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Original Research

Pesticide Use and Impact Assessment of SKUAST-K Spray Schedule on the Socio-Economic Conditions of the People of Apple Growing Region of Jammu & Kashmir

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ABSTRACT

Pesticide use has changed considerably the overall scenario of horticulture over the past few decades throughout the world. It has revolutionised the gamut of horticulture in terms of quality and quantity of produce. Jammu and Kashmir the northern state of the Indian union produces high quality apple that are exported to every nook and corner of the country along with few international borders as well. Pesticide trade has shown a remarkable growth in the valley from past few decades. About 70-80 per cent of populace in the region is involved directly or indirectly with the apple trade be it apple production, transportation, marketing, cold-storage, box-making, packing material, labour and the dealers and sub-dealers of pesticides and fertilizers. The worse part of pesticide business in the region is that from past few years the sub-standard and spurious brands have taken over the market and has reduced production and quality of apple resulting the distress and poverty of apple growers in the region. The only Agricultural University; Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K) in the region has framed a spray schedule, but unfortunately, either due to ignorance or lack of extension services, the growers are not fully following the schedule, resulting in losses and huge financial expenses. In this backdrop, the present study was undertaken with an extensive survey of 600 apple growers from the valley comprising of 260 adopters of SKUAST-K spray schedule and 157 non-adopters of spray schedule. Propensity score matching model was employed to get accurate results. In addition, four matching methods were employed to get counterfactual/equally likely match of the adopter and non-adopters in distribution. Results of nearest neighbour method, kernal method, radius method and stratified method, respectively revealed that adopters of spray schedule are at saving side by saving Rs. 1.13/-, Rs. 33717.75/, Rs. 9773.69/- and Rs. 11952.90/- of money as compared to their controlled group.

Keywords: *Impact assessment, propensity score matching, spray schedule, counterfactual, financial gain.*

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INTRODUCTION

Apple (*Malus domestica* Borkh. Family: *Rosaceae*) is produced commercially in ninety-eight countries, among them China, USA, Turkey, Italy, Poland, India, France, Iran, Brazil, and Chile are the top ten apple producing countries (Satyagopal et al., 2014). Traditionally agriculture and horticulture are highly dependent on high level use of chemical inputs like fertilizers and pesticides. Everywhere in the world there is a huge concern among the people regarding the presence of pesticide residues in ecosystem and fruits especially apple (Aubertot et al., 2005). The challenge of pesticides residues is at higher side in case of fruits where pesticides application is done for control and curbing the attack of pests and other pathogens (Codron et al., 2003). Presently, high awareness and access to information regarding the presence of pesticide residues in fruits has changed the consumer choices, preferences and demand too resulting in the concept of organic cultivation of fruits and vegetables (Berrie and Cross, 2006).

Apple being a delicate and highly vulnerable to pests and other pathogenic attacks is mainly dependent on frequent use of pesticide applications throughout the growing season even up to the stage of harvesting and after harvesting even some sort of chemicals are applied for protection against postharvest losses from rats. Thus, need arises to analyse and study the alternative methods to reduce such huge dependence on these pesticides through the conception of innovative systems and/or orchard redesign (Brown and Mathews, 2005; Fernandez-Cornejo et al., 2014; Wilson and Daane, 2017). Due to advancement in

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agricultural research, alternatives to chemical control for the management of a single pest has been provided, but it still fails to address the design of overall sustainable strategies which can reduce pesticide use as well as economic loss to the growers (Simon e al., 2011). Due to excessive use of chemicals in apple production, an economic loss of € 549.71 per hectare was assessed in Turkey (Yilmaz et al., 2015). The cost-benefit analysis of pesticide use significantly differs between developed and developing countries. Developing countries use pesticides because they cannot afford any kind of famine or food security issue. Therefore, in such countries use of pesticides is considered a quick, easy, and inexpensive solution for controlling weeds and insect-pests. But due to over utilization of pesticides in developing countries, they are facing heavy economic losses in the form of human health and environmental vagaries (Akhtar and Isman, 2013). The developed countries like USA have witnessed, accrued and accounted huge economic losses like; public health $1.1 billion a year, pesticide resistance in pests $1.5 billion, crop losses caused by pesticides $1.4 billion, bird losses due to pesticides $2.2 billion, and groundwater contamination $2.0 billion (Pimentel, 2009). Keeping in view the importance, economic costs and use of pesticides for horticultural crop like apple in Kashmir, the present study undertook the impact analyses of ruthless use of pesticides and simultaneously not following scientific parameters in the region. This methodology has not been yet applied to the horticulture sector anywhere, we had made a novel attempt to analyse the pesticide use data.

RESEARCH METHODOLOGY

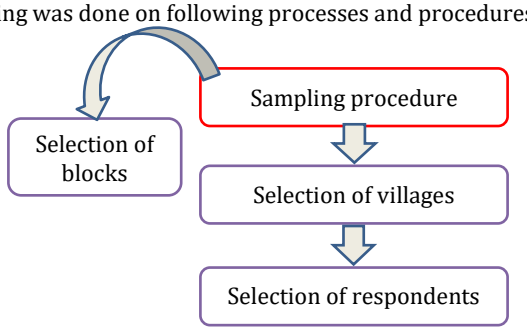
To accomplish the objectives of present study, the methodology adopted is broadly discussed as under.

Selection of the study area

Kashmir valley is having three different zones with different agro-ecological ecosystems. The present study was undertaken in the all three zones of the Kashmir valley viz, South Kashmir, Central Kashmir and North Kashmir, giving equal representation to all the agro-ecological ecosystems.

Sampling design

Commensurate with the objectives of the study, a multistage stratified cluster sampling technique was followed, and sampling was done on following processes and procedures.



Selection of blocks

In the first stage of sampling, two blocks from each of the three zones were demarcated for collection of data on apple crop. The blocks include Shadimarg and Zainpora from South Zone, Nagam and Harwan from the Central Zone and Zainageer and Rafiabad from the North Zone of the Kashmir valley. Selection of these blocks was made because of having more inclination of the farming community towards diversification of agriculture through apple cultivation and representing an aggregation of Kashmir valley that form extensive territorial zones characterized by dominance of common physical, economic and social peculiarities.

Selection of villages

In the second stage of sampling a cluster of 2 to 3 randomly selected villages was outlined from the selected blocks that fall within a radius of 5 to 10 kilometres from tehsil/block headquarters.

Selection of respondents

In the third stage of sampling, a complete list of respondents in selected villages was compiled along with their land holdings. Thereafter, 100 respondents were selected randomly from each of the sampled zones. Hence a total of almost 600 apple growers were selected randomly for the data collection.

Survey schedule and data collection

Survey schedule

In consonance with the objectives of study, a pre-tested interview schedule was prepared and served to all the stakeholders/respondents to collect relevant and requisite data from the selected functionaries related to various aspects of pesticide delivery systems in apple.

Plan of study

Present study was carried out in three phases as follows:

Phase I → Sampling and survey tools
Phase II → Data collection
Phase III → Tabulation and analysis

Data collection

After finalization of schedules, data collection from respondents was carried out by using survey schedules. Primary data from apple growers on different aspects of production, marketing and plant protection was collected.

Econometric Models

Propensity score matching (PSM)

Before delving into the explanation of PSM technique, it is required to understand the exact meaning of Propensity score, which is defined as the probability of treatment assignment conditional on observed baseline characteristics (Rosenbaum and Rubin, 1983). Thus, in a set of distribution, all those who have same p-score (propensity score), the distribution of

observed baseline covariates will be same between the treated and untreated respondents. Propensity score for i^{th} respondent may be symbolically represented as:

$$e_i = \Pr(Z_i = 1 \mid X_i)$$

Where Z_i is indicator variable for application or non-application of treatment (0 or 1, respectively). Propensity scores are generally estimated using a logistic regression model, which in this study, is Probit Regression.

PSM involves forming matched sets of treated and untreated respondents who possess a similar value of the Propensity score. PSM implemented here is a stratification approach, which involves stratifying respondents into mutually exclusive subsets based on their estimated Propensity score. In this study, the respondents were classified into five subsets using quintiles of Propensity score, which eliminates about 90 per cent of the bias du to measured confounders while estimating a linear treatment effect. Within each Propensity score stratum, treated and untreated subjects had roughly similar values of the Propensity score. There were two pre condition for PSM; (1) being independence of the treatment assignment on potential outcomes conditional on the observed baseline covariates, and (2) being the non-zero probability of each respondent to receive either of the two treatments, in this case, adoption of SKUAST-K spray schedule and its non-adoption. If the conditions are satisfied, the Average Impact of the Treatment on Treated (ATT) can be estimated, which is defined as the average effect of treatment on those respondents who ultimately received the treatment. ATT could be represented as:

$$ATT = E\ (Y_1 - Y_0 \mid Z=1)$$

In this study, ATT was estimated using four algorithms, namely Nearest Neighbour Matching (NNM), Kernel Matching, Stratified Matching and Radius Matching. NNM matches each adopter with the non-adopter having the closest Propensity score within the neighbourhood, whereas, Kernel Matching uses a weighted average of all farmers in the adopter group to construct a counterfactual. A major advantage of Kernel Matching is that it produces ATT effects with smaller lower variance, as it utilizes greater information than the NNM. Similarly, Stratified and Radius Matching methods match an adopter with a non-adopter within specified strata and within a specified radius to find equally likely counterfactual.

RESULTS AND DISCUSSION

Cost analysis of essential sprays

Table 1 presents a comparative structure of the essential sprays and their cost analysis from the farmer's orchards during the year 2019-20. From the information and data collected from the field, the average cost on essential pesticides comes out to be Rs. 71,283/-, while on the same field if SKUAST-K spray schedule is followed, the average cost on essential pesticides comes out to be Rs. 31, 717/- that means there is a net difference of Rs. 39.566/-. Keeping the scenario in view, the Propensity score technique with different matching methods was used to scientifically prove this hypothesis.

Table 1: A comparative structure of the essential sprays and their cost analysis in Kashmir valley.

Particulars	Amount (Rs./ha)
Average cost on pesticides at ground level (essential sprays)	71,283
Average cost on pesticides as per SKUAST-K spray schedule (essential sprays)	31,717
Savings	39,566

Table 2: Frequency of the adopters and non-adopters of SKUAST-K spray schedule in the distribution.

Treatment	Frequency	Percent	Cumulative
0	340	56.67	56.67
1	260	43.33	100.00
Total	600	100.00	

Table 3: The inferior bound, the number of treated and the number of controls for each block.

Range of Propensity score	Treatment		Total
	0	1	
.2	175	88	263
.4	148	138	286
.6	17	33	50
.8	0	1	1
Total	340	260	600

Propensity score of adopters and non-adopters of SKUAST-K spray schedule

Table 2 shows frequency of the adopters and non-adopters of SKUAST-K spray schedule. There were 340 non-treated (non-adopters of SKUAST-K spray schedule) observations with a percentage of 56.67 and 260 treated (adopters of SKUAST-K spray schedule) with a percentage of 43.33.

The study was carried out in the district Pulwama with 260 adopters and 340 non-adopters of SKUAST-K spray schedule. The Propensity score of the adopters in the distribution is given in table 3. The range of propensity for the number of adopters and non-adopters varied from .2 to .8. The highest number of both non-adopters and adopters fell in the propensity range of .2 and .4, while the lowest number fell in the propensity range of .6 and .8.

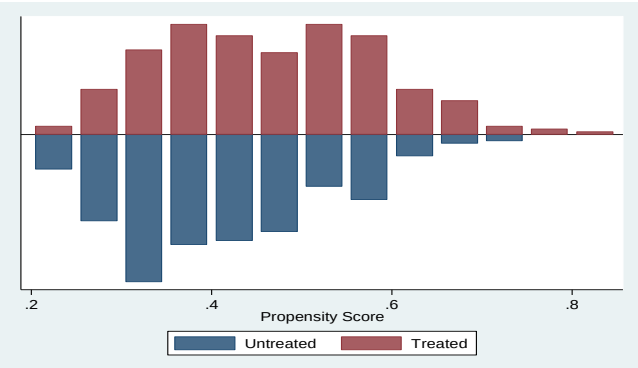


Figure 1: Propensity score matching of the adopters and non-adopters of the SKUAST-K spray schedule.

Table 4: Matching methods and the estimated value of the Propensity score.

Matching Method	Replications	No. of treatments	No. of controls	Bias	Observed value	ATT	Standard error	t-value	95% Confidence interval	
Nearest neighbour matching method	100	260	157	-41560.45	112891.3	27352.13	69513.499	1.624	-25038.53 81713.19 18502.02	250821.2 (N) 192694.7 (P) 249141.2 (BC)
Kernel matching method	100	260	340	1580.976	33717.75	33717.751	52638.35	0.641	-70728.16 -78148.71 -78148.71	138163.7 (N) 142319 (P) 142319 (BC)
Radius matching method	100	260	340	-643.9126	9773.691	9773.692	54087.969	0.181	-105154.7 -92855.27 -91921.44	124702 (N) 137085.9 (P) 150353 (BC)
Stratification matching method	100	259	341	10743.91	11952.9	11952.901	56621.36	0.217	-100396.2 -101799.8 -107379.2	124302 (N) 135938.5 (P) 121039.4 (BC)

N, normal; P, percentile; BC, bias-corrected.

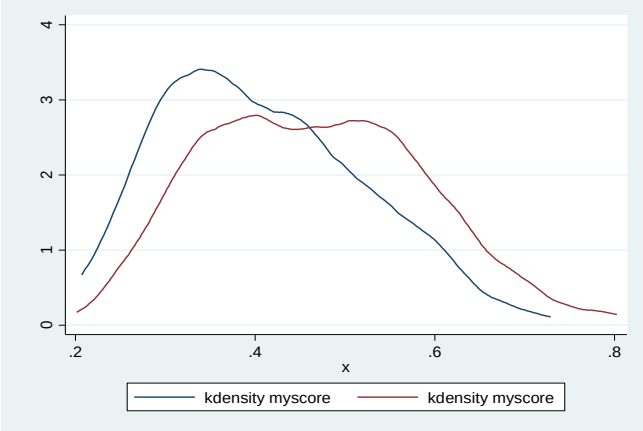


Figure 2: Kernel density of adopters and non-adopters of SKUAST-K spray schedule.

Table 4 shows the total number of adopters and non-adopters of SKUAST-K spray schedule in the whole distribution. From the table it can be concluded that total number of adopters were 260 and non-adopters were 157. The calculated average treatment effect on the treated (ATT) comes out to be 1.13 with a standard error of 75391 and t-value of 1.497.

Table 4 also shows the average treatment effect on treated (ATT) calculated from different matching methods employed to the set of observations. The ATT estimated from nearest neighbour matching method by using 100 replications to the data set comes out to be Rs. 27352.13/- with a bias of -41560.45 and standard error of 69513.499 at 5% level of significance. Similarly, the ATT estimated through kernel matching method, radius matching method and stratification matching method by using 100 replications each comes to the tune of Rs. 33717.751/-, Rs. 9773.692/-, Rs. 11952.901/- with a bias of 1580.976, -643.9126, 10743.91 and a standard error of 52638.35, 54087.969, 56621.36 at 5% level of significance, respectively meaning thereby that adopters of the SKUAST-K spray schedule are benefiting in terms of extra savings.

Propensity score graph (Ps-graph)

The propensity score matching graph is utilized to show the number of adopters and non-adopters who got support and who do not find their support in the distribution. Ps graph shows the adopters in brown on top and the non-adopters in blue on bottom. Figure 1 looks promising, because, almost all the beneficiaries and non-beneficiaries have propensity score ranging from 0.2 to 0.6 and there seems to be less cases having propensity score greater than 0.6 and, similarly, some of the cases are there which does not find any support in the distribution and likewise some cases are there in the treated which not at all have any support in the non-treated group.

Kernel density

Estimating the density with a histogram is easy but it is not smooth enough to get a good enough of a picture of the distribution. In order to get a smoother picture kernel density method is employed. In kernel density the data are divided into

non-overlapping intervals, and counts area made of the number of data points within each interval. To be specific in kernel density, the range is still divided into intervals, and estimates of the density at the centre of intervals are produced. From figure 2, it can be seen that the density ranged from 0 to 4 as shown along the Y-axis and the scale of propensity is shown along X-axis. Area under brown line (non-adopters) whose propensity ranges from 0.2 to 0.8 and the majority of the adopters (blue line) also fell in 0.2 to 0.7 range, that means almost 70 to 80 per cent of the adopters fell within the range and found their common support in the data set and few of the observations were there which did not find their support in the distribution.

CONCLUSION

Apple cultivation being one of the livelihood providing sectors in the region of Jammu and Kashmir, provides employment to 70-80 per cent of the population be it processing, marketing or sale or distribution of pesticides or fertilizers. There are scores of dealers and sub-dealers of the pesticides outlets present in the region and the availability of pesticide had become most easy and accessible to apple growers. This study concluded that the adopters of the SKUAST-K spray schedule were able to save Rs. 27352.13/-, Rs. 33717.75/, Rs. 9773.69/- and Rs. 11952.90/- of money than non-adopters in three selected zones of Kashmir valley, respectively. Therefore, by adopting the recommended SKUAST-K spray schedule the socio-economic condition of apple growers can be improved by saving thousands of rupees which could be utilized for other necessary requirements.

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