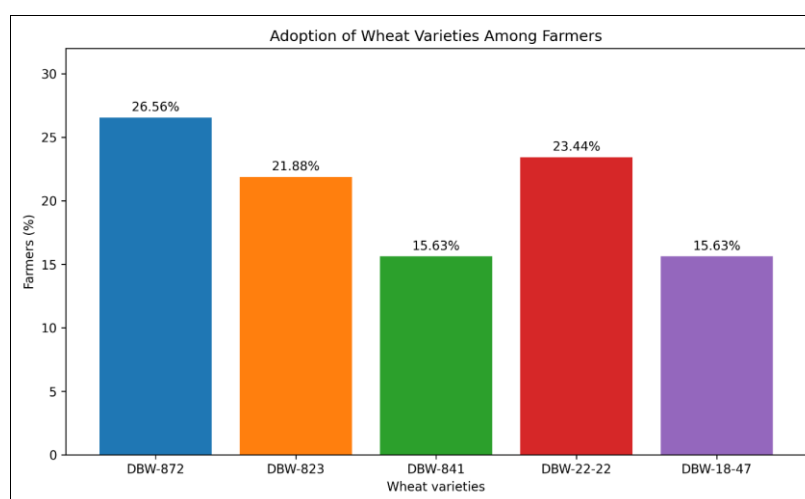
farmers grew mustard, making it the most important second crop behind wheat and rice. Given the significance of livestock-based farming in the region, 68.75% of respondents grew fodder (berseem). 15.63% of farmers grew potatoes, while 20.31% grew maize, indicating a somewhat low adoption level. According to the survey of farmers, sorghum (3.13%) and sugarcane (6.25%) have very little presence as minor crops. The data overall point to the predominance of a wheat-rice farming system with some diversification through mustard and feed crops, while the output of maize, potato, sugarcane, and sorghum stayed rather low in the researched towns.

Crop Varieties

1) Wheat varieties grown

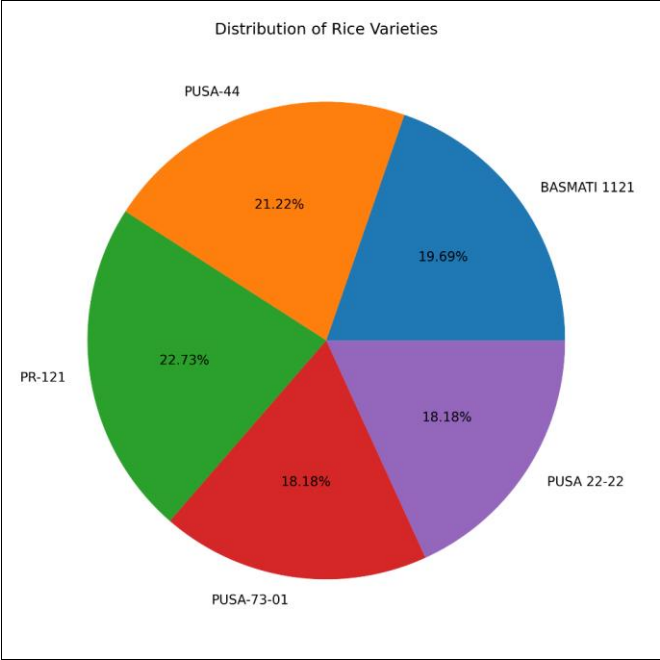
After surveying the farmers, we learned about the different varieties of wheat grown in the villages. Among these,

Sr. No.	Wheat variety	Bajheri (n=18)	Deh kalan (n=10)	Mehmadpur (n=6)	Mandlan (n=8)	Kalaundi (n=6)	Karimpur (n=10)	Dugri (n=3)	Dumna (n=2)	Dholan Majra (n=1)	Overall (N=64)
1.	DBW-872	7	2	0	2	1	3	0	2	0	26.56%
2.	DBW-823	4	3	1	3	0	2	1	0	0	21.88%
3.	DBW-841	2	2	1	1	0	3	0	0	1	15.63%
4.	DBW-22-22	4	0	3	2	4	0	2	0	0	23.44%
5.	DBW-18-47	1	3	1	2	1	2	0	0	0	15.63%



2) Rice varieties grown

Sr. No.	Rice variety	Bajheri (n=18)	Deh kalan (n=10)	Mehmadpur (n=6)	Mandlan (n=8)	Kalaundi (n=6)	Karimpur (n=10)	Dugri (n=3)	Dumna (n=2)	Dholan Majra (n=1)	Overall (N=64)
1.	BASMATI 1121	5	2	1	2	0	2	1	0	0	20.31%
2.	PUSA- 44	3	4	2	2	0	3	0	0	0	21.88%
3.	PR -121	2	2	1	1	4	2	2	1	0	23.44%
4.	PUSA-73-01	5	0	2	2	2	0	0	1	0	18.75%
5.	PUSA 22-22	3	2	0	3	0	3	0	0	1	18.75%



Other varieties grown

In maize, both Ganga-5 and PMH-1 varieties are cultivated; however, PMH-1 is the predominantly adopted variety in the surveyed region, as reported by local farmers. Punjab Chari-1 is widely grown as the major fodder variety of sorghum. For sugarcane, CoJ 64 is the dominant variety under cultivation, while Kufri Jyoti and Kufri Bahar are the most commonly adopted potato varieties, according to field observations and regional cultivation records.

Method of sowing

Crop	Method of sowing
Wheat	Seed drill, Broadcasting
Rice	Transplanting
Fodder (Berseem)	Broadcasting
Maize	Seed drill, broadcasting
Sugarcane	Ridge and furrow
Potato	Ridge and furrow
Sorghum	Broadcasting
Mustard	Line sowing (drilling)

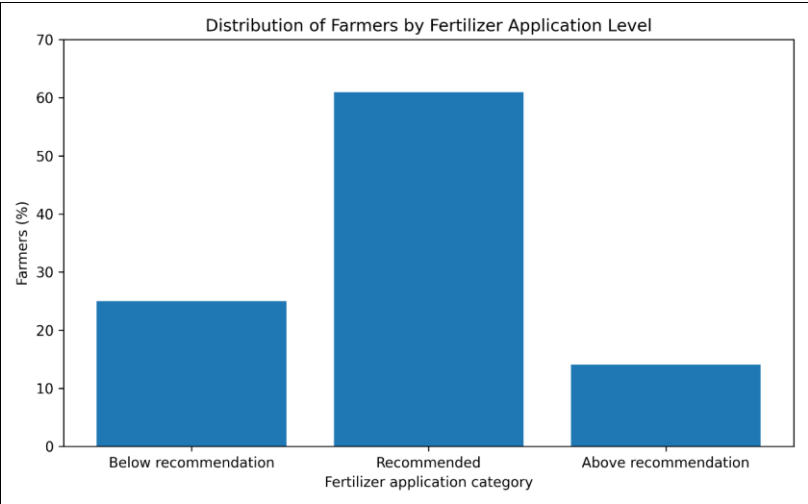
The data on planting techniques showed that farmers used several approaches depending on the crop type and agronomic needs. The use of both contemporary and traditional approaches by farmers is shown by the planting of wheat and maize using both seed drilling and broadcasting methods. The only way to cultivate rice was through transplantation, which remains the primary technique for paddy production in the study area. The fact that broadcasting was the main way berseem (fodder) and sorghum were planted suggests that it is the preferred approach for growing fodder crops. Potatoes and sugarcane were grown using the ridge and furrow method, which is great for root development, water management, and crop yields. Line sowing (drilling) was the main way that mustard was planted, which suggests that better farming methods were being used to grow oilseed. According to the data, farmers' choice of sowing techniques relied on the unique needs of every crop; the most often used methods of crop establishment were seed drilling, broadcasting, transplanting, and ridge and furrow.

Seed rate

Sr.no	Crops	Bajheri (n=18)	Deh kalan (n=10)	Mehmadpur (n=6)	Mandlan (n=8)	Karimpur (n=10)	Kalaundi (n=6)	Dholan Majra (n=1)	Dugri (n=3)	Dumna (n=2)	Overall (N=64)
1.	Below recommendation	5	3	1	2	4	1	0	0	0	25.00%
2.	Recommended	10	6	5	5	3	5	1	2	2	60.94%
3.	Above recommendation	3	1	0	1	3	0	0	1	0	14.06%

The data revealed that most farmers (60.94%) used fertilizers at the recommended amount, indicating broad acceptance of recommended nutrient management methods in the study region. But 25.00% of farmers utilized fertilizers at levels below those advised, maybe as a result of limited input availability, financial limitations, or a lack of knowledge of optimal practices. The meager 14.06% of farmers who applied fertilizers at levels

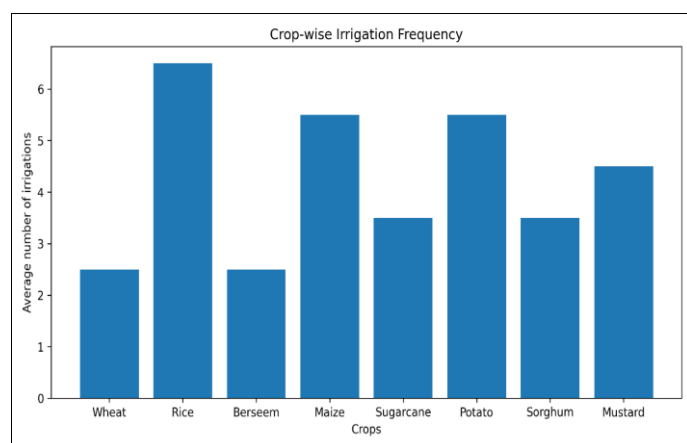
above those advised suggests that some respondents might have overused them, therefore influencing environmental sustainability and input efficiency. Overall, the findings indicate that although most farmers did, a sizable number of them did not adhere to recommended fertilizer application techniques—either by under-applying or over-applying.



Irrigation management

Crop	Source of Irrigation	Method of Irrigation	Number of Irrigations
Wheat	Tubewell/groundwater	Flooding	2-3
Rice	Tubewell/groundwater	Flooding	6-7
Berseem	Tubewell/groundwater	Check Basin / Furrow	2-3
Maize	Tubewell/groundwater	Check Basin / Furrow	5-6
Sugarcane	Tubewell/groundwater	Check Basin / Furrow	3-4
Potato	Tubewell/groundwater	Flooding	5-6
Sorghum	Tubewell/groundwater	Flooding	3-4
Mustard	Tubewell/groundwater	Flooding	4-5

The irrigation management data showed that most of the studied crops were irrigated by tubewells or groundwater, which shows that the region relies heavily on groundwater resources for agriculture. Flood irrigation was the main way that wheat, rice, potatoes, sorghum, and mustard got water. For berseem, maize, and sugarcane, people used the check basin/furrow method. The frequency of irrigation differed based on the crop's water requirements. Rice had the most irrigation (6-7), followed by maize and potatoes (5-6), which implies they need more water. While mustard needed four to five irrigations, sugarcane and sorghum needed three to four. The lowest irrigation frequencies were required for wheat and berseem (2-3). The total findings indicate crop-specific irrigation regimes, high groundwater reliance, and the widespread use of traditional surface irrigation methods among farmers.



Nutrient management- Organic management-

Crop	Organic manure used	Dose
Wheat	FYM	8 ton/acre
Rice	Green manure	-
Berseem	FYM	7 ton/acre
Maize	Poultry waste	2-3 Ton/acre
Sugarcane	FYM	9 ton/acre
Potato	FYM	8-9 Ton/acre
Sorghum	Poultry waste	3-4 Ton/acre
Mustard	Poultry waste, FYM	9-10 Ton/acre

Based on the data on organic manure utilization, it was evident that farmers utilized several organic nutrient sources depending on their crop needs and available resources. With application rates ranging from 7 to 9 ton per acre, farmyard manure (FYM) was the main organic fertiliser used for wheat, berseem, sugarcane, and potatoes. Green manuring rice implies that adding organic nutrients in situ helped to sustain soil fertility. In maize and sorghum, poultry waste was applied at a rate of 2–4 tons per acre; however, mustard received a combination of poultry waste and FYM at a considerably greater dosage of 9–10 tons per acre. Among the crops, mustard got the most organic manure; then came potatoes and sugarcane, while maize got the least. Overall, the findings indicate that a wide spectrum of organic nutrient management methods are being used, with FYM serving as the main organic input together with green manuring and chicken waste for some crops to boost soil health and harvest output.

Nutrient management- inorganic management

Crop	inorganic manure used	Dose
Wheat	DAP, Urea, Zinc	50kg/ha,140kg/ha, 10kg/ha
Rice	DAP, Urea	50kg/ha,145 kg/ha
Berseem	SSP, Urea, Boron	30-40kg/ha,30-40kg/ha, 3kg/ha
Maize	MOP, DAP, Urea, Magnesium	35-40kg/ha,50 kg/ha,140 kg/ha
Sugarcane	MOP, Zinc, SSP	35-40kg/ha,10-12kg/ha,40-45kg/ha
Potato	Urea, DAP, Potassium	30-40 kg/ha,22-23 kg/ha, 20-21 kg/ha
Sorghum	Urea, DAP	23-25kg/ha, 50-45 kg/ha
Mustard	DAP, Urea	45-48kg/ha, 70-80 kg/ha

Based on the data on inorganic nutrient management, farmers utilized a mix of vital fertilizers (N, P, K) with chosen micronutrients, depending on the demands of the crop. The inorganic fertilizers most often applied to important crops were urea and DAP, therefore highlighting their essential role in controlling nitrogen and phosphorus levels. The intensive nutrient application in cereal crops is reflected in the comparatively greater doses of urea (140–145 kg/ha) that rice and wheat received, as well as 50 kg/ha DAP. Berseem was fertilized with SSP, urea, and

boron, therefore highlighting the involvement of both macronutrients and micronutrients in fodder development. The fertilizer mix for maize was somewhat diverse, made up of MOP, DAP, urea, and magnesium, while sugarcane got a mix of MOP, zinc, and SSP, therefore showcasing crop-specific nutrient management techniques. Potatoes got urea, DAP, and potassium; sorghum and mustard got urea and DAP. The inclusion of micronutrients like zinc, boron, and magnesium in some crops is additional evidence of farmers' awareness of balanced fertilisation. The findings suggest that

inorganic nutrient management in the research area largely relied on fertiliser mixes customized to each crop, with urea and DAP functioning as the primary inputs employed to enhance crop yield.

Major Diseases observed in the field

S. No.	Disease name	Frequency (N=64)
1	Yellow rust	16
2	Red rot	12
3	Maydis leaf blight	7
4	Root rot	4
5	Bacterial leaf blight	12
6	Powdery mildew	7
7	Unspecific	6

Among the prominent illnesses seen in the field were viral, bacterial, and fungal infections affecting the productivity and development of several crops. The frequency of disease was influenced by crop type, weather conditions, and field management techniques. Using methods including chemical control and cultural approaches, farmers used preventative and therapeutic approaches to lower the prevalence of disease and yield losses. The prevalence of disease was generally seen as a major constraint affecting crop health and the sustainability of agricultural production.

Major pests observed in the field

S. No.	Pest name	Frequency (N=64)
1	Aphids	19
2	Stem borer	7
3	Shoot borer	4
4	Termites	11
5	Grasshopper	15
6	Rice Hispa	8

Field data on major pests revealed that aphids were the most often mentioned pest, with 29.69% of farmers (19 respondents) reporting it; followed by grasshoppers (23.44%) and termites (17.19%). 12.50% of farmers reported rice hispa, whereas less frequent were stem borer (10.94%) and shoot borer (6.25%). According to the findings, sucking and chewing insects had a major influence on crop health in the research region. The frequency of pests differed between fields overall, with aphids being the most often reported problem by farmers.

Sr.no	Crops	Bajheri (n=18)	Deh kalan (n=10)	Mehmadpur (n=6)	Mandlan (n=8)	Kalaundi (n=6)	Karimpur (n=10)	Dholan Majra (n=1)	Dugri (n=3)	Dumna (n=2)	Overall (N=64)
1.	Wheat	45 quintals/ha	46 quintals/ha	44 quintals/ha	40 quintals/ha	42 quintals/ha	43 quintals/ha	41 quintals/ha	43 quintals/ha	45 quintals/ha	43.22 q/ha%
2.	Rice	62 quintals/ha	61 quintals/ha	62 quintals/ha	64 quintals/ha	60 quintals/ha	63 quintals/ha	62 quintals/ha	62 quintals/ha	63 quintals/ha	62.11 q/ha%
3.	Fodder (Berseem)	520 quintals/ha	540 quintals/ha	495 quintals/ha	490 quintals/ha	500 quintals/ha	560 quintals/ha	530 quintals/ha	517.5 quintals/ha	530 quintals/ha	520.28 q/ha%
4.	Maize	37 quintals/ha	36 quintals/ha	35 quintals/ha	38 quintals/ha	35.5 quintals/ha	39 quintals/ha	37.5 quintals/ha	36.86 quintals/ha	38 quintals/ha	36.98 q/ha%
5.	Sugarcane	790 quintals/ha	780 quintals/ha	820 quintals/ha	785 quintals/ha	800 quintals/ha	830 quintals/ha	810 quintals/ha	802.14 quintals/ha	785 quintals/ha	800.46 q/ha%
6.	Potato	260 quintals/ha	272 quintals/ha	268 quintals/ha	275 quintals/ha	279 quintals/ha	277 quintals/ha	256 quintals/ha	269.6 quintals/ha	268 quintals/ha	269.62 q/ha%
7.	Sorghum	455 quintals/ha	460 quintals/ha	467 quintals/ha	467 quintals/ha	480 quintals/ha	495 quintals/ha	500 quintals/ha	475.29 quintals/ha	467 quintals/ha	474.48 q/ha%
8.	Mustard	14 quintal/ha	16 quintal/ha	15 quintal/ha	16 quintal/ha	14 quintal/ha	19 quintal/ha	11 quintal/ha	12 quintal/ha	10 quintal/ha	14.11 q/ha%

Common Pesticides used

S.no.	Pesticides
1	Chlorpyrifos
2	Cartap hydrochloride
3	Imidacloprid
4	Fipronil

The data show that farmers in the study region most often utilized Chlorpyrifos, Cartap hydrochloride, Imidacloprid, and Fipronil for pest control. These pesticides were developed to eradicate a range of sucking and chewing insect pests attacking several crops. Overall, the findings show that farmers rely on chemical pest control techniques to lower pest incidence and protect crop yield.

Common weedicides/Herbicides used

S.no.	Herbicides
1	Butachlor
2	2-4D
3	Atrazin
4	Pendimethalin
5	Metribuzin

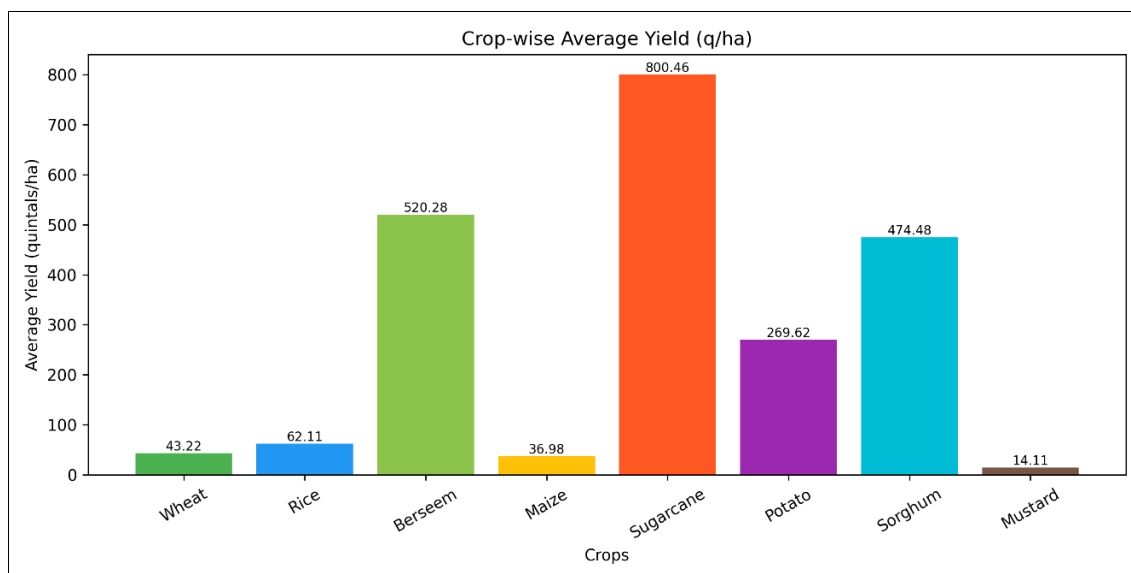
The data showed that farmers regularly used Metribuzin, Butachlor, Atrazine, Pendimethalin, and 2,4 -D for weed management in several crops. These herbicides were used to control both grassy and broadleaf weeds, therefore lowering weed competition and encouraging greater crop growth. The data imply that farmers in the research area are mostly using chemical weed control techniques.

Harvesting and Yield

The yield of major crops in the study area varied depending on crop type, input use, and management practices followed by farmers. Higher yields were generally associated with the adoption of recommended agronomic practices, including proper fertilizer application, irrigation scheduling, and pest management. Overall, yield performance reflected the combined influence of resource availability, farmer knowledge, and environmental conditions.

Harvesting

Harvesting of major crops in the study area was carried out using both manual labour and mechanized methods, depending on crop type and resource availability. Timely harvesting was observed to be crucial for minimizing losses and maintaining grain quality. The adoption of improved harvesting techniques contributed to better efficiency and reduced post-harvest losses among farmers.



Conclusion

The study stresses that the rice-wheat cropping system, which continues to be the foundation of farm production, is the primary characteristic of agriculture in the Punjab settlements researched. Though farmers have adopted a number of recommended agronomic techniques including appropriate seed rates, judicious fertilizer application, and crop-specific irrigation schedules, they continue to rely heavily on groundwater and traditional flood irrigation methods, therefore generating concerns about the long-term viability of these practices.

Including both organic fertilizers (FYM, green manure, chicken dung) and inorganic fertilizers (urea, DAP, micronutrients) suggests a slow shift toward balanced nutrient management; nevertheless, differences in adoption underline the need of more knowledge and extension support. The occurrence of pests and diseases still influences crop output, which has led to the adoption of chemical management strategies.

Though farmers have somewhat embraced sustainable agricultural practices, the study stresses the need of improving resource-use efficiency, diversifying cropping systems, and promoting ecologically sensitive techniques to guarantee the long-term viability of agriculture in Punjab.

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