Economics of Pesticide Use in the Apple producing areas of Kashmir Valley

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ABSTRACT

A Study on ''Assessment of farmers' knowledge and awareness regarding pest control technologies in the apple growing belts of Kashmir valley" was carried out in the three zones of the Kashmir valley during 2017-18. Apple being main horticultural crop has predominant position in area, production and productivity. The primary data was analyzed to interpret the results for this study. The data was collected extensively from six blocks of the Kashmir Valley, two each from North, South and the Central Zone by using multi-stage stratified sampling technique and the secondary data was also collected from various published/unpublished records The study has pointed out to the need for a detailed look on the pesticide-use pattern, distribution systems, regulatory mechanism and farmers perception about pesticide use at a micro level. The results of the study revealed that expenditure incurred on pesticides is quite high in apple. Besides that, not only the intensity of pesticide use but also the high risk pesticides are being used in crop production in the study area. The study indicated that the farmers apply pesticides indiscriminately in violation of the scientific recommendations. About one-third of the pesticides available in the market are reported to be either sub-standard or spurious. The existence of unlicensed dealers/ traders has further accentuated the magnitude of malpractices in the pesticide delivery system. The results of the study further indicated that farmers had limited knowledge of pest management as well as the consequences of pesticide use. Almost all the apple-growing farmers (95 per cent) were of the opinion that there was heavy severity of disease in the study area. The expenditure on fertilizers and manures, average price of pesticide and pest intensity has significantly influenced the pesticide use in apple. High pesticide use was observed and most of the pesticides belong to high and moderate risk chemicals. The determinants of apple yield revealed that the estimated coefficients for fertilizer expenditure, area under the crop and expenditure on pesticides were found to be positive and significant. Farmers are willing to pay average price premium up to 15 per cent for environmentally safer formulations of pesticides. This confirms that a market exists for safer or environment friendly pesticides in the study area. Increasing farmers' awareness of pesticide hazards, proper regulation of pesticides and promotion of spray schedule adoption is essential for reducing adverse economic and environmental implications. The study has put forth a few policy suggestions for encouraging scientific application of pesticides and reducing the negative externalities arising from pesticide-use.

Key words: *Pesticides, negative externalities, spurious/sub-standard pesticides, apple, Kashmir.*

INTRODUCTION

With the growing population, the demand for food is increasing. Food crops have to compete with various species of weeds, insects and nematodes which destroy every year about 20 to 40 per cent of these crops. Pesticides coupled with other modern inputs undoubtedly have enabled the country to achieve unparalleled increase in agricultural productivity over the last five decades and thus enabled to achieve food security. However, evidences indicate that in India, pests cause crop loss of more than Rs. 6000 crores annually, of which 46 per cent is due to insects and diseases, 33 per cent is due to weeds, 10 per cent by birds and rodents and the remaining (11 per cent) is due to other factors (Rajendran, 2003). The major objective of most agricultural development programmes targets the increase in productivity. The major inputs which facilitate production and productivity are high response varieties, hybrids, fertilizers etc. However, the technologies are usually associated with the high incidences of pests and diseases. Plant protectants play a vital role in smart agriculture which includes fast growing horticulture sector (Uday

Kumar, 2009).

India is the largest producer of pesticides in Asia and in usage it ranks 12th in the world. Majority of population in India is engaged in agriculture and therefore gets exposed to the pesticide use. The pesticide consumption has not been uniform in the country, and it varies with the intensity of pests and diseases, cropping pattern and agro-ecological regions with good irrigational facilities and in areas where commercial crops are grown. Although average consumption of pesticides is far lower than many other developed economies, but the problem of pesticide residues turned very high and has also affected the export of agricultural commodities in the last few years (Abhilash and Nandita Singh 2009). After Japan, India is presently the largest manufacturer of basic pesticides among the South Asian and African countries; however, it is the fourth largest producer of crop protection chemicals, after United States, Japan and China. The Indian pesticides market worth of US$0.6 billion turned 12th largest in the world (Hundal *et al*, 2006).

Pesticide application has been an essential ally in the farmers' struggle to protect crops. Despite their higher use, losses throughout the production system remain high owing to various negative externalities like rejection of agricultural export due to the presence of high pesticide residues, pesticide-related health hazards (WHO, 1990, WRI, 1998) and the extent, severity and frequency of associated environmental problems. In 2012, the total consumption of technical grade pesticides by weight was estimated at 1789 metric tonnes (Anonymous, 2015) in which shares of companies by status vary significantly. Pesticide market of the state in terms of value was estimated around ` 400 million and the calculated shares of the MNCs and NCs were 33.6 per cent and 52.3 per cent, respectively. Fungicides alone accounted for 71.1 per cent of total pesticide sale in the state followed by insecticides (15.4%) and acaricides (7.7%). The pesticides applied on apple together constituted about 83 per cent of total value of agro-chemicals utilized in the state (Baba et al., 2012). Pesticides coupled with other input technologies have enabled the farmers to enhance the apple productivity in J&K during the last three decades. However, excessive/indiscriminate uses of pesticides not only increase the cost of apple cultivation but, also resulted in many human health problems and environmental contaminations.

During the past two decades, there has been a substantial increase in the use of pesticides in terms both of volume and value. The demand for agrochemicals depends upon the type of crops grown, farmers' knowledge about technologies and their profitability and also upon the availability, affordability and ease in accessing the input and output markets. Among different crops grown in Jammu & Kashmir, apple cultivation is highly capital-intensive, the maintenance cost of bearing orchards was found to be Rs. 277803 per hectare in case of non-adopters and Rs. 242117 per hectare for adopters, of which the total variable costs constitute the maximum chunk of 78.57 per cent and 83.88 per cent for non-adopters and adopters respectively. Similarly the fixed costs constitute about 18.13 per cent and 17.41 per cent of the total costs for non-adopters and adopters respectively. Another feature of the cost structure was that the maximum expenditure was incurred on pesticides in case of non-adopters i.e. 25.03 per cent, however, in case of adopters expenditure on fertilizers and manures was the highest constituting 22.43 per cent of the total costs followed by expenditure on pesticides (12.15%). The steady increase in apple productivity in the valley during the past three decades was, by and large, achieved by increasing the use of fertilizers and pesticides. In the apple-growing belt of the valley, chemicals are being used indiscriminately without considering scientific recommendations. There are many activities in apple cultivation that require huge investment, in which pesticides alone comprises a huge share. Costs incurred by the farmer on part of pesticides come under category of variable costs and it can vary from 30 to 60 per cent depending on orchard condition. Generally, around 7 fungicides, 2 insecticides, 1 acaricide and 1 HMO is recommended in J&K in apple and it can go up to 9 fungicides, 7 insecticides, 6 acaricides and 2 HMO's in extreme conditions of disease and pest incidence, thereby, increasing cost of production to huge extend. In this backdrop, this paper has overviewed the pesticide business status in the apple-growing belt of Kashmir valley and the extent of sub standard chemicals. Therefore, it is very much relevant to document a large number of empirical evidences regarding farmer's level, pattern and impact of pesticide use in apple as well as examining the economic and environmental impact of pesticide use. So that it would be useful to policy makers and researchers in understanding the gravity of problems and framing suitable policy options.

MATERIAL AND METHODS

The study envisaged the primary data pertaining to different facets associated with economics in apple in the Kashmir valley. The data was collected extensively from six blocks of the Kashmir Valley, two each from North, South and the Central Zone by using multi-stage stratified sampling technique. The nature and sources of data required for the analysis comprised the statistical and econometric techniques. Various economic aspects of pesticide usage were considered. Various inputs used in production of apple and their relative shares along with the major cost components were worked out. The tabular presentation was used to assess the cost, gross returns and net returns from apple. The various cost concepts were used for arriving at standard results.

1. Cost concepts

Cost A : It includes expenses on planting material, manures and fertilizers, plant protection chemicals ; irrigation charges ; miscellaneous expenses and interest on working capital

Cost B : Cost A plus interest on fixed capital
Cost C : Cost B plus imputed value of family labour

Return concepts

Farm business income = Gross income – Cost A

Family labour income = Gross income – Cost B

Net income over Cost C = Gross income - Cost C

2. Economic benefits of spray schedule in apple

Farm level economic impact of pesticides was ascertained by comparing some parameters like pesticides use as per spray schedule, reduction in quantity as well as expenditure of pesticide use, unit cost of production, changes in net returns etc. Partial budget was prepared to assess the economic impact of pesticides for the apple crop. The change in net revenue was calculated as:

$$\Delta R = R_A - R_{NA}$$

Where,

R_A = per hectare net revenue of selected crop on spray schedule adopters.

R_{NA} = per hectare net revenue of selected crop on spray schedule non-adopters.

3. Production function analysis

The production function is the mathematical relationship providing the information concerning the variation in the kind and the amount of product that may be expected when certain quantity and quality of inputs are used in the production process. The production function estimates to determine the effect of major inputs on Gross returns in apple were estimated using the function:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \varepsilon_i$$

Where,

Y = Gross return of apple (Rs/ha)

X1 = Farm area (ha)

X2 = Number of sprays

X3 =Expenditure on fertilizers & manures (Rs/ha)

X4 =Expenditure on human labour (Rs/ha)

X5 =Expenditure incurred on HMO at farm level (Rs./ha)

X6 = Expenditure incurred on fungicide at farm level (Rs./ha)

X7 = Expenditure incurred on insecticide/ acaricide at farm level (Rs./ha)

B_o = Constant

B_i= Regression coefficients

e_i = Random distribution term

RESULTS AND DISCUSSION

1. Socio-economic characteristics of selected apple growers

Efficiency of farming is influenced more or less by the resource availability at the command of an individual farmer and socio-economic overheads. Formulation of various developmental programmes and their implementation necessitate a critical examination of the existing resource endowments at farm level. The socio-economic characteristics of sample households have immense influence on the decision making process and profitability of apple enterprise. An effort has been made to compare and contrast the resource endowments of apple producers in the zones under following sub-sections.

i. Average family structure of the sample respondents

The economic growth and employment generation depends on the availability of labour force in the family, which ultimately depends upon family size. The type and size of the family, work force and literacy among the apple growers are the important factors influencing the apple crop enterprise, which happens to be family labour based occupation at the village level. These factors determine the socio-economic well-being of the family in particular and the area under consideration at large. It plays a vital role in farm business and marketing activities. Information on family profile was collected from the sample households in the study area and the results are presented in Table 1. The overall average family size was 6.76 persons consisting of about 3.52 males and 3.24 females. The average family size varies across the zones of the Valley and was found to be highest 7.30 persons in case of sample respondents from the south zone as compared to 6.92 persons and 5.93 persons in North and Central zones respectively. On an average it was observed that there were 920 females for every 1000 males and were in close proximity to the figures obtained in the human census of 2011.

Table 1: Average family structure of the sample respondents (Number/family)

Particulars	North zone	South zone	Central Zone	Average
No. of sample respondents	70	70	60	200
Males	3.68	3.72	3.09	3.52
Females	3.24	3.58	2.84	3.24
Total per family	6.92	7.30	5.93	6.76
Sex Ratio	**880**	**962**	**919**	**920**

Source: Field survey, 2017 & 2018

ii. Educational Indicators

Literacy level plays a catalytic role in the scientific management of farming and more so in case of new technology adoption. Education plays a vital role in the betterment of socio-economic conditions and provides healthy as well as clear environment for a good standard of living through a developmental change in social and cultural life of the people, living both in plains and hilly regions. The educational status of farm families is an indicator of human capital formation and economic status. An educated head of household is an important indicator to influence decision making process in managing his livelihood sources efficiently and effectively. Better formal education helps the farmer in improving his/her ability to know modern science and technology and in utilizing them for betterment of living. Education also helps in adopting better cultivation practices of the crops as well appropriate technologies. Keeping this point in view the respondents were categorized into four categories viz. illiterate, primary/middle education, high school education and college education. The distribution of sample households according to the education of the head of the family is shown in Table 2. On an average 40.81 per cent heads of respondents were having primary/middle level education. The persons having high school education and graduation and above qualification, comprised of 21.54 and 7.33 per cent respectively. The analysis among the zones

revealed that incidence of illiteracy was on higher side in the South zone (31.80%) than the North and the Central Zones of the valley. With an average of 30.32 per cent, illiteracy was more pronounced in the sample respondents in all the zones.

Table 2: Distribution of head of household according to educational status (in per cent)

Educational status	North zone (n= 70)	South zone (n=70)	Central Zone (n=60)	Average
Illiterate	29.80	31.80	29.00	30.32
Primary/Middle	38.50	42.40	41.80	40.81
High school	25.30	17.80	21.50	21.54
Graduate and above	6.40	8.00	7.70	7.33
Total	**100.00**	**100.00**	**100.00**	**100.00**

Source: Field survey, 2017 & 2018

iii. Occupational distribution

Occupational distribution of the head and other members of the family is very important in determining the economic status of the family. It is assumed that more developed is the area, the more diversified the employment pattern and same would result in increased income to the household. Across all the surveyed zones, the main livelihood activities were agriculture with about 67.56 per cent of working force (Table 3). Although, not significant, there is general tendency for the relative importance of agriculture as the subsidiary activity. Other occupations i.e. labour; business etc. could not find a significant place as an occupational source in the sampled zones. On an average, labour, business and service contributed 17.77, 15.80 and 9.02 per cent respectively. To sum up one may conclude that wage labour is more prominent among North and South zone farmers, while business was more predominant among Central zone farmers. Only 9.07 per cent farmers on an average were seen engaged in professional jobs or services and their incidence was more prominent in the North zone of the valley.

Table 3: Occupational pattern of the respondents (per cent of households)

Occupation	North zone (n= 70)	South zone (n=70)	Central Zone (n=60)	Average
Farming	52.20	57.70	51.00	53.89
Service	10.40	7.30	9.50	9.02
Labour	18.66	16.58	18.19	17.77
Business	14.94	14.22	19.11	15.80
Others	3.80	4.20	2.20	3.52
Total	**100.00**	**100.00**	**100.00**	**100.00**

Source: Field survey, 2017 & 2018

***iv.* Land resources and utilization pattern**

a. Categorization of sample households on the basis of land holdings

An insight into the land utilization pattern is pertinent to frame developmental strategies and future policies. Land holdings are important for raising crops increasing agriculture growth, ensuring food security and livelihood. It may be noted that Indian agriculture is the home of small and marginal farmers. Therefore, the future of sustainable agricultural growth and food security depends on the performance of small and marginal farmers. As per the field survey in the study area, the households were seen possessing

land holding ranging from 0.1 to more than 2 hectares. It was seen that 45.90 per cent farmers belonged to small farm category, 52.09 per cent marginal farm category and rest 2.01 per cent belonged to large farm category. However, it was observed that the majority of households belonged to small farm category (83.33%) in Central zone as compared to the other two zones. This can be attributed to the fact that this zone has more area under the vegetable cultivation, that requires less area to bring under cultivation than is required for the cultivation of fruit crops in general and apple in particular, that is dominated in North and South zones of the valley (Table 4). The dominance of small/marginal farm category in the study area emphasized upon their development.

Table 4: Categorization of sample farm households in different zones of the Valley (%)

S.No	Farm category	North zone (n= 70)	South zone (n=70)	Central Zone (n=60)	Average
1	Small (0-1ha)	37.14	27.14	83.33	45.90
2	Medium(1-2ha)	61.43	70.00	15.00	52.09
3	Large(>2ha)	1.43	2.86	1.67	2.01
	Total	**100.00**	**100.00**	**100.00**	**100.00**

Source: Field survey, 2017 & 2018

b. Average land holding

Land is the main resource base of farmers in the production process. The economic and social progress of the farmers in India largely depends on the size of operational holding (Dhaka *et al.,* 1998). The small size of holdings is one of the principle causes of inefficiency of our agriculture with perceptible tendency towards a continuous decrease in size due to rapid population growth. Land distribution pattern among landholders was highly skewed with high proportion of smallholders. The average holding size is so low in the state that if scientific farm practices/diversification not followed livelihood asset is not economically viable (Wani *et al.,* 2004).

Table 5: Average land holding (ha/household)

Particulars	North zone (n= 70)	South zone (n=70)	Central Zone (n=60)	Average
Land under field crops	0.51	0.59	0.47	0.53
Orchard land	1.36	1.01	0.54	0.99
Operational land	**1.87**	**1.60**	**1.01**	**1.52**
Land put to other uses	0.06	0.05	0.13	0.08
Total	**1.93**	**1.65**	**1.14**	**1.60**

Source: Field survey, 2017 & 2018

The data presented in the Table 5 revealed that the operational area in case of sample households was relatively maximum at North and South zone i.e. 1.87 and 1.60 hectares respectively, because of more farm diversification towards apple cultivation as compared to the Central zone (1.01 hectares) On the average, of the total land holding, orchards occupied nearly 0.99 hectare area, followed by land under field crops (0.53 ha). The average area occupied by the fallow land and other land uses comprised of 0.08 hectares.

c. Cropping pattern and intensity

Agriculture in the state is characterized by subsistence farming a prominent feature of hill agriculture. The cropping pattern shows the spatial distribution of different crops with respect to area at a

particular point of time and thus, indicates the relative importance of each crop in the total cropped area. Allocation of area under crops depends mainly on physical and environmental factors like the type of soil, climate, etc. It is also governed by the economic factors such as prices of the outputs, income, cost of inputs, farm size, availability of inputs, marketing outlet, etc. The spatial allocation of area under different crops grown in the study area has been given in Table 6. Overall apple farming dominates the whole cropping scenario, occupying on an average more than 0.99 hectares per farm. Paddy and vegetable crops were found to be most important kharif crops in the zone. These field crops were grown by orchardists to meet their domestic demand. The cropping intensity was higher (194 %) in the Central zone than the North and South zones of the valley (114% and 139% respectively), with an overall average of 147 per cent. Low cropping intensity in the North and South zones could be attributed due to perennial crops dominating the production system. Though Kashmir division of J&K state falls under temperate zone as such the state has by and large a mono-cropping system. However, all the respondents cultivate vegetables both in kharif and rabi seasons as such the cropping intensity was more in the vegetable growing areas in the Central Kashmir.

Table 6: Cropping pattern and intensity (ha/household)

Particulars	**North zone (n= 70)**	**South zone (n=70)**	**Central Zone (n=60)**	**Average**
Rice	0.51	0.59	0.47	0.53
Fruit crops	1.36	1.01	0.54	0.99
Oilseeds	0.03	0.42	0.17	0.21
Vegetables	0.21	0.19	0.75	0.37
Others	0.04	0.02	0.03	0.03
Gross cropped area (GCA)	2.15	2.23	1.96	2.12
Operational holding	1.87	1.60	1.01	1.52
Cropping intensity (%)	**114**	**139**	**194**	**147**

Source: Field survey, 2017 & 2018

2. Average number of pesticide application in apple

Since apple constitutes more than 85 per cent of area under all fruits in the valley, it receives considerably high quantity of pesticides. The scientific spray schedule, developed by SKUAST-Kashmir in collaboration with concerned Development Department of Government of Jammu & Kashmir, for apple recommends only 6 essential fungicides to be sprayed at various stages of fruit development. Contrary to this, farmers had adopted diverse spraying system and the majority of them had sprayed their crops 9 times in all the three zones of the valley. However, in the North and Central zones, 21.43 and 23.33 per cent of farmers respectively had even treated apple crop with more than 10 sprays (Table 7). Whereas, in comparison, 21.43 per cent farmers from South zone of the valley had sprayed their crop 8 times in a season. This difference in the number of sprays between the zones could be attributed to the adverse weather conditions that prevail in these two zones as compared to the South zone which often witnesses moderately favourable weather conditions, hence resulting in the good quality apple fruit with less disease infestations. Further, pesticides were applied on apple without the consideration of stages of fruit development and even a good proportion of farmers were found repeating same chemicals up to 3 or 4 sprays.

Table 7: Average number of pesticides application by the farmers

Sprays	**Farmers responded (per cent)**			
	North zone	**South zone**	**Central Zone**	**Average**
Upto 5	0.00	4.29	3.33	2.46
6	4.29	11.43	5.00	7.09
7	7.14	14.29	13.33	11.42

8	18.57	21.43	16.67	19.10
9	31.43	30.00	25.00	29.18
10	17.14	11.43	13.33	14.03
>10	21.43	7.14	23.33	16.72
Total	**100.00**	**100.00**	**100.00**	**100.00**

Source: Field survey, 2017 & 2018

3. Economics of pesticide use in apple cultivation

The continuance of production of any crop depends on its costs and returns. The profitability realized by the crop production motivates farmers to enhance production. In this connection, the economics of production as well as pesticide use in the study area was examined.

a. Major cost components in apple cultivation (bearing age orchards)

The cost of cultivation is of wide interest to the users of cost data and assumes importance in the area of planning. The utility of data on the cost of cultivation of horticultural commodities for planning assumes importance as it guides the planners about the area where it is economical to produce and the regions which would accordingly be most suitable for the development of industries based on the horticultural raw material. At the micro level, it enables the farm management experts to study the efficiency of the various cultivation practices and alter the crop planning by providing information regarding their profitability. This helps the experts to make practical recommendations for farm planning aimed at better allocation of existing resources and introduction of improved agronomic practices which would increase the efficiency of apple production. Cost structure, output and return from apple crop grown in the study area has been discussed under cost of maintaining the orchard and its expenditure incurred during the bearing stage. For estimating the costs and returns for apple crop, it has been assumed that (i) first bearing starts from 8^{th} year (ii) the major operations and input requirement vary in 8-15, 16-20, and above 20 years. The above mentioned groups are based on the physiological growth and productivity pattern of the plant. In order to have a comparison of spray schedule adopters and non-adopters in apple, the input costs were derived for both the categories of farmers. Maintenance cost of bearing orchards for the spray schedule adopters and non-adopters in the study area are presented in Table 8. This included input on labour, fertilizers and pesticides, inter cultural practices, interest on working and fixed capital, land revenue and taxes and depreciation on buildings, machinery and implements. The maintenance cost of bearing orchards was found to be Rs. 277803 per hectare in case of non-adopters and Rs. 242117 per hectare for adopters, of which the total variable costs constitute the maximum chunk of 78.57 per cent and 83.88 per cent for non-adopters and adopters respectively. Similarly the fixed costs constitute about 18.13 per cent and 17.41 per cent of the total costs for non-adopters and adopters respectively. Another feature of the cost structure was that the maximum expenditure was incurred on pesticides in case of non-adopters i.e. 25.03 per cent, however, in case of adopters expenditure on fertilizers and manures was the highest constituting 22.43 per cent of the total costs followed by expenditure on pesticides (12.15%).

Table 8: Maintenance cost of bearing age apple orchards (Rs. / ha)

Cost items	**Cost of spray schedule non-adopters**	**Cost of spray schedule adopters**
A. Variable cost		
Pruning and training	20765(7.47)	25000 (10.33)
Hoeing	8067(2.90)	7500 (3.10)
Weeding	11595(4.17)	10000(4.13)
Fertilizer & Manure	33587(12.09)	54310 (22.43)
Plant Protection Chemicals	69543(25.03)	29418(12.15)
Supporting Poles	17498(6.30)	20000(8.26)
Labour and energy component for sprays	27314(9.83)	25000(10.33)

Watch and ward	12953(4.66)	15000(6.20)
Miscellaneous Cost	2392(0.86)	3300(1.36)
Interest on working capital	14566(5.24)	13551(5.60)
Total variable cost	**218280(78.57)**	**203079(83.88)**
B. Fixed cost		
Depreciation on machinery, buildings and implements	25000(9.00)	18500(7.64)
Rental value of owned land	22000(7.92)	22000(9.09)
Interest on fixed capital	3361(1.21)	1650(0.68)
Total fixed cost	**50361(18.13)**	**42150(17.41)**
C. Prorated establishment cost	9163(3.30)	10500(4.34)
Total maintenance cost	**277803(100.00)**	**242117(100.00)**

Source: Field survey, 2017 & 2018 **Figures in parentheses are percentages*

Labour was also the most expensive component in both the cases. No expenditure was incurred on the land revenue and taxes, as there is no taxation in case of un-irrigated lands now. The inputs bore a direct relationship with the age of orchard. With the advancement in age of the orchard the quality and quantity of fruits produced is considerably reduced, lowering the overall returns from the orchards, thus, discouraging the use of inputs like fertilizers, pesticides, etc. Among the fixed costs, depreciation (9%) and rental value of land (7.92%) accounted for maximum chunk of the total costs in case on non-adopters, however, in case of adopters rental value of land constituted a maximum of 9.09 per cent and depreciation about 7.64 per cent of the total costs.

b. Intensity and composition of pesticide use in apple cultivation

The survey results from the farmers across various zones of the valley during the year 2017-18 revealed average cost on pesticides to the tune of Rs. 69,543 per hectare (Table 9). Highest cost of Rs 8,750 was incurred at delayed dormancy on HMO spray followed by Rs 8,689 at Fruit development-I stage on fungicide and insecticide spray. There exists huge gap with respect to appropriate use of plant pesticides, technical know-how of pesticide formulations, appropriate time of spray, frequency and quantum of pesticide sprays, compatibility of various chemicals; besides lack of knowledge regarding different brands/trade names viz a viz quality, knowledge and adaptation rate of SKUAST-K spray schedule and externalities of pesticides. However, application of pesticides as per scientific recommendations and procedures could reduce cost of this input significantly.

Table 9: Pesticide use in apple cultivation for non-adopters (Rs/ha)

S. No.	Stage	Fungicide *Insecticide/Acaricide*	Quantity	Unit cost (Rs/kg/lt)	Total cost (INR)
1	Delayed Dormancy	Mak All Season HMO	70 Lt	125/Lt	8750
2	Green Tip	Dithane M-45	13.65 Kg	403/Kg	5501
3	Pink Bud	Superstar *Rogor*	2.45 Kg 3.85 Lt	2030/Kg 463/Lt	4974 1783
4	Petal Fall	Score *Rogor*	1.4 Lt 3.62 Lt	3900/Lt 463/Lt	5460 1676
5	Fruitlet (Pea Size)	Dithane M-45 *Coroban*	11.45 Kg 3.89 Lt	403/Kg 330/Kg	4614 1284
6	Fruit Development-I	Ergon *Coroban*	1.58 Lt 3.85 Lt	4695/Lt 330/Lt	7418 1271

7	Fruit Development-II	Rely *Magister*	2.10 kg 1.75 Lt	1056/Kg 2280/Kg	2218 3990
8	Fruit Development-III	Dithane M-45 *Rogor*	11.75 Kg 3.5 Lt	403/Kg 463/Lt	4735 1621
9	Fruit Development-IV	Cabriotop	3.85 Kg	2033/Kg	7827
10	Pre-Harvest	Zed-78	8.75 Kg	530/Kg	4638
11	Post-Harvest	*Rogor*	3.85 Lt	463/Lt	1783
Total					**69543**

Source: Field survey, 2017 & 2018

Similarly cost of Rs 7,827 of fungicide spray (Cabriotop) was incurred on Fruit development-IV stage, followed by costs on Petal fall stage (Rs. 7,136), Pink bud stage (Rs. 6,757), Fruit development-III (Rs. 6,356), Fruit development-II (Rs. 6,208) on fungicide and insecticide sprays. Pesticide cost can be reduced hugely by following proper dosage, proper quantum of spray per plant and least cost of chemicals available in the market. There are large numbers of plant protection chemicals in various markets of J&K with different trade names. On the basis of availability of various agro-chemicals in market, least cost combination can be estimated with great ease knowing the market rates of various plant protection chemicals. As per the spray schedule issued by Department of Horticulture and SKUAST-K, a minimum of 7 fungicides, 2 insecticides, 1 acaricide and 1 HMO is recommended for apple and these figures can go up to 9 fungicides, 7 insecticides, 6 acaricides and 2 HMO's depending on disease and pest incidence.

c. Economic benefits of spray schedule adoption

The comparative economics of apple by spray schedule adopters and non-adopters is presented in Table 10. The results show that costs of production was not much different between the adopters and non-adopters. The returns from the bearing orchards were calculated on per hectare basis so as to present the actual picture of the economics of orchards raising in apple. The results revealed that the orchards exhibited the gross returns of Rs. 708750 and the net returns of Rs. 430947 for the non-adopters. However in case of adopters these returns amounted to Rs. 830970 and Rs. 588853 respectively. The average production per hectare for non-adopters was found to 1875 boxes of apple, where one box contains 18 kg of fruit, and the cost per box was found at an average of Rs. 375. However, in case of adopters these returns are comparatively higher that may be on account of better and timely management decisions followed by the spray schedule adopters that minimize the cost of production and enhance the quality of the produce, thereby increasing the overall returns in the crop.

Table 10: Comparative Economics of apple on spray schedule non-adopted and adopted farms (Rs/ha)

Particulars	**Cost of spray schedule non-adopters**	**Cost of spray schedule adopters**
Total production cost (Rs.)	277803	242117
Average production (kg)	33750	39570
Gross returns (Rs.)	703125	830970
Net returns (Rs.)	430947	588853
Average production cost per kg	7.02	6.12
Output/input ratio	2.55	3.43
Incremental net return		**157906**

The net returns from apple can be increased in case of non-adopters if the extension services strengthened to educate the people about the proper input use which was found below merit during the course of investigation. The average production cost per kg was found to be Rs. 7.02 with the benefit cost

ratio of Rs. 2.55 in case of non-adopters. In case of adopters average production cost per kg was found to be Rs. 6.12 with the benefit cost ratio of Rs. 3.43. The incremental net returns due to adoption of spray schedule was estimated as Rs. 1,57,906 per hectare.

d. **Determinants of apple production**

To obtain the production coefficients of the variables, Cobb- Douglas (C-D fucntion) was used. The determinants of apple yield at farm level were hypothesized to depend on various explanatory variables such as area under the crop, expenditure on fertilizers and manures, cost of labour expenditure and expenditure on HMOs, Fungicides and Insecticides/acaricides have been included. The dependent variable was gross returns obtained from apple. The production coefficients presented in Table 11 indicated that explanatory variables accounted for 83 per cent of the variation in the model. The estimated coefficients for area under the crop, expenditure on labour, HMOs, fungicides and insecticides/acaricides were found to be positive and significant. Thus a unit increase in area under the crop and expenditure on labour, HMOs, fungicides and insecticides/acaricides results in increase in the gross returns by the respective production coefficients. The coefficient of pesticide expenditures, which were important in the study showed that 1 per cent increase in expenditure on labour, HMOs, fungicides and insecticides/acaricides in apple production will increase the gross returns by 0.484 per cent, 0.076 per cent, 0.062 per cent and 0.042 per cent respectively. This result shows that there was little scope for increasing the pesticide expenditure to enhance the returns from apple production.

Table 11: Estimated Production coefficients in apple

	Coefficients	**p-value**
Intercept	1.769 (0.244)**	0.001
Area	0.187 (0.061)**	0.003
Number of Sprays	-0.055 (0.091)	0.548
Expenditure on Fertilizers & Manures	0.334 (0.223)	0.137
Expenditure on labour	0.484 (0.155)**	0.002
Expenditure on HMOs	0.076 (0.004)**	0.001
Expenditure on Fungicides	0.062 (0.019)*	0.027
Expenditure on Insecticide/Acaricides	0.042 (0.010)*	0.013
R^2	**0.834**	
Adj. R^2	**0.830**	

Figures in parentheses indicate standard error

*** and * indicates significant at 1 and 5 per cent, respectively*

The results presented show that pesticides used had a positive contribution to revenue from apple and farmers can benefit financially by increasing investment on pesticides. It is however very important to note that the study did not take into consideration the full costs of pesticides such as health related costs to the farmer and the community and the potential damage to the ecosystem. Results from this study only give the financial benefits that a farmer may get from increasing pesticides used and do not show the full economic costs of pesticides. The results therefore overestimated the benefits of pesticides especially from the aggregate economic point of view. The study was intended to serve as a starting point to facilitate a detailed and more encompassing economic evaluation of pesticide used in smallholder apple production.

CONCLUSIONS AND POLICY IMPLICATIONS

Pesticide and its use in agriculture and apple crop in particular in J&K state is a multi-dimensional and multi-departmental management problem from institutional perspective, besides its consequential positive and negative externalities on the state economy and environment. There is no denying about the fact that pesticides are an important input to apple fruit production system in the state as the non-use of sprays result in poor yield and quality with negative returns to growers. However, the negative impacts of pesticide use is not internalized in the production system or accounted for, thereby, leaving ample scope for its over/ misuse. Credit linked pesticide use for captive growers and partial adoption of spray schedule particularly with respect to dosage of various molecules mostly affected by dealer's choice and advice result in over use of pesticide besides irrational combinations resulting in more environmental hazards than its beneficial outcomes with returns from apple crop. So there is need to aware the growers/ captive growers about its long term implications and provide them necessary support in terms of finances as well as information and proper guidance.

The study has pointed out to the need for a detailed look on the pesticide-use pattern, distribution systems and regulatory mechanism at a micro level. Pesticide use has become an important input in modern agriculture. Results revealed that expenditure incurred on pesticides are quite high in apple. Besides that, not only the intensity of pesticide use but also the high risk pesticides are being used in crop production in the study area. This has profound implications for agricultural sustainability. An analysis of determinants of pesticide use at farm level pesticide expenditure could be achieved if farmers were given better information on real impact of pest problem, which could reduce farmers' attitude tow pest management. It was observed that farmers had limited knowledge of pest management as well as the consequences of pesticide use in apple cultivation. Increasing farmers' awareness of pesticide hazards to the environmental components should be included in the local extension activities. The scientists and agricultural extension workers should have regular interactions with R&D wing of pesticide companies to become familiar with the upcoming products. They should conduct research on contemporary issues of pesticides and externalities and may collaborate with them in the required endeavors. Most of the pesticides used by the farmers in the study area belonged to high and moderate risk chemicals. Farmers and skilled workers should be encouraged to adopt various safety devices during pesticide mixing, formulation of solution and spraying. Innovation in the form of location-specific light weight and easy to carry safety devices may enhance its adoption by the applicators. The state government should ensure the availability of pesticides listed in the scientific spray schedule and enforce a check on spurious/ sub-standard pesticides in the market. Enhanced institutional credit, testing of pesticides on fast track basis, labeling of pesticides and information regarding handling, formulation and methods of spray printing in local language would be of immense importance.

ACKNOWLEDGEMENT

This study is a part of Ph.D research work conducted at School of Agri. Econ. & HBM, SKUAST-K, Shalimar. The assistance extended for this research work by the advisory committee members and research staff of the School especially Dr. Fehim J. Wani and Dr. Haseeb ur Rehman, is duely acknowledged. Gratitude is also extended towards the respondents especially office bearers of pesticide companies for sharing their experience and confidential business information.

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