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Use of Sewage Water for Radish Cultivation: A Case Study of Punjab, Pakistan

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ABSTRACT

A study was designed with the objective to assess the impact of sewage water on radish cultivation during 2002-03. Dummy variable was used to estimate the impact of sewage water on radish yield. Production function having independent variables like land preparation, seed, fertilizer and labour along with dummy variable and interaction terms between dummy variable and other independent factors was used to assess the response of different inputs like seed, fertilizer, land preparation, etc. due to sewage water. The findings of the study showed that by the introduction of interaction terms in the model, the coefficients of seed and insecticide variables changed significantly. This model also indicated that sewage water reduced the efficiency of tractor hours used for land preparation and fertilizer. The results of this study depict several policy actions to be taken immediately to preserve soil productivity and to reduce the health hazards. The most important step is to treat sewage water before applying to crops and those vegetables that are tolerant to sewage water and leafy ones should be irrigated by this type of water and conjunctive use of sewage and canal/tube-well water must be practised to maintain soil productivity.

Key Words: Radish; Sewage water; Consequences; Cross sectional data; Punjab

INTRODUCTION

Pakistan has majority of urban and rural population surviving on vegetables, which is relishing food due to nutritive value such as vitamins, proteins, Calcium, phosphorous, iron, water and mineral salts etc. In its varying climatic conditions, the vegetables grown may vary from leafy to cole crops, root vegetables to bulb or tuber crops, flower vegetables to immature fruit vegetables etc. grown in different parts of the country. The area under vegetable cultivation excluding potato and sweet potato but including onion, garlic and chillies was 0.381 million hectares (about 1.67% of the total cropped area), producing about 4.06 metric tons of vegetables. There is increasing demand of vegetables from rural to urban areas due to domestic consumption directly in food either in raw or cooked form. But, vegetables have variety of uses in the preparation of pickles, chutney ketchup, soups, sauces, salads etc. except their edible usage for cooking purposes (Tunio & Majeedano, 2001).

In most of the cities of Pakistan, the wastewater from municipal areas as well as the effluent from the industries is disposed off untreated to the natural water surface bodies. It has been reported that about 212.2 million gallon tones of sewage is being thrown in water bodies and there is no proper mechanism for sewage collection and treatment/safe disposal. Such practices are causing environmental pollution. The sewage water is used for irrigating various crops in the surroundings of the cities (Hernandez *et al.*, 1991; Qadir *et al.*, 1997) and this is considered the cheapest way to dispose off sewage. The farmers also prefer to use this water because waste water is extremely valuable source for farmers as pumping cost from sewage nallah or drains is cheaper than a borehole, which makes the practice more accessible to farmers with fewer financial resources.

Sewage water contains higher amounts of nutrients, increases crop yields substantially and reduces the need for fertilizer, thereby decreases overall cost of production. Although use of sewage water creates crop management problems like weed infestation and incidence of pests, however, these problems are tackled with the use of plant protection measures. Continuous use of waste water may lead to environmental problems such as soil sickness, soil and groundwater contamination and phytotoxicity (Hunshal *et al.*, 1997; Hicks & Hird, 2000; Siddiqui, 2000; Bradford, 2001). Ghafoor *et al.* (2004) and Murtaza *et al.* (2003) found that in soils irrigated with waste water, heavy metals were found above permissible limits. Higher concentration of metals was observed in vegetable leaves. The continuous intake of untreated sewage irrigated vegetables may develop Pb, Cu, Zn and Fe levels in human body to toxic levels. Furthermore, irrigation with sewage poses serious health risks, as untreated sewage is a major source of pathogens and may contain high concentration of harmful chemicals from industrial sources (Furedy *et al.*, 1999; Zarsky & Hunter, 1999).

The city effluent is mainly used for raising vegetables in the vicinity of the cities (Qadir *et al.*, 1999). This is one of the reasons that vegetables are mostly concentrated around the big cities. Leafy vegetables like cauliflower, cabbage, spinach, etc. grow quite well in the presence of sewage water whereas vegetables such as radish, carrot, turnip, etc. are sensitive to sewage water. Bakhsh *et al*. (2005) concluded that poor quality of ground water caused considerable losses to root crops. Similarly, sewage water also affects badly root crops such as radish during maturity stage and as a result the production decreases substantially (Bakhsh, 2002).

The present study was designed to estimate and compare cost of production and profitability of radish growing farmers who were, using sewage with those not using sewage water and to see what happens to the response of the various inputs like seed, fertilizer, labour use, etc. in the presence of sewage water.

METHODOLOGY

Analytical framework. Descriptive statistics, partial budgeting and regression analysis techniques were used to determine the profitability and investigate whether or not sufficient evidence is available from farmers' fields that the use of sewage water is affecting radish yield positively or negatively. Our objective was that whether the intercept and the slope parameters in regression equation are affected by the use of sewage water. The dummy variable approach was adopted for demonstrating the differentials in input use efficiencies. This approach is well explained in Iqbal *et al*. (2002) and Gujarati (2000).

Root crops such as radish, carrot, turnip, etc. are sensitive to the use of sewage water because the application of sewage water deteriorates quality of such vegetables and it also affects the growth of vegetables badly. To see the impact of sewage water on radish cultivation, four functional forms were used. The first model was tried to analyze the effects of different inputs on radish cultivation and it was supposed that sewage water did not influence intercept and slope coefficients. The general form of the first model is as under:

$$Y = f\,(LP, SEED, FERT, LABOR, D_1) \qquad (1)$$

Where Y is the yield per acreage, LP, SEED FERT and LABOR are, respectively tractor hours used for land preparation, seed rate fertilizer (NP) and labour used for different operations excluding harvesting per acreage and D_1 is a dummy variable. It was taken as one if disease attack was reported else zero. All variables except labour were significantly affecting radish yield. However, this model ignored the effect of sewage water on radish cultivation. Dummy variable for sewage water users was introduced in the above model to determine its effect on intercept only. The functional form of this model is given below:

$$Y = f\,(LP, SEED, FERT, LABOR, D_1, D_2) \qquad (2)$$

Where D_2 is dummy variable for sewage water and it has a value of one if farmer was using sewage water otherwise zero and others variables are defined as earlier. This dummy variable well influences the intercept term. In the next step, we introduced interaction terms of sewage dummy variable and other inputs to find out the impact of sewage on slope coefficients only. This form is as under:

$$Y = f\,(LP, SEED, FERT, LABOR, D_1, D_2LP, D_2SEED, D_2FERT, D_2LABOR) \qquad (3)$$

In the last model, it was supposed that sewage water affected both intercept and slope coefficients. This functional form is as follows:

$$Y = f\,[LP, SEED, FERT, LABOR, D_1, D_2, D_2LP, D_2SEED, D_2FERT, D_2LABOR] \qquad (4)$$

In order to select the best production function or model, F-test is used which is detailed as:

$$F = \frac{(RSS_R - RSS_{UR})/m}{RSS_{UR}/(n-k)} = \frac{\left(\sum \hat{u}_R^2 - \sum \hat{u}_{UR}^2\right)/m}{\sum \hat{u}_{UR}^2/(n-k)} \qquad (5)$$

Where $\Sigma\hat{u}_R^2$ and $\Sigma\hat{u}_{UR}^2$ are, respectively residual sum of squares of the restricted and unrestricted regression m is number of linear restrictions, whereas k and n are number of parameters in the unrestricted regression and number of observation respectively (Gujarati, 2000).

The F test can also be expressed in terms of R^2 as follows:

$$F = \frac{\left(R_{UR}^{\;2} - R_R^{\;2}\right)/m}{\left(1 - R_{UR}^{\;2}\right)/(n-k)} \qquad (5_a)$$

Where R^2_{UR} and R^2_R are, respectively the R^2 values obtained from the unrestricted and restricted regression (Gujarati, 2000).

On the basis of the results of F test, it was found that the model 3 was the most suited model to the given data. Because of space limitation, only results of model 3 are reported in the results and discussion section.

Iqbal *et al.* (2002) used linear production function to determine the effect of zero-tillage technique on wheat yield. In our case, scatter grams of log of yield were made against log of independent variable inputs like tractor hours used for land preparation, seed rate, fertilizer and labour. These graphs showed a linear relation between dependent and independent variables. On the basis of these diagrams (not included in the text due to space limitation), the following log linear production function was assumed for radish yield in the study area.

$$LnYLD = ß_1 + ß_2LnLP + ß_3LnSEED + ß_4LnFERT + ß_5LnLABOR + ß_6D_1 + ß_7LnD_2LnLP + ß_8D_2LnSEED + ß_9D_2LnFERT + ß_{10}D_2LnLABOR + U \qquad (6)$$

Where

LnYLD = Natural logarithm of radish yield in kg per acreage

LnLP = Natural logarithm of tractor hours used for land preparation per acreage
LnSEED = Natural logarithm of radish seed in kg per acreage
LnFERT = Natural logarithm of total fertilizer (NP) in kg per acreage
LnLABOR = Natural logarithm of labour hours used per acreage
D_1 = Dummy variable for disease/pest attack. It was taken as one if there was disease attack else zero
D_2LnLP = Sewage water dummy cross natural logarithm of tractor hours used for land preparation per acreage
D_2LnSEED = Sewage water dummy cross natural logarithm of radish seed in kg per acreage
D_2LnFERT = Sewage water dummy cross natural logarithm of total fertilizer (NP) in kg per acreage
D_2LnLABOR = Sewage water dummy cross natural logarithm of labour hours used per acreage
U = Random error term independently and identically distributed with zero mean and constant variance

The data. For the purpose of this study, a primary data set was collected using personal interview schedule. Large varieties of vegetables are grown throughout the year in Pakistan. However, we collected detailed information for radish due to limited resource availability. Radish cultivation is mainly concentrated in two districts of Punjab namely Sheikhupura and Sahiwal. A comprehensive questionnaire was used to collect information from radish growers operating in various villages of the selected districts during 2002-03. Villages and the radish growing farmers were purposively chosen. The reason for using purposive sampling technique was that cultivation of radish is limited to small cropped area in the both districts. A total of 97 farmers were interviewed, out of these, 33 farmers were using sewage water for irrigating their radish crop.

RESULTS AND DISCUSSION

Descriptive statistics of various variables of radish growing farmers were estimated and it was found that the farmers growing radish, on average, were 40 years old and they got education up to 4.3 years. This finding showed that schooling year of the concerned farmers was low. Mean farm size was 16.7 acre with a range from 2 to 63 acre but on an average radish was grown only on 1.9 acres. The mean application rate of NP fertilizer was 51 kg per acre, the range of fertilizer use varied across farms from 9kg per acre to 105 kg per acre. The mean yield of radish over the sampled farms was 6032kg per acre with a range of 2400 to 12000 kg per acre (Table I).

Thus, there was a gap of around 5960 kg per acre between average and highest farm yield, suggesting that there are opportunities for increasing radish yields from a given set of technology.

Cost of production. Cost of production was calculated for those using sewage water and those not making use of sewage water separately. The farmers using sewage water incurred Rs. 1458 for preparing land to plant their radish crop whereas those who were using other sources of irrigation spent Rs. 1331 for the land preparation and this cost is relatively less than the former. Amount of radish seed used remained the same for farmers using sewage water and those not using it. The average seed rate of 1.36 and 1.47 kg was used by the respective farmers; therefore, there was no significant difference in the cost incurred on seed. It is a well known fact that sewage water contains large amounts of nutrients and increases productivity of certain vegetables like spinach, cauliflower in the short run. However, it decreases soil productivity in the long run if it is used continuously over time and finally crop productivity diminishes. The radish growers using sewage water made less use of inorganic nutrients as compared to those who were not applying sewage water to their radish crop, therefore, it was found that cost of fertilizer application was substantially higher for farmers using other sources of irrigation compared to those using sewage water. Mostly, sewage water is available on free of cost, but in some districts nominal prices are charged for its use. A total of Rs. 547 was paid for using sewage water while cost of irrigation from other sources was Rs. 1170 per acreage. Weed and disease infestation was commonly reported on the farms where use of sewage water was applied. The farmers were of the opinion that such type of infestation was the outcome of sewage water application. Therefore, plant protection measures expenses were far higher for such radish growing farmers as compared to others. Labour cost was estimated as Rs. 2510 and 2970 for those using sewage water and others (Table II). As it is well known fact that harvesting cost is the function of yield, therefore higher cost of harvesting was calculated for other sources as compared to those using sewage water. This ultimately increased the total cost incurred on labour. Otherwise, labour cost excluding harvesting was substantially higher in the case of farmers using sewage water.

Gross income and margins. The gross income of the farmers using sewage water and other sources of irrigation categories was calculated as 10160 and 13040 rupees per acre respectively. The partial budget analysis of the two irrigation sources showed that the other sources of irrigation like tube-well and canal was more economical than the sewage water source. The sewage water source resulted in the gross returns of 3512 rupees per acre, whereas the gross benefits of the other sources were Rs. 5388 per acre (Table II). These results are in full agreement with those of Bakhsh *et al.* (2005). Although, they conducted study to determine effect of poor quality of ground water on carrot production, but the main emphasis was to show the sensitivity of vegetables towards quality of water. The lower returns in case of sewage water as source of irrigation are going to provide a big issue for concerned authorities. And also the application of sewage water points out that sewage water should be treated before applying to vegetables from economic and health point of views.

The regression analysis. The multiple regression

Table I. Summary statistics of different variables of radish farmers

Variables	Sample mean	Sample standard deviation	Minimum	Maximum
Family size (No.)	6.7	45.4	2	11
Farmer's age (year)	40	12.7	18	70
Farmer's education (Year)	4.3	4.5	.01	12
Farm experience (year)	20	12.6	1	60
Farm size (acre)	16.7	16.1	2	63
Radish area (acre)	1.9	2.1	0.2	10
Land preparation (tractor hours/acre)	6.7	1.1	3.3	8.5
Seed (kg/acre)	1.4	0.5	1	3
Fertilizer (kg/acre)	50.9	23.3	9	105
Labour (hours/acre)	83.8	37.5	23	175
Radish yield (kg/acre)	6032	1814.96	2400	12000

Table II. Gross Returns Analysis for Various Sources of Irrigation

Items	Use of sewage water (Rupees/Acre)	Other sources*
Land Preparation	1458	1331
Seed @ Rs. 250/kg	340	368
Fertilizer	975	1475
Plant protection measures	818	338
Irrigation	547	1170
Labour	2510	2970
Total cost of production	6648	7652
Radish yield (Kg/Acre)	5080	6520
Price (Rupees/Acre)	2	2
Total Returns	10160	13040
Gross Returns	3512	5388

* Other sources include tube-well and canal water, separately or jointly

Table III. Results of Regression Analysis

Variables	Coefficient Estimates	t-value	Significance
Constant	3.374	11.545	0.000
LnLP	0.638	3.726	0.000
LnSEED	-0.069	-0.732	0.466
LnFERT	0.235	3.942	0.000
LnLABOR	-0.052	-0.834	0.406
D_1	-0.096	-1.631	0.106
D_2LnLP	-0.317	-1.136	0.259
D_2LnSEED	-0.483	-3.039	0.003
D_2LnFERT	-0.134	-1.535	0.128
D_2LnLABOR	0.159	1.512	0.134

R^2 = 0.54 Adjusted R^2 = 0.49 F = 11.38

equation discussed in methodology was estimated by using ordinary least squares method and the results are presented in Table III. The F-statistics is significant at one% level of significance indicating that the explanatory variables incorporated in the model collectively have significant influence on radish yield. An R^2 value of 0.54 depicts that that the independent variables included in the model explains 54% variations in the radish yield. For a cross sectional data it represents quite a good fit and suggests that the estimated model fits the data well. The number of tractor hours used for land preparation and total fertilizer nutrients (NP) constituted the important determinants of radish yield. The coefficients of these variables were positive and significant at less than one% level of significance. The amount of seed applied and labour used for different farming operations showed a negative but insignificant affect on radish yield. The negative coefficient for disease/pest attack dummy pointed out that disease/pest attack was decreasing radish yield in the selected district.

The coefficient for the cross term of land preparation and sewage dummy is negative hinting that efficiency of tractor hours used for land preparation decreases while applying sewage water to the radish crop, however, its coefficient was statistically non-significant. This may be due to the fact that sewage water has many insoluble materials like polythene bags, and other related materials. Concentration of such materials hinder in better land preparation. The cross term of seed and sewage water is negative and significant at less than 1% probability level. It hints the fact that radish yield is severely affected by the use of sewage water because of the presence of polythene bags and other materials. The cross term of sewage dummy and fertilizer has a negative coefficient as it was expected and significant at 13% level. The negative interaction term was due the fact that sewage water is rich in organic nutrients. The coefficient of the interaction term between labour used for various farming activities excluding harvesting and dummy variable for sewage water is positive and significant at 13% level showing that with increased application of sewage water, labour use also increases because of more weed infestation and it has a positive effect on the radish yield.

The resulted higher yield is due to better land preparation and yield losses saved due to better plant protection measures, since disease/pest attack dummy shows a negative effect on radish yield.

CONCLUSIONS AND SUGGESTIONS

The study evaluated the impact of sewage water on radish yield in Punjab. Such an evaluation is needed to understand the farming community's problems (especially small farmers growing vegetables) when they have to apply sewage water to vegetables because of shortage of canal water and non-availability of financial assistance.

Radish like other root crops is sensitive to the use of sewage water. Interaction terms included in the model showed that such type of water for irrigation purposes in radish cultivation decreased profitability substantially. Gross and marginal returns per acre were significantly lower as compared to those who were applying water by using other sources of irrigation. However, partial budget analysis hints that cost incurred on fertilizer application remained lower on the farmers' fields using sewage water, since use of city effluent is rich in nutrients essential for plant growth. But one should keep it in mind that post application effects of continuous use of such kind of water are quite high as compared to short period benefits.

Negative cross term of sewage dummy and tractor hours used for land preparation highlights that the joint effect of these variable inputs would result in lower per acre yield, since vegetables like radish, carrot, etc. need well prepared seed beds for a good germination. However, sewage water makes it difficult to prepare land thoroughly due to accumulation of materials like polythene bags. It is, therefore, suggested that the farmers should make arrangements to purify water from such materials before applying it to the radish and other vegetables.

The coefficient of cross term of labour hours used in radish cultivation and sewage dummy has a positive coefficient showing that the increased use of sewage water enhances labour efficiency because application of sewage water generally creates weed infestation problems and to tackle this problem, the farmers have to employ more labour force.

There is an urgent need to develop plans dealing in treatment of city effluents. Water treatment plants are the need of time to treat sewage and other city waste water before applying to crops. This treated water would serve two purposes: a) it would solve the waste water disposal problem in the large urban cities which is the most important issue for urban authorities b) on the other hand; it would reduce cost of production of the farmers because the farmers have to make less use of inorganic nutrients. The most important aspect of treated sewage water would be reduced health hazards.

In the era of World Trade Organization (WTO), our vegetable farmers using sewage water are not able to compete in the world market. Also consumers are more conscious about the health hazards. One way of reducing application of sewage water is to force the industrialists to set up their own treatment plants and those who are throwing untreated water in the sewage system be taxed or penalized. The amount collected from these penalties/taxes should be spent to treat sewage water and on the welfare of the local communities. Appropriate research studies are needed to suggest various alternative policies.

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