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Print ISSN: [3006-2497](#) Online ISSN: [3006-2500](#)Platform & Workflow by: [Open Journal Systems](#)<https://doi.org/10.5281/zenodo.23672794>**Determinants of Wheat Yield under Different Irrigation Systems: Evidence from Daraban Kalan, Pakistan****Muhammad Zubair**

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Email: riffat_saddozai@yahoo.com**ABSTRACT**

Wheat production relates to water availability, use of farm inputs, choice of seed varieties, and production arrangements. This paper compares wheat yields under three farming systems rain-fed, Kalla Pani (Rod Kohi), and tube-well irrigation during the 2024–2025 agricultural season, using survey data from 900 wheat farmers, with 300 farmers surveyed in each system in Daraban Kalan, Khyber Pakhtunkhwa, Pakistan. The mean yield is calculated in bags per acre, and ordinary least squares (OLS) regression models are estimated separately for each system. The average production of kalla-pani farms is highest at 18.32 bags per acre followed by 'tube-well farms' 12.69 bags per acre and rain fed farms 9.67 bags per acre. The regression analysis showed that water application, tillage cost, seed application, urea cost, and pesticide cost were all positively associated with wheat yield across the three systems. There was also a positive and statistically significant association between improved seed and yield in each system, while DAP cost was statistically significant at the 5% level in the Kalla Pani and tube-well systems, but not in the rain-fed system. Holding other variables constant, the estimated yields of lease and share cultivators were lower than those of owner cultivators across all three systems. The same was true for the improved seed quality, which produced higher yields than local seed. The data are cross-sectional, and the estimates will only show conditional associations rather than causal effects. These findings highlight the importance of appropriate water management practices, good seed quality, and the timely and effective use of farm inputs for wheat production.

Keywords: *Wheat yield; irrigation systems; Rain fed; Rod Kohi; tube well farm inputs; improved seed; cultivation arrangements; Daraban Kalan, Pakistan*

1. Introduction

Wheat is among the major food-security crops of Pakistan and cultivation in Semi Arid Regions is vulnerable to irregular precipitations, water stress and the limited availability of water at recommended planting time. This situation implies that wheat production is not only driven by availability of water resources but also by timing and water management as well as the management of other agricultural inputs. Evidence obtained from irrigation scheduling studies across the country reveals that there were different responses between arid and semi-arid conditions in terms of yield and water use efficiency. In certain situations, water conservation would result in better WUE, but in other situations, it would lead to reduction in yield (Jabeen et al., 2022). The management of water is closely linked to other wheat production parameters, such as the use of seeds, field preparation, fertilizer use, and crop protection. A review of irrigation management and wheat performance emphasizes the importance of managing water according to crop growth requirements and production conditions (Si et al., 2023). Likewise, studies in the Pothohar basin of Pakistan report variations in wheat productivity from rain-fed and irrigated production systems (Khalil et al., 2026). This is especially important in the case of the wheat crop in a semi-arid environment where rain could be inadequate or not well-distributed throughout the growing season. Changes in precipitation and temperature may change crop requirements for water and the results of cultivation, and availability of inputs may reflect the capacities of farmers to treat precipitation or temperature change. Study in rain-fed wheat production in Pakistan concluded that there was a positively significant relationship between cumulative precipitation and the mean yield whereas there was a negatively significant relationship between the mean yield and rising temperature. The study also analyzed the association of seed rate and access to the input market with the yield and its variation (Mahmood et al., 2019). Research on wheat under rain-fed conditions in the Pothohar Plateau further highlights the importance of seasonal conditions and management practices for yield and water and nitrogen-use efficiency (Osman et al., 2021). Moreover, empirical study based on Pakistan level data have studied relationship between wheat productivity and inputs like improved seed, water availability, fertilizer and machinery (Chughtai & Jamal, 2023). The overall evidence suggests that it is important to consider the availability of water with other factors affecting production and that their effect on yield may vary by farm setting.

The present study focuses on Daraban Kalan, District Dera Ismail Khan, Khyber Pakhtunkhwa, and examines three groups of wheat farmers: rain-fed, Kalla Pani/Rod Kohi, and tube-well irrigation. These categories represent a standard for comparing average wheat yield across water-access conditions, and allow a test of whether the relationship between farm practices and yield is similar or different between sub-groups. However, differences in average yield may also reflect other farm and production characteristics. The observed differences and regression estimates therefore are descriptive comparisons and statistical associations, not the effects of irrigation-system choice.

The variability of rain-fed wheat production, optimal irrigation strategies, climate, and agricultural inputs have been previously investigated in relation to wheat productivity in Pakistan (Mazhar, N., Sultan, M., & Amjad, D. 2020). On the basis of this literature, the present study compares the mean wheat yields for the three groups and specifies the relationships of water applications, tillage cost, seed application, DAP cost, urea cost, pesticide cost, cultivation arrangement and seed variety with yield, where these are involved in any of the appropriate yield models. The study provides local evidence of yield variability and associated farm level factors in Daraban Kalan that can inform the discussion on agricultural production management.

General Objective

To analyze wheat yield and observed farm level determinants of wheat yield in rain-fed, Kalla Pani (Rod Kohi) and tube-well production systems in the area of Daraban Kalan.

Specific Objectives

1. To compare mean wheat yield across the three irrigation systems.
2. To estimate the system-specific associations between wheat yield and resource inputs, specifically water and seed application rates, alongside the costs of tillage, DAP, urea, and pesticides.
3. To examine the associations of cultivation arrangement (owner, lease, and share cultivation) and seed variety (local or improved) with wheat yield within each irrigation system.

2. Literature Review and Research Gap

2.1 Irrigation Strategies and Wheat Productivity

Studies suggest that the yield response of wheat to the availability of irrigation water would vary from place to place and irrigation water rates applied in relation to timing would affect yield. Jabeen et al. (2022) noted that the impact of lower irrigation on wheat yields was different between locations using the crop modeling technique for arid areas and semi-arid areas such as Pakistan. Likewise, Abdelraouf et al. (2021) reported in Egypt, a field and models experiment that the general response of wheat was negative under the reduction of this irrigation water. However, there was no significant difference between the yield achieved at 80% of the potential yield and that of full irrigation, and there was benefit in water productivity. The results indicate that there are location-specific trade-offs of crop productivity and water use in irrigation-wheat productivity relationships.

Other studies were also conducted from Pakistan to investigate irrigation systems and crop establishment practices. Jamali and Laghari (2019) found the yield advantage of 17.2% for wheat achieved by using raised bed irrigation in comparison to the usual flooding irrigation at Jaffarabad, while irrigated water applications were decreased. Asif et al. (2019) concluded that bed sowing achieved larger wheat crop and more water productivity than flat sowing in a rain-fed experiment carried out in Potohar. Suryavanshi and Buttar (2020) also investigated effects of irrigation under different methods and schedules on wheat yield and water productivity under field experiment in India. More recent study by Khalil et al. (2026) has measured the difference between rain-fed and irrigated wheat farming, and tested the performance of conventional flooding system with high-efficient irrigation system in Potohar. Together these studies indicate that irrigation system, crop establishment and the local growing conditions are important factors to consider when considering wheat productivity.

Other research has been conducted on water-saving practices, from which deficit irrigation and water-saving strategies emerged. Fahad et al. (2019) investigated wheat cultivars under deficit irrigation in Faisalabad, Pakistan. Mehmood et al. (2025) used conventional, alternate, and fixed furrow-irrigation and also varied the quantity of irrigation water in Sindh and analyzed the irrigation efficiency. They reported that conventional furrow irrigation gave the highest grain production while alternate furrow irrigation gave better water use efficiency and less water use, but resulted in some yield decrease under the conditions they tested. The results of the above studies are not directly comparable due to differences in experimental designs, wheat varieties, irrigated periods, and locations. However they provide a framework for exploring the link, between water use and wheat production in various production systems.

2.2 Seed, Fertilizer, Tillage, and Integrated Input Management

The water and nutrients management may affect the productivity of wheat jointly. In an experiment of furrow irrigation, Bedaso et al., (2023) reported that different levels of irrigation and different applications of nitrogen influenced wheat yield and water productivity.

Their economic analysis also shows that the treatment giving the best physical yield was not always the best in terms of economic efficiency. Specifically, the highest reported benefit/cost ratio was obtained for 85% of crop evapotranspiration (ET_c) and 69 kg of nitrogen per hectare. Patel et al. (2024) also investigated the comprehensive impact of irrigation regimes, mulching, and nitrogen rate on wheat yield and yield stability in Jammu, a subtropical region in India, which yielded similar outcomes. Si et al (2023) present a detailed review about the effects of irrigation systems and schedules on wheat physiological characteristics and yield and quality. These studies are complementary in that they both emphasize the need for considering intersection of irrigation and agricultural inputs instead of them being entirely separate inputs.

2.3 Farm Economics, Irrigation Access, and Cultivation Arrangements

Farmers' socio-economic parameters and farming practices are also related to wheat productivity. Ahmad et al (2021) measured wheat yield based on survey data of wheat farmers from Punjab and explored socioeconomic and agricultural aspects involved in wheat production. They found relevant education and land ownership status of the farmers and their agricultural activities. A study conducted in Dera Ismail Khan by Niamatullah et al. (2022) to examine the linkage between tubewell irrigation and agricultural production in the same district, does not only conceptualize the linkages that are relevant to the local context, but also offers evidence on irrigation access and agricultural production, albeit with a broader view than just wheat yield. Khajjak et al. (2024) Used a production-frontier method to measure how important technical efficiency (TE) is across different irrigated wheat farms in the central part of Sindh. These studies help explain wheat production by examining the conditions, on the farms. They consider the features of the farms the resources farmers have and how well irrigation is set up. This gives a picture of why some farms produce more, than others.

2.4 Research Gap

Previous studies investigated the optimization of irrigation scheduling, irrigation practices, farm input management and socio-economic aspects of wheat production through field trials, crop modeling or farm surveys carried out in various geographical contexts. The relevant literature reviewed here, however, does not have enough directly comparable evidence of the wheat yield differences among the three farming systems rain-fed, Kalla Pani (Rod Kohi), and tubewell and their influencing factors in Daraban Kalan. Hence, the present study compares the mean wheat yield over the 900 wheat growers by using survey data from 300 wheat growers in each farming system, and estimates separate regression models, specific to each farming system, of wheat yield. The analysis focuses on the relationships between agricultural input expenditures, seed type and the arrangement for wheat production within each system. The study is descriptive and associational in that it reveals differences in sample mean yields and system-specific relationships between measured farm characteristics and wheat productivity rather than estimates of what is caused by a switch from irrigation type.

3. Materials and Methods

3.1 Study area, Data and Sampling: The study was undertaken in the village Daraban Kalan of district Dera Ismail Khan, Khyber Pakhtunkhwa in the 2024-2025 crop season. In this study, the wheat farmers, who utilize one of the three production environments, rain-fed, Kalla pany (Rod Kohi) and tube-well, formed the study population. The primary data were obtained from 900 wheat farmers using a structured questionnaire that

was applied during face-to-face interviews. The questionnaire was drafted in both languages Urdu and English. A stratified random sampling approach was reported, across irrigation groups of 300 respondents.

3.2 Outcome and explanatory variables: Wheat yield in bags per acre is a dependent variable. The reported number of water applications, total tillage cost, seed application rate, DAP cost, urea cost, pesticide cost, cultivation arrangement and seed variety are the explanatory variables. Cultivation indicators shall be considered lease cultivator and share cultivator, and its reference category shall be owner cultivation. The improved seed is represented in the model by a dummy variable, the local seed is the reference category.

3.3 Econometric specification and estimation: Ordinary least squares (OLS) regressions were estimated separately for each irrigation system. The specification can be written as:

$$Yield_i = \beta_0 + \beta_1 WA_i + \beta_2 TC_i + \beta_3 SA_i + \beta_4 DC_i + \beta_5 UC_i + \beta_6 PC_i + \beta_7 Lease_i + \beta_8 Share_i + \beta_9 ImprovedSeed_i + \varepsilon_i$$

Yield is wheat yield in bags/acre, while WA indicates the reported water-application measure, TC is tillage cost, SA is seed application, DC is DAP cost, UC is urea cost and PC is for pesticide cost; Lease and Share are indicators of how the wheat was cultivated; ImprovedSeed is an indicator of improved (not local) seed; and ε is the error term. The same set of explanatory variables was used in separate models for the three irrigation groups. A p-value of less than 0.05 is considered as statistically significant. Any p-value slightly higher than 0.05 would be said to not be statistically significant for this threshold and not evidence that there is no relationship.

4. Results

4.1 Mean wheat yield by irrigation system

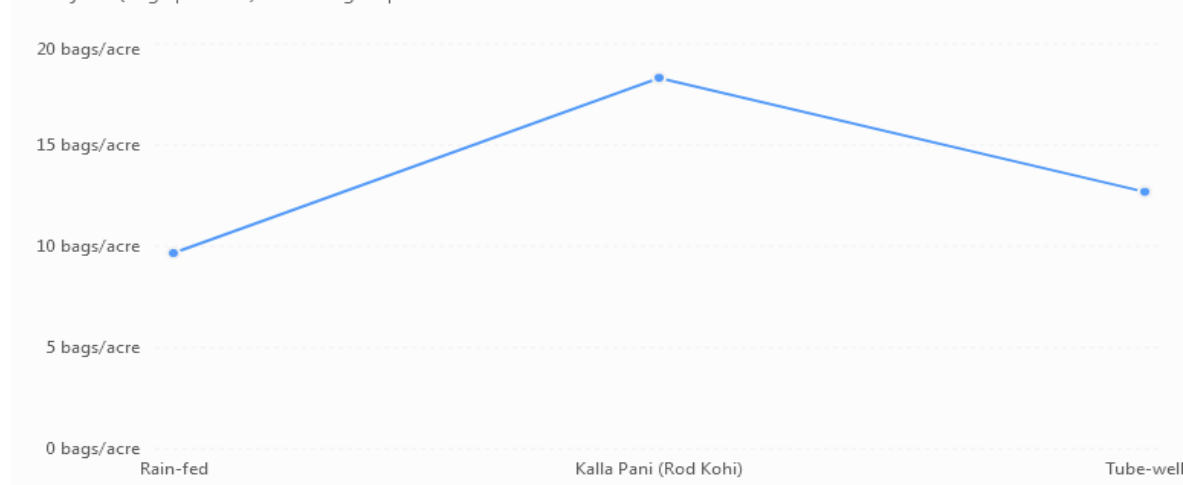
The reported mean yield varies among the three irrigation systems. The highest mean of 18.32 bags per acre is recorded by the farms raising Kalla Pani, followed by tube well farms at 12.69 bags per acre and rain-fed farms at 9.67 bags per acre. The Kalla Pani mean is 8.65 bags per acre higher than rain fed mean and 5.63 bags per acre higher than tube well mean; and the tube well mean is 3.02 bags per acre higher than rain fed mean. These are only descriptive differences. The results provided are from descriptive analysis and not a test of statistical differences among group means.

Table 1. Reported mean wheat yield by irrigation system

Irrigation system	Number of farmers	Mean yield (bags/acre)
Rain-fed	300	9.67
Kalla-Pani (Rod Kohi)	300	18.32
Tube-well	300	12.69

Wheat Yield Across Irrigation Systems

Mean yield (bags per acre) for each group of 300 farmers.



4.2 Regression estimates

The regression coefficients and the p-values supplied from the individual OLS regression of rain-fed, Kalla-Pani and tube-well farms are reported in Table 2. The reference categories are the owner cultivators and the local seeds. Associations are interpreted as conditional associations, holding other variables included in the respective system constant.

Table 2. OLS estimates for wheat yield by irrigation system

Variable	Rain-fed		Kalla Pani		Tube-well	
	B	p-value	B	p-value	B	p-value
Constant	2.540	0.005	3.982	0.010	6.153	0.009
Reported water applications	1.296	0.001	2.872	0.020	2.089	0.011
Tillage cost	0.001	0.001	0.004	0.013	0.003	0.004
Seed application rate	0.145	0.001	0.239	0.001	0.190	0.001
DAP cost	0.000	0.051	0.001	<0.001	0.001	0.013
Urea cost	0.001	0.047	0.002	0.012	0.002	0.020
Pesticide cost	0.003	0.043	0.005	0.025	0.004	0.021
Lease cultivator	-2.001	0.043	-3.331	0.028	-2.030	0.011
Share cultivator	-5.902	0.045	-7.410	0.035	-7.960	0.009
Improved seed	5.741	0.013	5.500	0.011	6.491	0.005

4.3 Main coefficient findings

Water Application: Water application is an necessary input for wheat production which directly impacting its growth and development. The study demonstrates the effects on using of water on three different irrigation method are described briefly, The coefficient value of the variable water application is equal to 1.296, which has very significant P-value (0.001) suggesting that impact of rain-fed irrigation is very significant on wheat yield. An increase of one unit in water application for rain-fed irrigation is likely to bring an average rise of 1.296 units in wheat production. Kalla-Pani irrigation effects on P-value is statistically significant at 0.020 level which means that it has an influence on dependent variable. Their coefficient value of 2.872 indicates that, when the input water application increases by one additional time, it tends to increase the wheat production by 2.872 units on average. The tube well irrigation method has coefficient 2.089 while p-value is 0.011 which is significant. This means that with all other factors remaining the same, there is 1 more additional water application to tube well irrigation, which has been increased by 2.089 units. This reveals positive and close relationship between increasing about water application and increasing about wheat production.

Tillage Cost: The tillage cost related to the preparation of soil for wheat production. It is a very important variable, and a soil well prepared by this action will improve germination of seed and hence yield. For rain-fed irrigation method the tillage cost coefficient value is 0.001 and that of P value is 0.000, which is significantly contributes to the wheat production. The value of the coefficient, 0.001 indicates that tillage cost is positively related to wheat production. With the Kalla-Pani irrigation method, tillage cost has a coefficient of 0.004 and a p-value of 0.013. The coefficient value for tillage application 0.004 indicates the increase of tillage cost by 1%, corresponding to an increase in the wheat yield by 0.4%. The value of coefficient of variable tillage cost with the tube wells irrigation is 0.003 and the value of probability is 0.004, which is statistically significant. When all other factors are held constant, an increase in the tillage cost by 1% tends to increase the wheat yield by 0.3% on average.

Seed Application: This is an important factor in wheat productivity as germinating wheat directly impacted by the infraction. The variable Seed application guarantees the plant's density, so proper seed application enhances the wheat yield. The probability value of variable seed application in rain fed irrigation is statistically significant, and the magnitude of the coefficient 0.145 means when the other variables are fixed at zero, wheat production would increase by 0.145 unit for every unit increase in the seed application. The seed application is statistically significant at p-value 0.001. The positive coefficient value of seed application for Kalla-Pani irrigation method is 0.239 implying a direct relationship indicates that on average increasing by 1 kilograms of seed increases wheat yield by 0.239 units when other variables are controlled. In the case of tube well irrigation method, variable seed application is statistically significantly P-value 0.000 and it shows the effect of seed application in wheat production. The increase in wheat production as seed increases per kg is found as 0.190 on average.

DAP Fertilizer: DAP stands for di-ammonium phosphate. It is a fertilizer with a rich nitrogen source of 18% and phosphorus of 46%. Phosphorus helps with root development process, and the early growth of plants, while the nitrogen helps with leaf development and the plants overall structure. The result obtained for variable DAP cost with p value 0.051 is not statistically significant and shows that DAP application has no effect on wheat production because of insufficient availability of water for rain-fed irrigation. The coefficient and p value for DAP in the Kalla-Pani irrigation are 0.001 and 0.000, respectively. It indicates that on average, a rise of 1 unit of DAP application led to an increase of 0.001 unit of wheat yield. The probability value of

DAP application under the Tube well irrigation is 0.013 which indicates that it has significant effect on wheat yield. However the coefficient value of 0.001, indicates a positive relationship between wheat production with the application of DAP. It implies that wheat production rose by 0.001 unit for every additional unit of DAP.

Urea Cost: Urea is a fertilizer that contains high amount of nitrogen and is used in agriculture. It contains 46% of nitrogen which is necessary for the optimal yield of a plant and for its growth. It is soluble in water immediately and will directly benefit the growth of the leaves, grains and plant itself. For the variable urea cost under the rain-fed irrigation, the coefficient value is 0.001, and the p-value is 0.047, which demonstrate the impact of urea application on wheat yield, increasing the urea application by one unit, tend to increase the wheat production by 0.001 units on average when all other factors are held constant. The variable urea cost has a P value of 0.012, which means that there is a direct relationship between the independent variables and the dependent variable under the kalla-pani irrigation system. For urea cost of tube well irrigation, it is found that P value is 0.020. It seen that a positive coefficient value of 0.002 shows a direct relationship, adding an additional unit of urea fertilizer, increases the wheat yield on an average by 0.002 unit.

Pesticide Cost: Pesticide is a chemical, use in agriculture to control pests, insects, and weeds. These pests and weeds affect crops, and cause reduction for wheat yield. Application of pesticides can sometimes be beneficial to the crop, and enhances wheat growth. The p-value of pesticide is 0.043 which is statistically significant and Coefficient is 0.003 implying positive relationship between the cost of pesticides and wheat yield under rain fed method of irrigation. Pesticide cost under irrigation method Kalla-Pani results p value of 0.025 and coefficient value of 0.005, indicating a significant impact on wheat production. Each additional unit of pesticide cost increases tends to increase the wheat yield by 0.005 units; when other factors are held constant. The probability value using the tube irrigation is statistically significant, 0.021. The coefficient value of 0.004 is directly related with application of pesticide and wheat yield.

Lease Cultivator: A lease cultivator is a farmer who leases cultivated land from the owner of the land on a lease agreement for a specific period. Probability value for the variable lease cultivator is 0.043 which is very statistically significant. Under the rain-fed irrigation, coefficient is -2.001 which reflects inverse relationship between the category of cultivators and leases. The negative coefficient value shows that, when switching from "own cultivator" to the "lease cultivator" decreases yield to 2.001 units on average. The P-value in the Kalla-Pani irrigation is 0.028 which is statistically significant. There is an inverse relationship between the lease and the own cultivators as the coefficient value is -3.331. The p value for the lease cultivator is 0.011 and the coefficient value is -2.030 in the tube well irrigation method, which is showing a decline in the lease cultivator compared to the own cultivator. When the nature of cultivation changes from the "own cultivator" to the "lease cultivator," the output decreases by 2.030 units on average when all other factors are held constant.

Share Cultivator: A share cultivator is a farmer, who cultivates irrigated land with the agreement to share some part of the production with the landowner. Under the rain-fed irrigation system, the probability value of the variable shareholder cultivator is 0.045 which is significant in wheat cultivation. A coefficient of -5.902 refers to a negative impact on the lease cultivator. It states that when shifting the nature of Cultivation from "own cultivator" to the "share cultivator", decreases the wheat yield by 5.902 units when all other factors are held constant. In the case of irrigation by Kalla p-value is statistically significant, as it is equal to 0.035. At the same time, the negative coefficient value of -7.410 states an inverse relationship on wheat yield when

shifting to the "own" cultivator. The obtained "P" value of the tube well irrigation method is 0.009 which is statistically significant. For share cultivator, the coefficient value is -7.960 which means there is indirect relationship between share and own cultivators.

Improved Seed: The regression results suggest improved seed satisfied with the increment in the wheat yield in all the three irrigation system with statistical significance which is positive.

For rain-fed farms, the coefficient of improvement of seeds is 5.741 and p-value is 0.013, which indicates that, if other factors are the same, farmers producing with these improved seeds will obtain about 5.741 number of bags of wheat an acre more than those using local seeds. Likewise, the coefficient of Kalla Pani (Rod Kohi) farms is 5.500 with p value of 0.011, which means that it is estimated to raise the number of bags by 5.500 per acre with the improvement in how the seeds are used. In the case of tube- well farms, the coefficient is 6.491 ($p = 0.005$) which is equal to an increase of about 6.491 bags per acre. The three regression coefficients are significantly positive at 5% level, indicating a uniform positive relation between variable use of seeds and wheat yields for the irrigation systems. Tube-well farms and rain-fed farms are the ones with a higher estimated association, followed by the Kalla Pani farms. The results point towards important potential of improved seed for boosting wheat productivity under various irrigation system.

5. Discussion

5.1 Wheat Yield Differences across Irrigation Systems: The results showed significant wheat yield difference among the three irrigation systems in Daraban Kalan. The average yields were maximum for the Kalla-Pani (Rod Kohi) farms followed by tube-well and rain-fed farms. From this pattern it is evident that irrigation facilities need to be taken into account when evaluating the prosperity of agriculture in the study area. Higher average yield under Kalla-Pani indicate that this system may offer more favorable growing conditions for wheat production than in tubewell and rain-fed farming. These differences may be due to differing levels of available water, when water was applied and how the farm is managed. The Kalla-Pani type of farming has its source of water from the neighboring mountainous regions and tube-well farming involves the utilization of groundwater. Rain-fed agriculture is relatively reliant on rain. These variations can affect water availability at important growth stages of wheat. The descriptive results are however, not enough to conclude that differences in irrigation type are the only reason for differences in yield that may exist as other farm characteristics may also have an impact.

5.2 Comparison of the regression findings between the three systems: The separate regression models enable a wider perspective on influencing factors in the production of wheat for the three irrigation systems. Overall the results indicate a consistent trend where, as expected, inputs required for wheat production are positively related to yield and Lease and Share wheat cultivation type is related to lesser yields than the owner type of wheat production. However, the level of strength and significance of individual relationships differ among the three groups. The results indicate that irrigation water supply is not the only component that affects wheat production. Cultivation practices and land tenure arrangements could also be important for production outcomes in the context of farmers' input decisions. That is significant because farms that fall into the same general irrigation classification could vary in their capacity to control production inputs and coordinate cultivation. The difference between the three models also suggests that the nature of each irrigation system should be taken into account in making recommendations to farmers.

5.3 Input Management and Wheat Productivity: Taken together, the findings highlight the relevance of appropriate input management for wheat production. Water availability needs to be taken into account along with land preparation, seed application, fertilizer application and the use of crop protection. The

production decisions can interact with each other and have an effect on establishment and yield rather than do so on their own. The results from the fertilizer also show that relationship between expenditure and yield is not the same for each irrigation group. This implies that input management should be evaluated taking into account the local production situation rather than the assumption that the same input spending pattern would have a comparable effect on each farm.

5.4 Cultivation Arrangements and Farm Performance: The negative associations between non-owner cultivation arrangements and wheat yield identify land tenure as another relevant consideration in the study area. Owner cultivators can make different production decisions than lease and share cultivators, or have access to different resources, or different incentives to invest in their land than would lease and share cultivators. The results show that the yield of agriculture should not only be measured by irrigation and production factors but also how land is managed. Understanding the constraints faced by lease and share cultivators could help identify whether differences in resources, investment incentives, or farm management contribute to variations in wheat production.

5.5 Implications to Wheat Production in Daraban Kalan: The study results have practical implications to wheat production in Daraban Kalan. The results presented under Kalla-Pani exemplifies the importance of awareness about water availability and the practices that are adopted by the farmers in the local area that affect wheat production. However, positive relationships between yield and production inputs also suggest that focus should also be directed to the proper usage of seed, fertilizers, pesticides, and land preparation. Agricultural support should be adapted to the needs of each farming group. Rain-fed farmers could need specific guidance on water-related production risks, and farmers with Kalla pani and tube well systems could benefit from efficient management of water and inputs. Consideration of support for cultivators under lease and share arrangements may also be considered as they have lower estimated yields than owner cultivators.

6. Conclusion

This study examined wheat yield differences and the factors associated with production under rain-fed, Kalla Pani (Rod Kohi), and tube-well irrigation in Daraban Kalan. The descriptive finding shows that the mean yield is higher in Kalla Pani farmers' fields as compared to tube well and rain fed fields. The differences between these are important when looking at the productivity of wheat with regard to irrigation, but have not been formally tested for statistical significance.

Based on the regression results, it is concluded that water application, tillage cost, seed application, urea expenditure and pesticide expenditure are found as positive-relation with the wheat yield in all the three irrigation systems. Under Kalla pani and tube well irrigation system, DAP has a significant positive relationship with yield while under rain-fed system the relationship between DAP and yield is not significant at 5% level. The results further indicate that improved seed is the most important requirement for achieving yield increases of wheat compared with local seed under the three irrigation systems suggesting the need to ensure access to quality seed to drive productivity on farms. Lease and share cultivation are also linked to lower yields than owner cultivation, implying that cultivation arrangements may also play a role in differences in the performance of agriculture. Overall, the findings suggest that wheat productivity in Daraban Kalan is associated with irrigation conditions, appropriate input management, seed selection, and cultivation arrangements. Strategies to improve wheat production may benefit from extension services, better seed, better water use, and fertilizer and pesticide use advice. Consideration should also be paid to understanding the constraints which are faced by lease cultivators and share cultivators.

The study provides Farm level evidences of wheat production with three irrigation systems in Daraban Kalan. Future research should formally test differences in mean yields and regression coefficients across irrigation systems and consider additional farm and environmental characteristics to better understand the factors underlying productivity differences. Such evidence could support more targeted agricultural policies and locally appropriate interventions to improve wheat productivity and the efficient use of farm resources.

7. Policy Implications and Recommendations

The findings suggest several priorities for improving wheat production in Daraban Kalan.

Improve and maintain Canals for irrigation: Improving and maintaining Kalla Pani (Rod Kohi) canals to ensure that available mountains water reaches more farmers and promote affordable access to tube well irrigation for farmers experiencing water scarcity where technically and environmentally feasible.

Encourage better use of seed inputs and more efficient input utilization: Make improved quality seed accessible and improve heatable agricultural extension services regarding farming practices such as water management, land preparation, fertilizer inputs, and pest control.

Support tenant farmers: Take the considerations of leaseholders and sharecroppers into account when developing agricultural support measures to help mitigate possible issues related to improving wheat productivity.

Further research: Any future studies should focus on the impact of erratic rainfall, shortage of water, drought, and hailstorms on wheat production in Daraban Kalan. Adaptation research linking climate change to wheat productivity could result in identifying climate changes that may pose a risk and in developing suitable adaptation responses to minimize the negative impacts.

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