Research Article

Exploring the Environmental Challenges and Mitigation Strategies of Rice crop in Narowal, Punjab, Pakistan

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Abstract | Food security has gradually become one of the most serious global issues prevalent today. Countries such as Pakistan have considerable dependence upon agricultural practices as the main source of livelihood for rural population. Rice *Oryza sativa* belonging to *Poaceae* family is a major staple food. Internationally, China is the biggest producer of rice in the World, whereas India is the second biggest producer followed by Bangladesh, Indonesia, Vietnam, Thailand, Brazil, Japan, Philippines and Pakistan. Pakistan ranks with the top ten countries that have high annual production of rice. At provincial level, Punjab contributes 52% to the total annual rice production, Sindh 38% and Baluchistan 8%. Pests such as Black bug, Mealy bug and Rice leafhopper negatively impact the rice crop. Rice requires water to grow, approximately 5000 liters of water is required to produce a single kg of rice grains. Some common and high prized rice varieties are Basmati 370, Basmati 385, Super Kernel and Super Basmati. Current work utilized ethnographic methodology, in-depth-interviews and participant observation methods to collect data on rice crop. It is recommended that Government should provide subsidies to farmer for good production of crop through private tube wells in cases of water scarcity. Government should set the standards of environment that ensure the environmental factors that impact rice growth.

Received | February 4, 2024; **Accepted** | May 24, 2024; **Published** | June, 2024
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Citation | Ashraf, A. and Chaudhry, A.G, 2024. Exploring the Environmental Challenges and Mitigation Strategies of Rice crop in Narowal, Punjab, Pakistan. *Journal of Innovative Biology and Environmental Sciences*, 4(1): 1-7
Keywords | Climate change, Food security, Rice, Basmati, Government subsidies

1. Introduction

Rice is the second staple food in Pakistan however in countries like China rice is the first staple food (Zhang *et al*., 2017; Abbas *et al*., 2022). More than the half of the World's population relies on this crop, especially the Asian countries (Bandumula, 2018). According to the National Bureau of Statistics, China is the world's number one rice producer (Tang *et al*., 2022). Pakistan ranks at number 10 in

the World for production of high quality and aromatic basmati rice (Bodie *et al*., 2019). The growth or production patterns of rice vary according to annual climate and weather patterns that have a strong impact on agriculture sector in World and not just one particular country (Wassmann *et al*., 2009). Every country faces climate challenge and has lost much portion of agriculture crops.

From an estimated 508.7 million tones global production, about 75% of rice is farmed in the flood areas (Minh *et al*., 2019). Among the various methods used for growing rice one such popular method is direct seed sowing in flooded areas (Bodie *et al*., 2019). Fertilizers that are used for rice crop are DAP (Diammonium phosphate), Urea, Nitrogen (N), Phosphorus (P), Potassium (K) and Zinc Sulphate. Some pests such as Black bugs, Armyworms, Rice hoppers, Mealy bugs and Rice leafhoppers have a strong impact on rice crop production (Jaswal *et al*., 2021). Rice crop is grown in kharif season. Crops such as groundnuts, cotton and bajra are also grown in kharif season (Singh *et al*., 2020).

Pakistan is the 6th most populous country in the world (Zahir, 2023). Agriculture is the back bone of Pakistan's economy. Agriculture sector contributes around 24% to the country's GDP and 40% in labor force (Raza *et al*., 2023). But the contribution has decreased due to many reasons including climate change, unpredictable weather patterns, drought, floods and famine as well as human activities. Mostly three varieties of rice are grown in Pakistan, Basmati, IRRI, and Cold tolerant (Fazal *et al*., 2023). Basmati rice is considered the best rice not only in Pakistan but across the globe. Basmati rice is preferred due to their good taste and aroma (Butt *et al*., 2008). The best duration of Basmati rice sowing is from May to June (Bodie *et al*., 2019).

2. Materials and Methods

2.1. Study Area

The research Area selected for current work was Narowal, Punjab, Pakistan. Narowal area was chosen due to its nutrient rice soils and quality crop production. Rice plantation requires large quantities of water which is available in this area in form of tube wells, rivers and lakes. Rain water is also stored for crop cultivation and vegetation growth (Chandio *et al*., 2020).

2.2. Study Design

The following work was a Qualitative Research Study (QRS), utilizing in-depth interviews, observation and focus group discussions as tools for data collection. Thematic analysis was used for analysis of data. The sample size was 40. Simple Random Sampling (SRS) techniques were used. All respondents were farmers.

2.3. Statistical Analysis

Statistical Package for the Social Sciences (SPSS) software was used for analysis of data.

3. Results

The results of interviews, observation and focus group discussions were compiled as source data and statistically analyzed for identification of environmental challenges and mitigation strategies of rice crop in Narowal, Punjab, Pakistan.

3.1. Study subjects

Farmers from Narowal, Punjab, Pakistan were recruited for current study as respondents. The respondent farming years (Table 1) along with the family (Table 2) and agricultural income (Table 3) are provided in respective tables.

3.2. Traditional farming

The total land of the respondents and areas allocated for rice cultivation are provided in Tables 4 and 5.

Table 1: Respondent farming years

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	10-20	7	23.3	23.3	23.3
	20-30	11	36.7	36.7	60.0
	30-40	7	23.3	23.3	83.3
	40-50	5	16.7	16.7	100.0
	Total	30	100.0	100.0	

Table 2: Family income of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	10,000	1	3.3	3.3	3.3
	25,000	3	10.0	10.0	13.3
	30,000	3	10.0	10.0	23.3
	40,000	6	20.0	20.0	43.3
	45,000	3	10.0	10.0	53.3
	50,000	3	10.0	10.0	63.3
	60,000	4	13.3	13.3	76.7
	70,000	2	6.7	6.7	83.3
	90,000	2	6.7	6.7	90.0
	1 lakh	1	3.3	3.3	93.3
	4 lakh	2	6.7	6.7	100.0
	Total	30	100.0	100.0	

Table 3: Agricultural income of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2 lakh	1	3.3	3.3	3.3
	3 lakh	3	10.0	10.0	13.3
	4 lakh	2	6.7	6.7	20.0
	5 lakh	1	3.3	3.3	23.3
	6 lakh	1	3.3	3.3	26.7
	7 lakh	1	3.3	3.3	30.0
	8 lakh	3	10.0	10.0	40.0
	9 lakh	3	10.0	10.0	50.0
	10 lakh	3	10.0	10.0	60.0
	11 lakh	1	3.3	3.3	63.3
	12 lakh	5	16.7	16.7	80.0
	14 lakh	2	6.7	6.7	86.7
	40 lakh	2	6.7	6.7	93.3
	60 lakh	2	6.7	6.7	100.0
	Total	30	100.0	100.0	

It was revealed that small land owner farmers opted to cultivate more rice as compared to large land owners. Farmers had no knowledge of agricultural technologies and were used the old methods such as burning the crop residues.

Table 4: Land areas of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5 Acre	1	3.3	3.3	3.3
	6 Acre	2	6.7	6.7	10.0
	8 Acre	2	6.7	6.7	16.7
	9 Acre	3	10.0	10.0	26.7
	10 Acre	3	10.0	10.0	36.7
	12 Acre	1	3.3	3.3	40.0
	15 Acre	3	10.0	10.0	50.0
	16 Acre	1	3.3	3.3	53.3
	18 Acre	3	10.0	10.0	63.3
	20 Acre	2	6.7	6.7	70.0
	22 Acre	1	3.3	3.3	73.3
	24 Acre	1	3.3	3.3	76.7
	25 Acre	3	10.0	10.0	86.7
	40 Acre	3	10.0	10.0	96.7
	100 Acre	1	3.3	3.3	100.0
	Total	30	100.0	100.0	

Table 5: Land allocated for rice cultivation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5 Acre	6	20.0	20.0	20.0
	8 Acre	2	6.7	6.7	26.7
	10 Acre	4	13.3	13.3	40.0
	11 Acre	1	3.3	3.3	43.3
	12 Acre	4	13.3	13.3	56.7
	14 Acre	2	6.7	6.7	63.3
	16 Acre	1	3.3	3.3	66.7
	18 Acre	2	6.7	6.7	73.3
	20 Acre	2	6.7	6.7	80.0
	30 Acre	1	3.3	3.3	83.3
	70 Acre	1	3.3	3.3	86.7
	80 Acre	1	3.3	3.3	90.0
	4 Acre	3	10.0	10.0	100.0
	Total	30	100.0	100.0	

3.3. Rice varieties

The most popular variety of rice cultivated in Narowal was Super Basmati (43.3%) and Basmati (36.7%) whereas the B-36, B-385 and Supra were the least grown varieties (Table 6).

Table 6: Rice varieties cultivated in Narowal

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Basmati	11	36.7	36.7	36.7
	Super Basmati	13	43.3	43.3	80.0
	Basmati Kernal	3	10.0	10.0	90.0
	B-36	1	3.3	3.3	93.3
	B-385	1	3.3	3.3	96.7
	Supra	1	3.3	3.3	100.0
	Total	30	100.0	100.0	

3.4. Water scarcity

The results show that due to water scarcity the farmers in Narowal cultivated Maize (56.7%) and Sugarcane (43.3%) as alternate crops (Table 7).

Table 7: Alternative crops cultivated in Narowal due to water scarcity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Maize	17	56.7	56.7	56.7
	Sugarcane	13	43.3	43.3	100.0
	Total	30	100.0	100.0	

3.5. Climate change and soil health

About 80% of respondents identified climate change to have a major impact on rice production (Figure 1). Results demonstrated that only 0.72% respondents used Organic fertilizers due to poor soil quality. The most popular fertilizer used was urea (50.16%) followed by Nitrogen fertilizer (45.76%) and Diammonium phosphate (DAP) fertilizers (3.36%) as demonstrated in Figure 2.

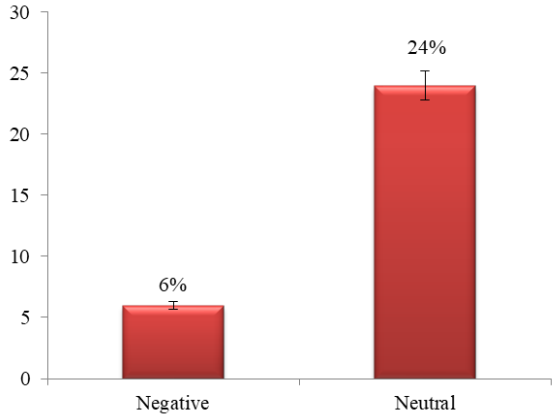

Figure 1: Climate impact on rice production

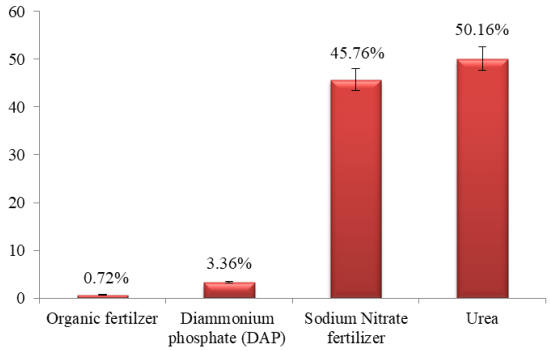

Figure 2: Fertilizers used due to poor soil quality

4. Discussion

Millions of people, mostly in Asia, rely heavily on rice growing as a source of food and revenue. Through commerce, it boosts the economy and helps small farmers maintain their standard of living (Goodman, 2020). Agri-scientists have modified new crops with desirable traits and genes. Through the Crop Monitoring and Management technologies like GPS farmers can easily monitor their crop health, growth and production rate (Bandumula, 2018). Agricultural is integral to Pakistan where 60% population relies on agriculture. Agriculture is also a source of livelihood for rural community in Pakistan and is the back bone of the country (Khan, 2020). Rice is the top cash crop of Pakistan. Narowal district is a good producer of rice in the Gujranwala division including Hafizabad and Sialkot. Basmati rice, Super Basmati Rice and Shaheen Basmati Rice are good qualities of rice that produced here (Ashraf, 2023).

In current study it was revealed that small landowner farmers opted to cultivate more rice as compared to large land owners. These findings are in accordance with recent studies which are aimed at identifying the factors influencing global trend of smallholder farmers' decisions to adopt organic rice farming (Sujianto *et al*., 2024; Seleky *et al*., 2024). This further highlights a major issue faced by the agriculture sector which is the wide spread prevalence of tradition farming. Farmers have no knowledge about the latest technology and they completely rely on old method of farming. Due to tradition farming the productivity of crops also decreases (Sehar, 2024). Farmers had no knowledge of agricultural technologies and were used the old methods such as burning the crop residues which effected soil health. This practice is still being commonly performed in Punjab (Chandio *et al*., 2023).

The most popular variety of rice cultivated in Narowal was Super Basmati and Basmati whereas the B-36, B-385 and Supra were the least grown varieties. These results are in agreement with several authors, who have reported that Basmati and Super Basmati are the most cultivated rice varieties due to consumer demand, high yield, extra-long grain and short production time (Akhter *et al*., 2019; Zohaib *et al*., 2022; Saifullah *et al*., 2024).

The results show that due to water scarcity the farmers in Narowal cultivated Maize and Sugarcane as alternate crops. Water scarcity or shortage of water is a current issue that the whole world is facing including Pakistan. Water is an essential element for agriculture. But due to urbanization and others factors water level

have decreased rapidly resulting in decrease of ground and surface water levels (Akhter and Haider, 2020). Improved environment friendly irrigation practices such as rainwater harvesting, drip and sprinkler irrigation are essential for sustainable and efficient water use in agriculture (Bin Rahman and Zhang, 2023).

Unpredictable rainfall patterns, droughts, or excessive rainfall can impact rice cultivation. Climate is very important for every crop. Recent disastrous floods damaged crops and disrupted human life badly (Wang *et al*., 2024). Heavy rainfall and melting glaciers become sources of catastrophic flood (Ahmad and Afzal, 2024). Smog has increased in Punjab, although the seasonal change is short, however the climate change is long term, and it has strong impact on crop production and its subsequent growth (Berardi *et al*., 2021; Rathnayake and Mizunoya, 2024). Government should introduce new climate resilient crops that are beneficial for climate as well as the agriculture sector (Bodie *et al*., 2019). Agriculture sector itself is a major contributor to climate change. Impacts of land clearance by fire, burning of residues, CH_4 and N_2O emissions, transportation of agro-industrial wastes, pesticides, insecticides and fertilizers are very pricey on climate change (Bandumula, 2018).

Advancements in agricultural technologies can play a crucial role in improving efficiency, sustainability and productivity of rice in the agricultural sector through use of drones, remote sensing, artificial intelligence and vertical farming (Chandio *et al*., 2023). Crop rotation is a farming practice that involves growing different crops on the same piece of land over. Planting leguminous crops like peas and beans can enhance soil quality making it ideal for rice plantation (Goodman, 2020).

5. Conclusion

Climate change is a natural phenomenon however agriculture is vulnerable to this change. Climate change, extreme temperatures, both high and low, unpredictable rainfall patterns, droughts, or excessive rainfall can affect rice growth and yield. Controlled anthropogenic activities and preparedness reduce crop related change can counter long-term effects of climate change and the shifts in temperature and weather patterns.

6. Conflict of Interest

There is no conflict of interests.

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