Research Article

# An Economic Analysis of Tunnel Farming in Enhancing Productivity of Off-Season Vegetables in District Peshawar

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**Abstract** | There has been an increasing trend of growing off-season vegetables in order to get best prices for the agricultural products and also provide food throughout the year. Growing vegetables in tunnel have been adopted by many farmers. However, growing off-season vegetables in tunnels entails added efforts and cost. Through this research study the economic analysis of Tunnel farming of off-season vegetables has been done for district Peshawar. Primary data was collected from eighty-four farmers who had grown off-season vegetables through tunnel-farming, and seasonal vegetables without tunnel and their productivity were compared. It was found that output per acre in tunnel was significantly higher than that of without tunnel. All the three vegetables viz tomato, cucumber and bottle gourd gave higher revenue, however tomato gave the highest return. Growing vegetables through tunnel farming involve higher cost in the shape of structure installation and inputs. Tunnel-farming is scientific farming and the growers need to be properly educated and trained. Establishing of cold storage facilities will greatly help farmers to fetch higher income. Additionally, credit facilities to the farmers would help potential progressive growers to adopt tunnel-farming and grow off-season vegetables, thus getting higher yield per acre.

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## Introduction

Agriculture has been the mainstay of Pakistan's economy since its inception. This sector is of immense importance being the major source of livelihood for a great chunk of the country's population and absorbing 37.61% of the labour force (GoP, 2019). It provides food for the ever-surging population of Pakistan. It provides raw material to various manufacturing units and hence sustains industrial growth. Agricultural and industrial sectors are inter-dependent and there is strong inter-relationship between these sectors, helping to develop one another. Modern technology has greatly helped-to increase agricultural output which in return increases demand for machinery and equipment. As such the demand for modern technology/ equipment increases (Raza and Siddique, 2014).

A great variety of vegetables are grown in different areas of Pakistan with different eco-systems i.e. dry and wet, low and high, rainy, irrigated and unirrigated. Commonly grown vegetables during summer and spring are tomato, cucumber, brinjal, chillies, okra, potato and gourds. Winter is important season for growing a large variety of vegetables which include

cabbage, lettuce, cauliflower, onion, potato, carrot, coriander, spinach, radish, turnip and peas etc. A variety of climatic conditions in different parts of the country help to ensure availability of different kinds of vegetables throughout the year. A variety of other vegetables may be grown in various localities which may be marketed within and outside the country during any season. The trend shows that the overall area and production of vegetables in Pakistan has increased over a period of time. During 2000-01 to 2017-18, the area under vegetables increased by 24% while production during the same period increased by 66% (GoP, 2018).

Vegetable cultivation is suitable in Pakistan and comparatively shorter period of maturity is one of the main reasons. Vegetables are even suitable for farmers with small pieces of land. In order to meet the needs of the increasing population in view of soil degradation and scarcity of irrigation water, vegetable production needs to be substantially increased. Moreover, multiplying vegetable production is essential to get self-sufficient and also earn foreign exchange by creating exportable surpluses. To meet this goal, off-season vegetables have been introduced in the farming system (Khokar, 2014).

Production of vegetables out of normal season through different techniques is called "off-season vegetable". Seasonal vegetables are grown at large scale, however, demand for vegetables exists around the year. Growing Off-season vegetables not only provide fresh vegetables to the daily dietary meal of the consumers but also helps farmers to get abnormal profit as supply in the off-season is always lower than that of its demand. Using tunnels to extend growing season by protecting plants from cold temperature abnormally improves productivity in the late season. Benefits from around the year production from growing off-season vegetables include throughout the year income, retention of the old customers by the farmers, attracting new customers, and higher prices for the produce at time when other growers have not produced (SMEDA, 2007).

Like other parts of Pakistan, Khyber Pakhtunkhwa has an agrarian economy. A big majority (78%) of the population depends, directly or indirectly, on Agriculture (GoKP, 2015). The Province of Khyber Pakhtunkhwa has a very diverse climatic condition. The annual temperature varies from below $0^0$ C in the north to over $45^0$ C in the south. Its diversified climate enables the growth of large varieties of crops, fruits and vegetables. The vegetable sector in Khyber Pakhtunkhwa has great potential if due attention is given and quality factors are properly addressed. The growers are generally not aware of the new technological applications and also face financial constraints (Jalal-ud-Din, 2011).

There has been an increasing demand for off-season vegetables, whereas their supply is comparatively low. Production of vegetables of winter season in summer season, in an artificial atmosphere is costly and hence cannot be applied at large scale in Khyber Pakhtunkhwa. However, it is possible to produce summer season vegetables during winter season, by creating required environment through tunnel technology, which is economical. Accordingly, Plastic sheets are used which retain energy of the sun providing enough warmth to the vegetables grown in the tunnel. This farming is commonly known as "Tunnel Technology". The farmers use plastic sheets to cover the crop in the tunnels so as to provide the required amount of heat to the crops. Plastic sheets cost less than that of glass sheets and are very economical. Different types of tunnels like low tunnel up to 3 feet in height, walk-in tunnel having height up to 6.5 feet and high tunnel with 12 feet height is used to produce off-season vegetable. However, high tunnel has been the subject matter of this research. High tunnels have effectively and profitably extended the growing season for warm and cool-season crops in certain climates (Wells and Loy, 1993). Common vegetables grown in Tunnels are cucumber, tomato, bottle gourd, bitter gourd, strawberry, squashes and pepper etc. Different types of tunnels are used in the country to produce off-season vegetables however; the high tunnel is commonly used to grow vegetables in off-season. High tunnels are adopted as affordable technology for season extension and producing off-season vegetables (Lamont et al., 2002).

The aim of the present study is to study the role of tunnel farming on the productivity of off-season vegetables and farmers' income and conduct cost and benefit analysis of tunnel farming. Major vegetables grown in the area in the Tunnel and without tunnel are tomato, cucumber and bottle gourd.

## Materials and Methods

The universe for this research study was restricted to six villages of District Peshawar namely Khanabad, Mamo Khatke, Shahi Bala, Wadpaga, Pakha Ghulam and Badbera where the tunnel farming technique has been adopted. The data were collected from those farmers of the above-stated villages who have established Hi-Tunnels for growing off-season vegetables like tomato, cucumber and bottle gourd. These vegetables were selected because these were grown seasonally without tunnel and off-season in the tunnel by the same farmers in the study area. Moreover, according to the farmers they have imparted training and provided with inputs and financial assistance to grow these vegetables in tunnels established under the Agribusiness project. This was a source of motivation for present study.

The research is based mainly on primary data which were collected through a pre-tested questionnaire, particularly designed for this study. Secondary data were also used for references and comparison purposes. Data were collected about input use and productivity of vegetables grown with tunnel and without tunnel. Each of the respondent farmers was growing vegetables with and without tunnel simultaneously. Data from the same farmers were collected regarding vegetables under both the farming systems. Moreover, data regarding demographic and socio-economic characteristics of the respondents such as age, education level, economic activities, family composition and their income, yield, cost and revenue of the and vegetables were collected. A total number of 84 farmers have established tunnels for growing off-season vegetables out of which 64 (76%) growers were randomly selected.

The data were analyzed with the help of SPSS and Excel Software. As the study compares the yields of vegetables with and without tunnel, applying the new farming technique, a paired t-test was applied to test the significance.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

Whereas;
$\bar{X}_1$= Average revenue of vegetable grown in tunnel; $\bar{X}_2$= Average revenue of vegetable grown without tunnel; $S_1^2$=Sample variance of vegetables grown in tunnel; $S_2^2$ = Sample variance of vegetables grown without tunnel; $n_1$ = Sample size of vegetables grown in tunnel; $n_2$ = Sample size of vegetables grown without tunnel.

Data regarding the cost of growing vegetables with and without tunnel was collected and analyzed. The cost of both the system for growing vegetables was compared. Similarly, the productivity per acre of both the systems was also worked out and compared. Moreover, gross revenue and net revenue of the farmers from farming with tunnel and without tunnel was analyzed and "p" value was calculated for test of significance.

## Results and Discussion

While analyzing the cost and benefits of growing vegetables with and without tunnel the cost of production of vegetable in both system was worked out and compared. Similarly, total productivity and gross and net revenue obtained from growing vegetables with and without tunnel were also calculated and compared.

### *Farmers' characteristics*

**Family composition:** Total family members of the 64 respondents were 632 out of which 214 (34%) were ageing under 15 and hence, were dependent. It was found that 13% of the respondents have a family size of 1-5, whereas 56% have family size 6 to 10. Similarly, 31% of the respondents have family size 11 and above.

The data further revealed that the majority of the working farmers were in the age group of 30-45. On the other hand, the number of adult workers at the age group of 45-60 was comparatively low i.e. 16% of male and 8% of female. Similarly, adult workers between age group of 15-30, were the lowest i.e. 11% for men and 10% for women. Similarly, among the adult non-workers the highest percentage (8% for both male and female) was found at age-group of 15-30.

**Education:** It was discovered that the majority (75%) of the respondents were literate, which indicates that education has been instrumental in the decision of adopting tunnel technology. Out of the literate farmers' 33% had education level of SSC (Metric) whereas 29% were graduate or above.

**Table 1:** *Inputs and cost of production per year (Rs. per acre).*

| System | Vegetables | Cost of inputs | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Machinery/ land prep | Seeds | Fertilizer | Pesticides | Irrigation | Manual labour | Others* | Total |
| Tunnel | Tomato | 4500 | 30000 | 24167 | 35238 | 5536 | 122629 | 41319 | 263,389 |
| | Cucumber | 2395 | 8413 | 10847 | 20938 | 3483 | 63888 | 16633 | 126,597 |
| | Bottle gourd | 3314 | 8093 | 10514 | 22474 | 2186 | 32625 | 35320 | 114,526 |
| Without Tunnel | Tomato | 4250 | 25600 | 18500 | 25000 | 4500 | 65500 | 25000 | 16,8350 |
| | Cucumber | 2100 | 7500 | 8600 | 17000 | 2500 | 35000 | 9600 | 82,300 |
| | Bottle gourd | 2700 | 6800 | 8500 | 18000 | 1500 | 18000 | 20000 | 75,500 |

**Source:** *Authors own calculations from field survey data; *Others include transportation, marketing and unforeseen etc.*

**Landholding:** Regarding landholding of the farmers, it was observed that 38% of the respondents had land size between 05-10 acres followed by 31% with below 05-acre landholding. Similarly, 19% respondents had 10-20 acres of land and only 13% respondents had land of 20 acres and above. This data revealed that the respondents with small landholding (below 5 and 5-10 acres) were more interested in efficiently using their land for achieving higher level of productivity and hence adopted Tunnel technology.

**Cost, production and Revenue analysis:** While growing different vegetables in open fields and Tunnels, a number of inputs were used which are the main determinants of the cost of production. The cost of inputs was calculated per acre per annum covering both Rabi and Kharif seasons. The details of input and cost, based on the data collected from the respondents are presented in Table 1.

It is evident from the figures in Table 1 that the cost of tomato grown in Tunnel is Rs. 263,389/- which is 56% more than that of the cost of tomato grown without tunnel which is Rs. 168,350/-. Similarly, the cost of cucumber grown in tunnel is Rs. 126,597/- and without Tunnel is Rs. 82,300/- showing an increase of 54%. The cost of bottle gourd grown in tunnel is Rs. 114,526/- which is 52% above the cost of bottle gourd grown without tunnel which amounts to Rs. 75,500/-. The major factors that contributed to the difference in cost are seeds, labour, transport and pesticides as shown in the above table. It is pertinent to mention that growing vegetables in tunnel involved cost of tunnels' construction which, according to the farmers was approximately Rs. 220, 000/- per tunnel. The farmers further revealed that the Agribusiness Project provided assistance to them for the establishment of tunnel structure in instalments, initially on preparation of foundation block, followed by erection of structure and applying plastic sheet. In addition to the above cash grant, the project also provided the farmers with the environment management kit consisting of safety boots, gloves, pruner, spray machines etc. and crop management kit comprising training and seeds.

It can be concluded on the basis of the figures given in Table 1 that cost of tunnel farming is significantly higher than that of without tunnel. The major reasons for the comparatively higher cost in Tunnel farming are variety of seeds, the intensive use of pesticides and insecticides, longer cropping period and more marketing. Ishaq et al. (2003) also found that cost of seed, labour wages, fertilizers, rent and marketing were the major contributor to the total cost of off-season vegetable production. According to Janke et al. (2017), it is eight times more expensive to grow tomatoes in high tunnels as compared to open field, however, tomato grown in tunnel gave four times greater yields. Ali et al (2017) identified high initial investment is one of the major problems faced by growers of off-season vegetables. Similarly, Galinato and Miles (2013) also observed that it was more expensive to grow tomato in high tunnel than in the open field because more labour and capital investment are required to grow these vegetables in high tunnel.

For the comparison of productivity, data were collected on the production of vegetable grown in open field and Tunnel. The data are presented in below table:

**Table 2:** *Farm productivity of various crops per acre tunnel and without tunnel (Kg/Acre).*

| Crops | Without tunnel | Tunnel | Difference % |
|---|---|---|---|
| Tomato | 11,700 | 32,434 | 177 |
| Cucumber | 16,988 | 21,306 | 25 |
| Bottle gourd | 12,450 | 21,017 | 69 |

**Source:** *Authors own calculations.*

The production of tomato in tunnel was 177% above the production of without tunnel (Table 2). This means that in tunnel output of tomato was nearly 03 times more than that of without tunnel. Similarly, cucumber was grown both in with and without tunnel and production within the tunnel was 25% higher than that of without tunnel. Bottle gourd grown in Tunnel gave 69% more output than that of without tunnel.

It can be concluded from the above discussion that yield per acre of all vegetables grown in the tunnel is much higher than that of vegetables grown in open field. The above table shows yield (in kg) of vegetables grown in open field and within tunnel.

In order to find out the difference in productivity in money terms, the data on revenue of vegetables were collected about both Rabi and Kharif and were presented in money terms per acre for the sake of comparison. The following table shows per acre revenue of crops and vegetable grown with and without tunnel.

**Table 3:** *Gross revenue of various crops (Rs.) per acre.*

| Vegetables | Without tunnel | Tunnel | % |
|---|---|---|---|
| Tomato | 250,000 | 603,531 | 141 |
| Cucumber | 238,625 | 319,585 | 34 |
| Bottle gourd | 145,000 | 240,000 | 66 |

**Source:** *Authors own calculations.*

The figure in Table 3 shows that per acre gross Revenue of tomato grown in tunnel is 141% higher than that of without tunnel. Similarly, cucumber is grown off-season as well as seasonal like tomato and gross revenue of cucumber grown in tunnel is 34% more than that of without tunnel. The gross revenue of bottle gourd grown in tunnel is 66% more than that of the without a tunnel. It can be concluded from above data that the gross revenue of all vegetables grown in tunnel is higher when compared to gross revenue of vegetables grown without tunnel.

With the use of tunnel technology, the production cycle in tunnel in case of growing tomato extends from November to July. In this case, inter-copping like bottle gourd further extended cropping cycle till October making the tunnels more profitable. With extended cropping cycle beyond normal period the total output increases manifold. Tunnel technology has a significant positive impact on the families as majority of the vegetable growers got benefits from the tunnels in term of increase in their income and also their area under vegetable growing increased, as also observed by Muhammad et al. (2015).

From the above discussion, it can also be concluded that tomato, being major vegetable and giving more production, has proved more profitable vegetable in tunnel as compared to all vegetables grown in tunnel or without tunnel. Jett and Read (2006) found that for growers who are interested in before-season tomato production, high tunnels is the best technology. However, it was observed during the study that due to non-availability of cold storage facilities and having no linkages with the exporters, the products are sold locally and at market price immediately.

*Comparison of net revenue of vegetables grown in tunnel and without tunnel*

As mentioned previously, the expenditures of production and gross revenue are jointly presented below for a comparative purpose.

**Table 4:** *Net revenue of various tunnel and without tunnel per acre (Rs.) (2014-15).*

| Crops | Without tunnel | Tunnel | % |
|---|---|---|---|
| Tomato | 81,650 | 340,142 | 317 |
| Cucumber | 156,325 | 192,988 | 23 |
| Bottle gourd | 69,500 | 85,474 | 23 |

**Source:** *Authors own calculations.*

The above table shows that net revenue of tomato grown in tunnel is 317% higher than that of without tunnel. Similarly, the net revenue of cucumber grown in the tunnel is 23% above than that of without tunnel. The net revenue of bottle gourd grown in tunnel is also 23% more than that of without tunnel.

Comparing all the vegetables grown in tunnel as well as without tunnel it is evident from the figures in Table 4 that the net revenue of tomato is the highest and hence cultivation of tomato in a tunnel is more profitable. High tunnel production of tomatoes extends the season for the crop which in return allows for higher price received for marketable Tomato (Reeder, 2006). Galinato and Miles (2013) also found that due to higher production and higher prices tunnel-grown tomatoes due to off-season the net return was three times greater for tomato grown in high tunnel as compare to field-grown.

*Benefit-cost ratio of crops grown in tunnel and without tunnel*

The benefit-cost ratio shows the overall economic performance of any activity. In the following table benefit-cost ratio of crops grown with and without tunnel is presented.

**Table 5:** *Benefit-cost ratio of crops grown with and without tunnel.*

| Vegetables | Benefit-cost ratio | |
|---|---|---|
| | Tunnel | Without tunnel |
| Tomato | 2.29 | 1.48 |
| Cucumber | 2.52 | 2.19 |
| Bottle gourd | 2.09 | 1.92 |

**Source:** *Author's own calculations based on field survey.*

As can be seen in Table 5 that for tomato grown with tunnel B/C ratio is 2.29 which means spending of Re.1 generates Rs. 2.29 whereas without tunnel the B/C ratio is 1.48, implies that spending of Re. 1 on production of tomato without tunnel will generate Rs. 1.48. Similarly, the B/C ratio for cucumber with and without tunnel is 2.52 and 2.19 respectively which means spending of Re. 1 on growing cucumber will generate Rs. 2.52 and Rs. 2.19 with and without Tunnel respectively. On the other hand, 2.09 and 1.92 benefit-cost ratio for bottle gourd with and without tunnel proves that spending of Re. 1 on producing bottle gourd with and without tunnel will generate Rs. 2.09 and 1.92 respectively. Tahir and Altaf (2013) while conducting comparative study of normal and off-season vegetables in Abbottabad also found not much fluctuation in the income among the farmers growing vegetable in normal season without tunnel but observed that the income from off-season vegetable production was almost double.

From the above figures, it can be concluded that the difference of benefit-cost ratio of tomato grown with and without tunnel is the highest and hence tomato is more productive vegetable fetching more revenue for the grower.

*Econometric analysis of tunnel and without tunnel farming*

Econometric analysis of the vegetables grown in Tunnel and without tunnel has been carried out on gross revenue and net revenue of the vegetables and is presented below.

**Comparative analysis of gross revenue of vegetables:** As the study tries to compare Revenue of vegetables grown with and without tunnel so a paired t-test has been applied to study the significance of the estimations. The gross revenue from each vegetable grown at a time in tunnel and without tunnel is compared and the results are presented in the table below:

**Table 6:** *Comparative analysis of gross revenue of vegetables.*

| Vegetable | Average yield per acre (Rs.) | | Difference % | t | Sig (p) |
|---|---|---|---|---|---|
| | Tunnel | Without tunnel | | | |
| Tomato | 603,531 | 250,000 | 141 | 53.726 | 0.000 |
| Cucumber | 319,585 | 238,625 | 34 | 2.034 | 0.041 |
| Bitter gourd | 240,000 | 145,000 | 66 | 2.021 | 0.040 |

**Source:** *Authors own calculation.*

In Table 6, the comparative analysis shows a significant difference in crops grown in tunnel and without tunnel. Tomato is highly significant whereas cucumber and bottle gourd are also significant at 95% level of confidence.

**Comparative analysis of net revenue of vegetables:** To further analyze the data, net revenue of vegetables grown in a tunnel and without tunnel has been compared and presented in below table:

**Table 7:** *Comparative analysis of net revenue of vegetables.*

| Mean net revenue | | | Difference % | T | Sig (p) |
|---|---|---|---|---|---|
| Vegetable | Tunnel | Without tunnel | | | |
| Tomato | 340,142 | 81,650 | 317 | 21.194 | 0.000 |
| Cucumber | 192,988 | 156,325 | 23 | 2.712 | 0.009 |
| Bottle gourd | 85,474 | 69,500 | 23 | 2.290 | 0.025 |

**Source:** *Authors own calculations.*

The net revenues of the vegetables grown in the tunnel and without tunnel are analyzed using a paired-t-test at 0.05 level of significance. The results in Table 7 show that in case of net revenue for tomato the p-value is 0.000 which shows high level of significance. This implies that there is significant difference in the net revenue of the tomato grown with and without tunnel. For cucumber grown in tunnel and without tunnel the p-value is 0.009 which shows a high level of significance and we conclude that there is significant difference between the net revenue of cucumber grown in Tunnel and without tunnel. Similarly, p-value of bottle gourd is .025 which again means high level of significance showing

that there is significance difference between the net revenue of bottle gourd in tunnel as compared to that of without tunnel.

Hence, on the basis of the above results, it can be concluded that there is significant difference between the net revenue of vegetables grown in the tunnel and without tunnel. It is proved that tunnel technology has been very beneficial while producing off-season vegetables. The above results further reveal that tomato has proved more productive and beneficial vegetable grown in tunnel as compared to cucumber and bottle gourd.

## Conclusions and Recommendations

Tunnel farming has significantly contributed to the productivity of off-season vegetables. Financial assistance provided by the agribusiness project has been very successful in introducing new farming techniques. Farmers' income and profit have considerably been increased with the adoption of tunnel technology. The capacity of the farmers has been improved while participating in training sessions. The farmers were interested to continue with tunnel technology as it was found more beneficial as compared to conventional farming. Cost of establishment of tunnel and higher inputs cost were the major obstacles faced by the farmers in the adoption of tunnel farming. The growers were having the problems of insecticides/ pesticides in their crops resulting in reduction in output. There is no cold storage facility in the area. The following recommendations are hereby given on the basis of the findings of the study.

- Awareness campaign shall be launched to encourage farmers to adopt new Tunnel Technology.
- Training be provided to the farmers through different agricultural extension activities to help them to adopt Tunnel Technology. Moreover, quality and appropriate seeds of tomato and other vegetables be provided to the farmers at a reasonable price.
- Research is direly needed to cope with the emerging diseases in Tunnels.
- Private investors should be encouraged to establish cold storage facilities so that products can be stored for longer time enabling the farmers to get maximum profit.
- Best farmers award should be introduced so that the progressive farmers are motivated and encouraged to grow off-season vegetables.
- The quality of the tunnel established by the Agriculture Department should be improved so that wastage of money is controlled and the tunnel should complete its average tenure of 10 years.

## Novelty Statement

This research paper has focused on tunnel technology as inno-vative farming technique. This will not only benefit the farmers but will also provide new avenues to the policy makers for the development of agriculture sector in Pakistan. The adoption of tunnel technology for growing off-season vegetables will help to ensure food security and enable the farming community for efficient utilization of their small landholdings and get higher return for their produce. This research paper is an addition to the existing literature relevant to innovative and progressive farming.

## Author's Contribution

Muhammad Bakhtiar Khan reviewed the literature, collected the data, developed methodology, analyzed data with the help of Jangraiz Khan and interpreted the results. Muhammad Bakhtiar wrote the manuscript while Jangraiz Khan reviewed and refined it.

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