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# Investigating the impact of Zero Tillage on small farmer's wheat production and Income: A case of District Sialkot, Pakistan

***Muhammad Wasim Akhtar, Faisal Rasool***

*Department of Economics, PMAS Arid Agriculture University, Rawalpindi, Pakistan.*

**Corresponding Author: Wasim Akhtar, Email: wasimakhtar2110@gmail.com*

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**ABSTRACT**

Zero tillage (ZT) implies the practice of planting a new crop in the soil left unprepared after the harvesting of the previous crop. The most dominant benefit of no-tillage is an improvement in soil biological fertility, making soils more resilient. Zero-tillage also reduces the cost of production and saves time for sowing of wheat by 10-15 days as compared to conventional tillage. District Sialkot was selected as the study areas of this study based on its diversity in agriculture and the probability of zero tillage practices in this area. Two groups of respondents were selected with almost similar socioeconomics characteristics practicing their farming operations under similar biophysical conditions. The first group comprises small farmers who were practicing conventional tillage technology and the second group include small farmers who were practicing zero tillage technology. Against this backdrop, the purpose of this paper is to assess the impact of zero tillage on small farmers' wheat production and to assess the impact of zero tillage on small farmers' income arising from the wheat crop. We collected primary data from 150 farmers through a structured questionnaire in district Sialkot of Punjab Province of Pakistan. The study identified that zero tillage wheat growing farmers used more quantity of seed than conventional wheat growing farmers in the study area. While a number of irrigations is also used more in conventional wheat as compared to Zero Tillage wheat. The results reflected that conventional farmers spend more on fertilizer, irrigation, chemical application than the zero tillage farmers. Variable cost is also higher for the conventional technique (Rs. 13698.02) than the zero tillage technique (Rs. 9723.9). Conventional wheat farmers have to spend more not only for irrigation but have to take extra care to look after in form of labor for their wheat crop, because of heavy investment made in conventional tillage wheat crop.

## INTRODUCTION

Agriculture is the lifeline for the economy of Pakistan. This sector contributes 19.5 percent to Gross Domestic Product of Pakistan. The agriculture sector is employing 42.3 percent of the labour force of Pakistan. This sector also provides raw material to other sectors of the economy. The healthier development in agriculture promotes domestic demand for industrial goods and other services and supplying raw material to agro-based industry, notably cotton fabric market which is the largest subsector of the manufacturing sector (Economic Survey of Pakistan, 2016-17).

Wheat is the staple crop of Pakistan. Wheat is the daily diet of inhabitants of people of Pakistan and stands at the main position in farming policies of the Government. The Govt. declared grain assistance cost of Rs.1300/- which created attention on the part of the farming community. Wheat accounts for 9.6% to the value added in agriculture

and 1.9% to GDP of Pakistan. The area under wheat grain was 9052 thousand hectares in 2016-17 decreasing from 9224 thousand hectares in 2015-16 showing a decrease of 1.9% over last season's area. While, on the other side Production of wheat has also increased around 25.750 million tonnes in 2016-17 as compared to 25.633 million tonnes in 2015-16 showing increase of 0.5 percent (Economic Survey of Pakistan, 2016-17).

Wheat is grown in eighty countries primarily for food, but a by-product of wheat crop (Toorri, a local word) is an important source of food for livestock in Pakistan. Millions of farmers and those employed along the entire wheat value chain are dependent on this single crop. Farmer's entire lifestyle and socioeconomic parameters are shaped by the performance of wheat sector – meaning, it is "The lifeline of the national economy.

Although Pakistan is one of the world's largest wheat producer, improvement is still needed in many areas to meet not only the export demand but also domestic requirements. Presently, wheat crop is facing a number of constraints including; low per acre yield as compared with other developed and developing countries of the world; very high prices of agriculture inputs (seeds, fertilizers, pesticides, etc.); deficiency of irrigation water; lack of advanced technologies; lack of awareness, and adulterations in pesticides and fertilizers.

**CONCEPT OF NO TILLAGE**

Tilling is used to remove weeds, shape the soil into rows for crop plants and furrows for irrigation. This leads to unfavourable effects, like soil compaction; loss of organic matter; degradation of soil aggregates; death or disruption of soil microbes and other organisms including mycorrhiza, arthropods, and earthworms and soil erosion where topsoil is blown or washed away.

The idea of modern no-till started in the 1940s with Edward Faulkner, author of Plowman's Folly, but it wasn't until the development of several chemicals after WWII that various researchers and farmers started to try out the idea. The first adopters of no-till include Klingman (North Carolina), Edward Faulkner, L.A. Porter (New Zealand), Harry and Lawrence Young (Herndon, Kentucky), the Instituto de Pesquisas Agropecuarias Meridional (1971 in Brazil) with Herbert Bartz.

No-till farming also called zero tillage or direct drilling is a way of growing crops or pasture from year to year without disturbing the soil through tillage. No-till is an agricultural technique which increases the amount of water that infiltrates into the soil and increases organic matter retention and cycling of nutrients in the soil. In many agricultural regions, it can eliminate soil erosion. The most powerful benefit of no-tillage is an improvement in soil biological fertility, making soils more resilient. Farm operations are made much more efficient, particularly improved time of sowing and better trafficability of farm operations.

No-till farming avoids these effects by excluding the use of tillage. With this way of farming, crop residues or other organic amenities are retained on the soil surface and sowing/fertilizing is done with minimal soil disturbance. Continuous no-till needs to be managed very differently in order to keep or increase the yield on the field. Residue, weeds, equipment, crop rotations, water, disease, pests, and fertilizer management are just some of the many details of farming that change when switching to no-till.

**Zero Tillage Farming as an option for Farmers:** Zero tillage (ZT) implies the practice of planting a new crop in the soil left unprepared after the harvesting of the previous crop. It is also known as zero till, no till or direct planting. This ancient practice continues to be followed by farmers in developing countries. The modern concept of ZT tends to imply seeding a crop mechanically in undisturbed soil-covered plant residues. "Though the name refers to only one practice, no till is actually a farm management system that involves many agricultural practices, including planting, residue management, weed and pest control, harvesting, and rotation" Zero tillage differs from reduced tillage (RT) in the sense that the latter still retains some minimal tillage prior to seeding (Ekboir, 2002).

Sowing of wheat in residual moisture through zero tillage technology not only facilitates the germination but also improves the soil fertility, soil physical properties and saves time hence increases the net return on a sustained basis. Zero-tillage also reduces the cost of production and saves time for sowing of wheat by 10 -15 days as compared to conventional tillage. The minimum tillage or direct drilling system is energy and cost-saving and environmentally friendly reducing the soil pollution as compared to conventional tillage practices.

Zero tillage is superior over conventional tillage because higher yield were attained by zero tillage farms than that of conventional tillage wheat farms in addition to its edge of eco-friendly practice. Zero till wheat is being introduced to avoid late planting and poor land preparation. It ensures timely planting, better stand establishment and higher grain yield than the

conventional method. It also saves 30% on irrigation and land preparation costs (Ahmed *et al*., 2013).

**Comparative Advantage of Zero Tillage over Conventional from Previous Studies:** The no-tillage system is more profitable than in the conventional tillage system as the farm saves various tilling steps. Cash cost is the most important cost component, but opportunity costs are also a very relevant cost factor. Savings in time is a very important component and the time saved by switching to the NT system could be used to expand livestock and crop production activities. (Boughlala *et al*., 2013).

Found in the study was conducted at PARC's research station Kala Shah Kaku, Lahore, in order to calculate the water productivity and economic efficiency of wheat-crop under different sowing methods in a combined harvested paddy filed. The sowing methods were direct drilling with FMI Seeder, Zero tillage and conventional method. The direct drilling in heavy residue gave 5.4 % more yield than the conventional method and 3.2 % more yield than zero tillage. The zero tillage ensured 2.1% more yield than the conventional method. The zero tillage saves Rs. 9319 $ha^{-1}$ (17.6%) over the conventional method. Thus, the resource conservation tillage technology is helpful for increasing water productivity as well as land productivity. (Asif *et al*., 2011).

No-tillage or zero tillage is a farming system in which the seeds are directly sown into untilled soil which has retained the previous crop residues. No other soil tillage operation is done. The residues from the previous crops will remain largely undisturbed at the soil surface as a mulch. If the soil is disturbed even only superficially then the system cannot be termed no-tillage and is defined as mulch tillage (Derpsch *et al*., 2011).

The adoption of new resource conserving technologies (RCT) (such as the zero till drill) which impacts on crop yields and household budgets is significant to the livelihoods of resources of poor farming families in terms of their food security and income. (Tahseen *et al*.2013).

Adoption of zero Tillage wheat has been found substantially decline in the cost of production, thereby increasing yield in many countries in the world. However, little evidence is available in the context of Pakistan. The purpose of the study was to find the economics of conventional & zero Tillage wheat production. Primary data were collected for the study from district Sialkot having irrigated-cum-tube well based agriculture system. The total number of respondents was 150 selected from different villages.

**METHODOLOGY**

The methodology adopted for this study included the universe of the study, selection of the sample and techniques was used for the collection and analyses of data.

**Study Area:** District Sialkot was selected as the study areas of this study based on its diversity in agriculture and the probability of zero tillage practices in this area. However, in view of the scope is academic research and constraints of time and budget, this study had purposively selected one Tehsil of the district called *Daska*. In this Tehsil, small farmers were observed practicing the zero tillage technology quite often. Therefore, it was more convenient to collect data from this Tehsil.

**Location:** The Sialkot is an export oriented city of Pakistan, the per capita income of Sialkot is more than US$ 1200, which is the highest in Pakistan. Sialkot lies between North latitude 3 I .42 and 32.52 and coast longitude 74`.14`` and 75`.03``. River Chenab separates it from Gujrat district. It is situated at an altitude of 829 feet above sea level. The district spreads over an area of 5,354 sq kilometres and stretches from Ravi valley on the South East to the Chenab River on the North West. The Northern portion is very fertile and the Southern portion is less fertile. The population of Sialkot is more than three million. 2830 government schools and a large number of private schools are trying to enhance academic education among the people of Sialkot. About 3 lac people are working directly or indirectly in the industrial sector of Sialkot.

Sialkot is one of the ancient cities of Punjab. It is said to have been founded by Raja Sul of Pando dynasty after whose name it was called Sulkot, which subsequently changed to Sialkot. Sialkot District is bounded on the north-east by the Jammu& Kashmir state, on the north-west by rivers of Tavi and Chanab, which separate it from the Gujrat District, on the west and south east by Gujranwala and Narowal District respectively. It is an irregular tract occupying the sub-mountainous portion of Rachna.

**Climate and soil:** Sialkot is hot and humid during the summer and cold during the winter. June and July are the hottest months. The maximum temperature during winter may drop to -2 °C. The land is generally plain and fertile. The average annual rainfall is about 1000 mm. Over 25.82% of the population of the district is urban.

**Infrastructure:** The district has 15,078 acres (61.02 $km^2$) of the forest, 12,295 km of metal roads, 12 grid stations, 45 telephone exchanges and 3229 industrial units.

**Agriculture:** The major crops and fruits of district Sialkot are wheat, rice, citrus and guava. Their average annual production over the period 1998-2001 was 453, 242, 6 and 11 thousand Metric Tons, respectively. A variety of vegetables are also grown in the district. There are 14 flour mills, 57 rice husking units, one sugar mill, one vegetable ghee unit and one fruit juice unit already working in the district. However, there exist good prospects for rice bran oil, rice husk briquettes, maize products, daal mills, etc. There are number of major factories which are contributing to make the economy stronger.

It is divided in four Tehsils i.e. Sialkot, Daska, Pasrur and Sambrial. The district is a plain, sloping down from the uplands at the base of the Himalayas to the level country in the south. Islam spread in this area when Hazrat Imam Ali ul Haq and Hazrat Pir Muradia came to this area. Allama Muhammad Iqbal (poet) was born in this city and his residential house is being used as Library nowadays.

Daska town was founded in the times of the Mughal King Shah Jahan (1592-1666). According to the revenue record, it was originally named Shah Jahanabad. The lands of the area were owned by the Das family and thus it came to be known as Daska. "Ka" denotes belonging to, it is like English preposition 'of', used to indicate possession, origin, association. According to another popular tradition the town is called Daska because it is located at an equidistance of Das Koh (24 Km) from all of its surrounding towns, hence it is called Daska. 'Das' means ten and 'Koh' is the indigenous unit of measuring distance.

**Target Group and Research Design:** The study targeted the smallholders only with land holdings up to 12.5 acres as per the definition of the State Bank of Pakistan (SBP 2010a). It was interesting to investigate the proposed research on small farmers to validate the findings of preceding studies conducted either in experimental fields or modern farms. As far as the research design was concerned, this was a comparative study which was based on a field survey. Two groups of respondents were selected with almost similar socioeconomics characteristics practicing their farming operations under similar biophysical conditions. These two groups were as follows:

**Group 1:** Small farmers who were practicing conventional tillage technology.

**Group 2:** Small farmers who were practicing zero tillage technology.

The study compared the costs, production and income levels of two groups using some statistical tools.

**Sampling Design:** As explained in earlier sections that the study had selected only one Tehsil "Daska" for the survey. Thereafter, it was followed by the multistage stratified random sampling technique. In the first stage, two union councils namely Gojra and Mitranwali were randomly selected as the target strata of the study. In the next stage, 10 villages were selected randomly from each stratum. By using Yamane's formula (1967), a sample size for two strata was estimated at 95% confidence level and ±15 % margin of error. Total estimated sample of all two groups was 140 (70 from each stratum) but actuality, 150 households were surveyed (Table 1).

$$n = \frac{N}{(1 + Ne^2)}$$

Where;

*n* = Sample size

*N*= Total number based farms

*e* =Precision which is set at 15% (0.15).

Table 1. No. farms, expected and survey sample for each group.

| Groups | Total Farms | Expected Sample | Survey sample |
|---|---|---|---|
| Group 1 | 9 | 70 | 73 |
| Group 2 | 11 | 70 | 77 |
| Total | 20 | 140 | 150 |

**Data Collection:** The study was exclusively based on primary data which was collected using the tools of standardized questionnaires, focus-group discussions and unstructured interviews. The researcher was himself conducted the survey in the proposed union councils (Gojra and Mitranwali).

**Data analysis:** For analysis, mainly descriptive statistical tools, i.e. averages, percentages, ratios and frequency, was used. However, the mean differences in costs, production and income of two groups was estimated using the t-unpaired test based on the comparison of two different groups.

To test the null hypothesis that two population means, $\mu_1$ and $\mu_2$, were equal. The difference between the two sample means $\overline{x}_1 - \overline{x}_2$ was estimated. However, to calculate the t-statistics $T = \frac{\overline{x}_1 - \overline{x}_2}{Se(\overline{x}_1 - \overline{x}_2)}$ was estimated. These statistics follow a t-distribution with $n_1 + n_2 - 2$ a degree of freedom.

In addition, benefit-cost ratio for both groups was also estimated for comparison.

$$\text{Benefit-cost ratio (for wheat)} = \frac{\text{Total benefits from wheat (Rs.)}}{\text{Total cost of production of wheat (Rs.)}}$$

**RESULTS & DISCUSSION**

Majority of the farmers started planting zero tillage for the first time where they come to know the concept of "zero tillage". Majority of growers do not have exact knowledge about high yield in zero tillage as compared to conventional tillage. Moreover, they have a wrong concept that zero tillage have good results.

**Age of The Respondents:** It is an important socioeconomic variable to determine the behaviour of a human being. It shows the ability to do work, efficiency, willingness to make progress and attitude towards various social and economic aspects of life and also in the production of wheat. Age can be defined as the total number of completed years since the birth of a person.

Table 2. Distribution of the respondents according to age.

| Age Categories (years) | Conventional Growers | Zero-Tillage Growers |
|---|---|---|
| | Frequency (%) | Frequency (%) |
| 20-30 | 2 (2.73) | 4 (5.19) |
| 31-40 | 12 (16.43) | 9 (11.68) |
| 41-50 | 28 (38.35) | 32 (41.55) |
| 51-60 | 21 (28.76) | 16 (20.77) |
| Above 60 | 10 (13.69) | 16 (20.77) |
| Total | 73 (100) | 77 (100) |

Table 2 shows that the majority of conventional and zero tillage wheat growers belonged to the age group of 41-50 years. In the case of conventional wheat growers, 2.73 percent respondents were up to 30 years of age and 13.69 percent were above than 60 years of age. In the case of zero tillage growers, 5.19 percent were up to 30 years of age and 20.77 percent respondents were more than 50 years of age.

**Literacy Level of The Respondents:** Education facilitates the socialization process or transmission of social culture heritage. It is a method of influencing human behaviour, so that it fits into the prevailing patterns of social interaction and organization. Education also stimulates people to move for their betterment. Education is considered to play a key role in human resource development or human capital formation, especially in those countries, which are confronted with the challenge of socioeconomic development.

Table 3. Distribution of the respondents according to education level.

| Literacy Level | Conventional Growers | Zero Tillage Growers |
|---|---|---|
| | Frequency (%) | Frequency (%) |
| Illiterate | 16 (21.91) | 12 (15.58) |
| Primary | 23 (31.50) | 20 (25.97) |
| Middle | 15 (20.54) | 13 (16.88) |
| Matriculation | 12 (16.43) | 25 (32.46) |
| Above Matriculation | 7 (9.58) | 7 (9.09) |
| Total | 73 (100) | 77 (100) |

Table 3 shows that mostly both the conventional and zero tillage wheat growers having education up to matriculation. In the case of conventional wheat growers, 16.438 percent were matriculated, education level of 9.58 percent farmers was above matriculation, 20.54 percent respondents have middle education and 21.91 percent farmer were illiterate. Above results show that the literacy level of the conventional tillage wheat growers was higher than zero tillage growers.

**Farming Experience of the Respondents:** Experience makes a man perfect. Experienced man is more technical than non-experienced man. Farming experience reduces the production cost by making efficient use of scarce resources. Information about the farming experience of the household head is presented in table 4.

Table 4. Distribution of the respondents according to a farming experience.

| Experience (years) | Conventional Growers | Zero Tillage Growers |
|---|---|---|
| | Frequency (%) | Frequency (%) |
| 1-10 | 8 (10.95) | 12 (15.58) |
| 11-20 | 20 (27.39) | 21 (27.27) |
| 21-30 | 21 (28.76) | 17 (22.07) |
| 31-40 | 17 (23.28) | 25 (32.46) |
| Above 40 | 7 (9.58) | 2 (2.59) |
| Total | 73 (100) | 77 (100) |

Respondents have been categorized into five categories on the basis of experience. Around 27.39 percent farmers in conventional wheat growers and 27.27 percent farmers in zero tillage wheat growers have 11-20 years of farming experience. Another dominant category is of 21-30 years of farming experience for conventional cultivation and 31-40 years of farming experience for Zero Tillage method of cultivation.

**Farms-To-Market Distance:** Farmer community is usually busy in farm & non-farm activities. In Pakistan, majority of farmers are small holding farmers who have to keep livestock & poultry at farm to cover much household expenditure. So, farmer has very scarce time to visit market for purchasing of inputs for crops (Seed, fertilizer, pesticide, other farm implements etc.). So, it's important to have an analysis of farm to market distance (table 5).

Table 5. Distribution of the respondents according to farm-to-market distance.

| Distance (KM) | Conventional Growers | Zero Tillage Growers |
|---|---|---|
| | Frequency (%) | Frequency (%) |
| 0-5 | 56 (76.71) | 67 (87.01) |
| 6-10 | 7 (9.58) | 8 (10.38) |
| 11-15 | 1 (1.36) | - |
| 16-20 | 9 (12.32) | 2 (2.59) |
| Total | 73 (100) | 77 (100) |

Table 5 indicates the distance from farm to market in a different group of wheat growers. Respondents have been categorized into four categories on the basis of distance from their farm to the input market. Around 76.71 percent farmers in conventional wheat growers and 87.01 percent farmers in zero tillage wheat growers have 0-5km of distance. Another dominant category is of 16-20 km farm-to-market distance for conventional cultivation and 06-10 category of distance from farm to market for Zero Tillage method of cultivation.

**Family Assets of the Respondents:** These factors assist farmers to efficiently utilize the financial resources to get high yield and ultimately profit because yield has an ultimate impact on total revenue.

Table 6 shows that mostly respondents have motorcycles which are a very good asset both for conventional and zero tillage wheat growers. But in the case of a car, very low percentages of farmers have this asset. While tractor which

is widely used in agriculture, the majority of conventional and zero tillage wheat growers did not possess tractor.

**Tenancy Status:** There is another important aspect which is about the ownership of the land. because it would determine the situation of farmers. Tenancy status or level tells us the importance of having good knowledge and application of the latest technology in all aspects of farming activities as shown in Table 7.

Table 6. Distribution of the respondents according to family assets.

| Family assets | | Conventional Growers | Zero Tillage Growers |
|---|---|---|---|
| | | Frequency (%) | Frequency (%) |
| Motorcycle | Yes | 59 (80.82) | 69 (89.61) |
| | No | 14 (19.17) | 8 (10.38) |
| Car | Yes | 4 (5.47) | 11 (14.28) |
| | No | 69 (94.52) | 66 (85.71) |
| Tractor | Owned | 13 (17.80) | 20 (25.97) |
| | Hired | 60 (82.19) | 57 (74.02) |
| Total | | 73 (100) | 77 (100) |

Table 7. Distribution of the respondents according to tenancy status.

| Tenancy Status | Conventional Growers | Zero Tillage Growers |
|---|---|---|
| | Frequency (%) | Frequency (%) |
| Owner | 68 (93.15) | 72 (93.50) |
| Tenant | 3 (4.10) | - |
| Owner-cum-tenant | 2 (2.73) | 5 (6.49) |
| Total | 73 (100) | 77 (100) |

Tenancy status of the farmers has been categories into three group's i.e. owner, Tenant and owner-cum-tenant. Mostly respondents fall in the category of owners and tenants in conventional wheat growers no one respondents were in the category of the tenant in zero tillage wheat grower. In the case of conventional wheat growers, about 93.15 percent respondents were owners, 93.50 percent respondents in zero tillage wheat growers were owners. Moreover, 2.73 percent were owner-cum-tenant in case of conventional wheat growers. Almost 6.49 percent respondents were owner-cum-tenant in case of zero tillage wheat growers.

**land holding status:** It means the total area on which a farmer performs various farming operations and from which a farmer receives income. Land holding size has an impact on the yield of wheat. Farmers have been categorized into three groups.

Table 8. Distribution of the respondents according to total land holding.

| Categories (Acres) | Conventional Growers | Zero Tillage Growers |
|---|---|---|
| | Frequency (%) | Frequency (%) |
| 0 – 5 | 66 (90.41) | 68 (88.31) |
| 6 – 10 | 6 (8.219) | 8 (10.38) |
| 11-15 | 1 (1.36) | 1 (1.36) |
| Total | 73 (100) | 77 (100) |

Figures in parenthesis are percentages.

Table 8 shows that in the case of conventional wheat growers, 90.41 percent were small farmers, 8.219 percent were medium farmers and 1.36 percent was large farmers. In case of zero tillage wheat growers, 88.31 percent were small farmers and 10.38 percent were medium and 1.36 percent was large farmers.

**Source of Seed:** There are various sources of seed available to farmers. They include seed dealers, friends, progressive farmers, etc.

Table 9. Distribution of the respondents according to the source of seed.

| Source of seed | Conventional Growers | Zero Tillage Growers |
|---|---|---|
| | Frequency (%) | Frequency (%) |
| Seed dealers | 32 (43.83) | 29 (37.66) |
| Friends | 23 (31.50) | 27 (35.06) |
| Relatives | 18 (24.65) | 21 (27.27) |
| Total | 73 (100) | 77 (100) |

Table 9 shows the source of the seed of the respondents. It was found that 43.83 percent respondents growing conventional wheat growers took seed from seed dealers and 31.50 percent took seed from friends and those purchasing from relatives were 24.65 percent. In case of zero tillage wheat grower's 37.66 percent respondents purchased seed from the seed dealers and 35.06 percent respondents purchased it from friends and those purchasing from relatives were 27.27 percent.

**Training of the Respondents:** The world has entered into twenty-first century and has become a global village. The agriculture has also modernized and special training for the farmers is needed to cope with the new invention in all operations of farming. In this study area, different government and private organizations are working and also giving training to farmers like Lok Sanjh Foundation, Agriculture Department, Bayer Crop Science and different seed and pesticide companies.

Table 10 shows that the majority of conventional and zero tillage wheat growers were taking training from some organizations. In the case of conventional wheat growers, 19.17 percent farmers were taking training from Bayer Crop Science. While in case of zero tillage wheat grower's 16.88 percent farmers were also taking training from Bayer Crop Science. It means "Bayer Crop Science" is mostly commonly delivering services in the study area.

**Number of Contacts with Extension Workers**: There is another government setup in the shape of "Extension workers". This setup had very strong roots in villages. Extension workers have also a good basic knowledge of agriculture, so these can also give useful information to the farmers.

Table 10. Distribution of the respondents according to training received from organizations.

| Organization | Conventional Growers | Zero Tillage Growers |
|---|---|---|
| | Frequency (%) | Frequency (%) |
| Syngenta | 11 (15.06) | 12 (15.58) |
| Bayer Crop Science | 14 (19.17) | 13 (16.88) |
| Agriculture Department | 10 (13.69) | 8 (10.38) |
| Seed company | 4 (5.47) | 6 (7.79) |
| Other pesticide companies | 22 (30.13) | 18 (23.37) |
| No Training | 13 (17.80) | 20 (25.97) |
| Total | 73 (100) | 77 (100) |

Figures in parenthesis are percentages.

Table 11. Distribution of the respondents according to number to contacts.

| Categories (No of contacts) | Conventional Growers Frequency (%) | Zero Tillage Growers Frequency (%) |
|---|---|---|
| No contact | 35 (47.94) | 42 (54.54) |
| 1-2 | 18 (24.65) | 19 (24.67) |
| 3-4 | 14 (19.17) | 9 (11.68) |
| Above 4 | 6 (8.21) | 7 (9.09) |
| Total | 73 (100) | 77 (100) |

Figures in parenthesis are percentages.

Table 11 shows that respondents having no contact with extension workers were 40 and 43 percent of conventional and zero tillage wheat growers, respectively. In the case of conventional wheat growers, 28 percent farmers have up to two contacts with extension workers. While on the other hand, in case of zero tillage wheat grower's 41 percent farmers have two contacts with extension workers.

**COMPARATIVE ECONOMICS OF CONVENTIONAL AND ZERO TILLAGE METHODS OF PRODUCTION**

**Impact of zero Tillage planting on the usage of resources:** The concept of zero tillage wheat planting is looking economically viable option for farming community, but we have to consider and have an open eye on some other aspects of this option of the planting of wheat in zero tillage. First and the foremost aspect is the social & operational effects if one would go for zero tillage planting of wheat, one has to forge wheat crop which is a staple crop. The second aspect is the impact of zero tillage planting of wheat on the usage of different aspects like the quantity of seed, no. of irrigation etc.

Table 12. Quantity of inputs used in wheat production.

| Variables/Categories | Conventional Growers | Zero Tillage Growers |
|---|---|---|
| Seed (kg/acre) | 42.89 | 46.53 |
| Irrigations (No.) | 3.93 | 3.75 |
| Weedicide (No) | 1.00 | 1.00 |

**Use of physical quantity of inputs:** Results of Table 12 reveal that zero tillage wheat growing farmers used more quantity of seed than conventional wheat growing farmers in the study area. While a number of irrigations is being used more in conventional wheat as compared to Zero Tillage wheat.

**Costs incurred on inputs:** Results of Table 13 reveal that conventional tillage wheat growing farmers spend more on fertilizer, irrigation, chemical application than the zero tillage wheat farmers in the study area. Variable cost is also higher for conventional tillage wheat farmers (Rs. 13698.02) than the zero tillage farmers (Rs. 9723.9). Conventional wheat farmers have to spend more not only for irrigation but have to take extra care to look after in form of labour their wheat crop, because of heavy investment made in conventional tillage wheat crop.

As can be seen, this additional cost of cultivation of wheat on the conventional basis cannot be attributed just to the higher fertilizer cost in conventional wheat (Rs. 6136.99/acre) more on conventional wheat than Zero tillage wheat (Rs. 5987.50/acre). Cost of irrigation (Rs. 5179.45/acre) for conventional wheat growers is also higher than zero tillage wheat growers (Rs. 4331.87/acre) due to more number of irrigations on conventional tillage than zero tillage wheat, indicating that conventional tillage wheat requires more irrigation water.

Table 13. Costs of inputs in wheat production.

| Variables/Categories | Conventional Growers | Zero Tillage Growers |
|---|---|---|
| Seed (Rs/acre) | 1461.58 | 1558.33 |
| Fertilizer (Rs/acre) | 6136.99 | 5987.50 |
| Irrigation (Rs/acre) | 5179.45 | 4331.87 |
| Weedicide (Rs/acre) | 789.86 | 721.71 |
| Labor (Rs/acre) | 130.14 | 290.79 |
| Variable cost (Rs/acre) | 13698.02 | 12890.2 |

Table 14. Output and Returns in wheat production.

| Variables/Categories | Conventional Growers | Zero Tillage Growers |
|---|---|---|
| Yield (kg/acre) | 1508.77 | 1684.41 |
| Price of output (Rs/kg) | 26.63 | 25.37 |
| Gross Revenue | 40178.54 | 43298.37 |
| Gross margin | 26480.52 | 30408.17 |

Many farmers spend at least ten thousand rupees more on conventional wheat in comparison to expenditure on Zero Tillage wheat. On average, the conventional wheat farmers incurred 60 percent more costs in cultivating their crops in comparison with Zero Tillage wheat per acre. While, the other side of the picture which is the main focus of this study is the difference of yield, Gross Revenue and Gross Margin between Conventional wheat growers & Zero Tillage wheat growers. The yield of Zero Tillage wheat is 1508 kilogram per acre while in case of conventional wheat it is 1684 kilogram per acre. Another important aspect is the price of output which is almost similar in conventional wheat growers (Rs. 26/kg) as compared to Zero Tillage wheat growers that is (Rs 25/kg).

While cost of cultivation is higher in conventional wheat growers, Gross revenue per acre is Rs. 43298.37 for Zero Tillage growers and Rs. 40178.54 for conventional wheat growers. Gross margin per acre of Zero Tillage wheat growers are Rs. 30408.17/acre and for conventional wheat growers Rs. 26480.51.

Thus, it is concluded so far that growing Zero Tillage wheat generates enough gross margin. In the present study, it is the yield and low cost of production resulting in huge financial returns to Zero Tillage wheat growers.

**YIELD DIFFERENTIAL FOR CONVENTIONAL WHEAT CULTIVATION**

The yield of conventional wheat depends on a number of factors (such as distance from farm-to-market, possessing of tube well by the farmer, distance from farm-to-input dealer, land holding, seed rate, the quantity of seed, fertilizer, number of weedicide, labour). The net yield effect could be estimated econometrically by using a production function approach.

In this study, we have used Cobb Douglas production function analysis to determine the impact of the factors on wheat yield. In this regression analysis, we have separated the combined sample of conventional wheat growers and Zero Tillage wheat growers. The sample size was 73. R-square value is 0.396, implying that 39 percent variation in the dependent variable is explained by independent variables that we have included in the production function. It also indicates that the production function fits well to the given data set. Similarly, F value is statistically different from zero with a value of 4.58 and significance level 0.000. This implies that the production function used in this study is overall statistically significant.

**Farm to market distance:** Farm to market distance is an important aspect contributing to wheat yield indirectly. The co-efficient of this variable has a value of 0.03 and is highly significant at 0 percent probability level. It indicates that there is a positive impact of farm-to-market distance on the yield of wheat.

**Tubewell:** Tubewell is an important factor that influences the wheat yield. The co-efficient of this variable has a value of -0.16 and is significant at 8 percent probability level. It indicates that there is a negative impact of owning a tube well on the yield of wheat implying that heavy usage along with rains have affected negatively to wheat. In fact, wheat is a low moisture crop. Number of irrigation has normally positive impact on the yield of the wheat crop but above from certain limit, it can be fatal.

**Distance from farm to Input Dealer:** Inputs are important factors that influence the wheat yield. The co-efficient of this variable has a value of -0.02 and is highly significant at a zero percent probability level. It indicates that there is a negative impact of distance from farm to market on the yield of wheat.

**Land owned by a farmer:** The land possessed by the farmer is also an important factor that influences the wheat yield. The co-efficient of this variable has a value of 0.04 and is highly significant at a zero percent probability level. It indicates that there is a positive impact of more possessing of land on the yield of wheat.

**Seed rate:** The seed is an important factor that influences the wheat yield. The co-efficient of this variable has a value of 0.12 and is insignificant at eighteen percent probability level. It indicates that there is a negative impact of seed on the yield of wheat. Four methods of seed sowing are used by the wheat growing farmers: 1) with drill sowing method and 2) broadcasting sowing 3) Bed sowing 4) sowing by Zero Tillage method.

**Quantity of Seed:** The seed is an important factor that influences the wheat yield. The co-efficient of this variable has a value of 0.02 and is insignificant at fourteen percent probability level. It indicates that there is a positive impact of seed on the yield of wheat.

**Fertilizer nutrients:** Fertilizer is an important input which enhances the yield of wheat. There are commonly three types of fertilizers present in the market. These are DAP, Urea and NP. The quantity of nutrients varies in these types of fertilizers. The collective quantity of nitrogen and phosphorus in fertilizers is an important variable whose co-efficient has a value 0.36 and is insignificant at one percent probability level. It indicates that there is a negative impact of fertilizer nutrients on

the yield of the wheat due to less number of bags used in the production process.

**No. of weedicide:** A number of weedicides is one of the main factors which effects on the wheat yield. This co-efficient for this variable has a value of -0.05 and is insignificant. It indicates that a one percent increase in the use of pesticide decrease the yield of the wheat farmers by 0.05 percent. Pesticide cost has a negative impact on the yield of the wheat.

**Labour:** It is the human resource who manages all other resources effectively and efficiently. Labour plays a crucial role in wheat production because huge labour is required at different stages of wheat production. The co-efficient for this variable is -0.00 and it is significant at five percent level. It indicates that a one percent increase in the efficiency of labour decreases the yield of wheat by 0.00 percent.

**YIELD DIFFERENTIAL FOR ZERO TILLAGE WHEAT CULTIVATION**

The yield of Zero Tillage wheat depends on a number of factors (such as education of the respondents, the experience of the farmers, tube well possessed by the farmer, distance from farm-to-input dealer, land holding, seed rate, seed and fertilizer). The net yield effect could be estimated econometrically by using a production function approach.

In this study, we have used Cobb Douglas production function analysis to determine the impact of the factors on wheat yield. In this regression analysis, we have separated the combined sample of conventional wheat growers and Zero Tillage wheat growers. The sample size was 77. R-square value is 0.535, implying that 53 percent variation in the dependent variable is explained by independent variables that we have included in the production function.

It also indicates that the production function fits well to the given data set. Similarly, F value is statistically different from zero with a value of 11.16 and significance level 0.000. This implies that the production function used in this study is overall statistically significant.

**Education:** Education of the farmer shows a significant effect on the wheat yield. The co-efficient for this variable is 0.02 and it is significant at the four percent level. But it indicates that a one percent increase in the education of the household head increases the wheat yield by 2 percent. It means that educated farmers are in a better position to increase their wheat yield by proper management having good family assets.

**Farming Experience:** Farming experience has a deep impact on wheat crop. The co-efficient of this variable is 0.01 and is insignificant at a 27 percent probability level. It indicates that there is a positive impact of farming experience on wheat crop. So, the experienced farmer can decline his cost of production by his long experience in farming activities.

**Tubewell:** Tubewell is an important factor that influences the wheat yield. The co-efficient of this variable has a value of 0.17 and is significant at 7 percent probability level. It indicates that there is a positive impact of owning a tube well on the yield of wheat implying that a smaller number of careful watering along with rains have affected positively to wheat. In fact, wheat is a low moisture crop. A number of irrigations has a positive impact on the yield of the wheat crop.

**DISTANCE FROM FARM TO INPUT DEALER**

Inputs are important factors that influence the wheat yield. The co-efficient of this variable has a value of 0.02 and is highly significant at a zero percent probability level. It indicates that there is a positive impact of distance from farm to market on the yield of wheat.

**Seed rate:** The seed is an important factor that influences the wheat yield. The co-efficient of this variable has a value of 0.24 and is insignificant at a five percent probability level. It indicates that there is a positive impact of seed on the yield of wheat.

**Quantity of Seed:** The seed is an important factor that influences the wheat yield. The co-efficient of this variable has a value of 0.20 and is significant at a zero percent probability level. It indicates that there is a positive impact of seed on the yield of wheat.

**Fertilizer nutrients:** Fertilizer is an important input which enhances the yield of wheat. There are commonly three types of fertilizers present in the market. These are DAP, Urea and NP. The quantity of nutrients varies in these types of fertilizers. The collective quantity of nitrogen and phosphorus in fertilizers is an important variable whose co-efficient has a value 0.11 and is insignificant at 17 percent probability level. It indicates that there is a positive impact of fertilizer nutrients on the yield of the wheat due to less number of bags used in the production process.

**CONCLUSION & RECOMMENDATIONS**

The farmers were divided into two groups on the basis of their land holding. Out of 150 farmers, 73 farmers were growing conventional wheat, 77 farmers were growing

Zero Tillage wheat. The area under zero tillage was 319 acres and the area under conventional wheat was 264 acres. The sample showed that the average landholding amongst zero tillage farmers was larger than conventional farmers. It was found that most of the farmers in the study area were of an average age of 50 years. All the farmers have an average experience of 26 years.

The findings reveal that conventional wheat growers spend more on fertilizer, irrigation and weedicide than zero tillage farmers in the study area. Total variable cost is also higher for conventional wheat farmers (Rs. 13698.02) than the zero tillage wheat growers (Rs. 12890.2). But seed and labour cost is higher in zero tillage growers as compared to conventional wheat farmers.

Conventional wheat growing farmers spend more on land preparation, irrigation and fertilizer than zero tillage wheat growing farmers. Per acre yield of zero tillage wheat growers was 42.11 mounds while in case of conventional wheat growers it was 37.71 mounds. It showed that farmers growing zero tillage wheat growers were more specialized in wheat production than farmers growing conventional wheat. While gross margins from zero tillage wheat were higher as compared to conventional wheat growers.

The research findings suggest that regression analysis to out impact of the factors on yield differential wheat yield. In this regression analysis, we have made a separated sample of conventional wheat growers and zero tillage wheat growers. The sample size was 150.

Main conclusions of the study are as under:

Different factors such as farm size, education, and age, farming experience and farm machinery had a positive impact on wheat production. Education affects the planning and managerial abilities of the farmers in different farm operations. It is concluded that highly educated farmers get more wheat yield and returns from it as compared to less educated farmers.

Cost of production of conventional wheat was more than zero tillage wheat because of the higher cost of fertilizer, use of a greater number of irrigation through tube well more labour requirement and other intercultural practices. In spite of this cost of production, farmers of the area have started giving preference to grow zero tillage wheat instead of conventional wheat because it gives better returns.

Production of zero tillage wheat is more profitable than conventional wheat. Because zero tillage wheat gives high yield (42.11 mounds/acre) as compared to conventional wheat (37.71 mounds/acre). There was not a significant difference in soil fertility of zero tillage and conventional methods, but zero tillage wheat fields still earned a greater profit.

Factors responsible for variation in profitability of zero tillage wheat and conventional wheat were the cost of ploughing, cost of seed, cost of irrigation, cost of FYM, cost of fertilizers, cost of weedicide, cost of fertilizer, cost of hoeing, manual cost and picking cost. Zero tillage wheat cultivation is more specialized in terms of crop production as compared to conventional wheat growing.

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