Economic Evaluation of High Density Apple (Ex-Ante) in Kashmir

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ABSTRACT
Union territory of Jammu and Kashmir, one of the leading producers of temperate fruits in India, is in the process of adopting high-density apple cultivation. Establishment of high-density apple orchard involves a very high cost which gets compensated by higher productivity during its productive life. Considering the profitability of cultivating high-density apple a need was felt to examine its quality and yield potential that could guide the Government to formulate a roadmap for its dissemination in its domain area. High-density apple (variety-Super Chief Sandridge) was recently introduced from Italy. It is reported to be very productive and quality wise, retains a high score of consumer acceptability, accordingly efforts are being made to extend its adoption in the union territory of Jammu and Kashmir. To formulate a policy for its adoption, ex-ante evaluation was carried out by employing economic surplus model on the experimental data collected from the technical expert group of scientists involved in its cultivation, assessment, evaluation and dissemination. The results reveal that productivity of apple has increased by 53.6 mt/ha and labor employment has increased by 676 man days/ha due to the adoption of high-density apple technology. The results further revealed that with an expected expansion of high-density apple orchards over 30% of the target area NPV, IRR and BC ratio would amount to 16.43 Billion US $, 62% and 98.60.

KEYWORDS
Economic evaluation; temperate fruits; plantation material; early bearing; profitability; high density

Introduction
Apple (Malus x domestica) crops thrives well at an altitude of 1,500–2,700 m. above m.s.l. and at an annual temperature ranging between 21 and 24°C. Indian states viz; Himachal Pradesh, Uttaranchal and Arunachal Pradesh including union territory of Jammu & Kashmir (J&K), provide niche for commercial apple cultivation. The distribution of the apple cultivation in the apple growing states is presented in (Annexure A1). Kashmir valley of the union territory of J&K, owing to its agro-climate is home to temperate fruits like apple, pear, peach, plum etc. Valley produces 2 million metric tons of apple in an area of 0.225 million hectares (2018–19) with an average productivity of 11–13 tons/ha (DoH, 2020). Out of the 0.331 million hectares, apple alone is grown on 0.246 million hectares. However, it suffers heavily on the account of the deadly diseases of apple scab (Venturia inaequalis), alternaria, leaf spot, powdery mildew, marsonina leaf blotch, root and collar rot etc. involving a very high cost of management. Also excessive rains and fog around fruit maturity result in poor fruit quality and color development. Under high-density plantation, the tree density is more than 5-fold compared to the traditional rootstock, which is maintained by using suitable scion varieties grafted on dwarfing rootstocks (Bakhtaver et al., 2020). High-density planting is highly precocious, starts bearing on the second year of planting and reaches full production in the 4th year, therefore, has very small
payback period compared to conventional orchards. Apart from this, high-density plantations produce the highest ratio of A-Grade fruits (>80%) which are qualitatively and price wise better (Rafiya, 2019). Yield of high density is two to five times higher compared to the traditional varieties, with a break-even period of just 6 and 4-5 years without and with government support, respectively (Insha et al., 2018). High-density orchards consume 70–80% less fertilizer pesticides (Jahangeer, 2019). SKUAST-K and Central Institute of Temperate Horticulture (CITH) have been contemplating to address these issues through introducing high-density apple varieties as a part of holistic approach toward strengthening apple economy of the region.

The high-density orchard maintains high tree density of more than 1500 trees per acre and comes into bearing within 2 to 3 years after planting (Shubhi, 2013). Precocious dwarfing rootstock is used to achieve early production, while advanced pruning maximizes its productivity (Aashiq, 2014; Rebecca, 2007). Dwarfing rootstocks (M9) is a preferred rootstock for high-density apple cultivation and has reported significantly higher yields in the third year maintaining a spacing of 0.8 × 3.2 m and plant density of 3906 per hectare (Masoodi, 2004). The initial establishment cost of high-density orchards accounts for approximately 4861US$ per hectare which are invested in the very first year of its establishment only (Michael, 2016). A permanent iron support system to enable the plants to stand firmly on ground requiring poles of concrete, compressed wood or of steel to maintain proper symmetry and spacing between the poles. Anti-hail net with retractable function to prevent damage from hail storm is also required (Terence, 2012). Better yield level and quality of produce in high-density apple plantation are expected to cover the initial establishment cost and the pay-back period has been recorded at 5 years.

The cultivation of high-density apple has transformed the scenario of apple production in the world in general and is also expected to give boost to the apple economy in Jammu & Kashmir as well. The adoption of high-density apple has increased the yield of apple manifolds compared to the traditional apple varieties. With the above background an attempt was made to undertake an economic evaluation of Super Chief Sandidge high-density variety of apple. The data collected from the expert group working on apple in SKUAST-K has been utilized to perform ex-ante evaluation of the newly introduced apple variety from Italy which though not yet grown on a large scale is expected to be adopted on 30% of the existing area which percentage area has been identified as target domain.

**Methodology**

This study is based upon data of experimental farms maintained by an expert group of SKUAST-K. The economic surplus model was used to estimate the social gains and economic viability through estimating the net present value (NPV), the internal rate of return (IRR), and the benefit-cost ratio (BCR). Direct benefits get generated by the adoption of new technologies in the target area. The adoption of high-density apple technology has both direct as well as indirect impact on farm economy. While the direct effects may translate in the form of yield gains and increase in income level, its indirect effects are widespread. The indirect effect of high-density apple plantation may be that the produce would fetch premium prices because of its better quality and by achieving various economies of scale. The economic surplus model is inclusive in that it takes into consideration both direct and indirect effects while capturing the impact or outcome of investment in research and extensions in taking technology to the field. Economic Surplus Model is better than Ordinary Least Square Regression (OLS) Model because unlike OLS it is not sensitivity to outliers and one or two outliers cannot seriously skew the results of a least-squares analysis and unlike later it takes into consideration price elasticities. The model was applied in a closed economy framework with the assumption of no spillover effects on international market as the target area fixed for this analysis is only 30%. For ease of analysis, it was assumed that the output supply function was unitary elastic and linear with a parallel research-induced supply shift, and the demand function was linearly inelastic. The assumptions of a simple case of linear supply and demand functions with parallel shift have been applied in most of the earlier studies on research benefits (Gopal, 1939; Hicks, 1940; Boulding, 1945; Winch, 1965; Alston
et al., 1995). This model has been employed by a number of scholars in India (Kumar et al., 2011, 2010) and abroad (Catherine and James, 2006) and was also used to measure the rate of returns to the research investment on the development of elite germplasm of maize and rice under various projects in J&K (Wani and Baba, 2011, Wani et al, 2013b; 2013a). Research benefits were computed as change in economic surplus as follows:

\[
\text{Change in total surplus} = KtPoQo(1 + 0.5Zt)
\]

where,

\[
Zt = Kt\{e/(e + h)\},
\]

K = Vertical shift in supply function,
\(e\) = Elasticity of supply,
\(h\) = Elasticity of demand,
\(Po\) = Base year output price, and
\(Qo\) = Base year output quantity

Results and Discussion

Impact of High Density on Apple Growers

High-density plantation of apple differs from its traditional cultivation not only in terms of yield levels but also with respect to quality, cost of cultivation and production costs. As is evident from Table 1, high-density apple could harvest 61 mt/ha which is multiple times the apple yield harvested from traditional root stock. This major proportion of the harvest from high-density apple exclusively falls in Grade-A while it is almost equally distributed among three grades (A, B &C) in traditional system of cultivating apple. Better quality of produce in high-density cultivation fetches better prices. Although high-density cultivation of apple is cost intensive but the manifold increase in apple productivity and better quality of produce resulted in overall reduction in its cost of production. Not only this, farmers realize far more quantity of marketable surplus of superior Grade-A fruit in high-density apple. The return from each US$ invested (0.106) in high-density apple is highly encouraging. Figures in the table also reveal labor-intensive nature of cultivation of high-density apple which is desired though a lot more is still to be done by way of strengthening value chain of apple in the territory.

Estimates of Economic Surplus Model

The estimates of price and supply elasticities of demand brought out by earlier studies (Kumar et al., 2010, 2011; Catherine and James, 2006) were used to perform the functional analysis of the model. The economic surplus model estimated a significant improvement in yield levels in the introduced variety

| Particulars                  | High density Apple | Traditional Apple | Change |
|------------------------------|--------------------|-------------------|--------|
| Apple Yield (MT/ha⁻¹)        | 61.00              | 8.00              | 6.63   |
| Grade A (%)                  | 80.0               | 37.50             | 1.13   |
| Grade B (%)                  | 13.77              | 25.00             | −0.45  |
| Grade C (%)                  | 6.88               | 37.50             | −0.82  |
| Gross returns (US $/ha⁻¹)    | 19,110             | 2,817             | 5.78   |
| Net returns (US $ ha⁻¹)      | 16,610             | 1,498             | 10.09  |
| Cost of cultivation (US $)   | 2,500              | 1,318             | 0.90   |
| Cost of production (US $/kg) | 5.5                | 18.6              | −0.70  |
| Returns per US$ invested (US $ ha⁻¹) | 0.106          | 0.029             | 2.66   |
| Marketable surplus (%)       | 90.31              | 87.0              | 0.04   |
| Employment (human days/ha⁻¹) | 801                | 125               | 5.41   |
of apple with the benefit-cost ratio of 98.60 and IRR of 62%. The investment on research and extension in dissemination of high density apple technology over 30% of the area targeted for this technology is estimated to generate net present value of 16.43 billion US USD. The various indicators of economic surplus model (Table 2) are highly encouraging and would definitely assist in encouraging the diffusion of the technology in the target area.

**Partial Budget Estimates**

Partial budgeting was used to further assess the impact of adopting high-density apple in terms of net economic gains. The results (Table 3) revealed that new technology (high density) required more costs compared to the traditional varieties. The maintenance cost and human labor accounted for 1181.00US $ha⁻¹ and 13655 US $ ha⁻¹ respectively. However, the credit side showed considerable gains in the form of increase in income by 16293 US $ha⁻¹ and increase in apple yield to the tune of 53.6 kg per hectare, amounting to the total credit of 1638US $ha⁻¹. The net change in returns led to an increased amount of 3094 US $ha⁻¹. Therefore, it could be concluded that the adoption of high-density apple improved the livelihood by generating additional employment and income to its cultivators.

**Conclusion**

The average productivity went up from 8.0 mt/ha to about 61.6 mt/ha after the replacement of traditional apple with high-density apple cultivars, so did the costs of new technology. Even though the costs have increased compared to traditional technology, it has benefitted adopters to a far greater extent in the form of higher productivity besides increasing the employability, which went up from 125 to 801 man-days/ha for both skilled and unskilled masses of the area. Private players were identified as potential stakeholders who need encouragement to help fruit growers for setting up such orchards across Kashmir valley. Proper irrigation, which is vital for raising this type of plantation, needs a bore

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**Table 2.** Returns from Investment on high density plantation revealed through Estimates of Economic Surplus Model (ESM).

| Particulars                                      | Values  |
|-------------------------------------------------|---------|
| Yield change Kg/ha⁻¹                            | 27.1    |
| Variable cost change per ha⁻¹ (%)               | 8.96    |
| Target area to be covered in 2020 (%)           | 30      |
| Time to achieve maximum adoption                | 10 yrs. |
| Elasticity of supply                            | 0.41    |
| Elasticity of demand                            | 0.282   |
| Prob. Success                                   | 1       |
| NPV(Billion US $)                               | 16.43   |
| IRR                                             | 62%     |
| BC Ratio                                        | 98.60   |

**Table 3.** Partial budgeting of high density apple (Ex-ante).

| Debit Particulars | Amount (US $/ha⁻¹) | Credit Particulars | Amount (US $/ha⁻¹) |
|-------------------|--------------------|--------------------|--------------------|
| Increase cost     | 1181               | Increase income    | 16293              |
| Maintenance cost  | 13655              | Apple yield        | 1'638              |
| Human labor       | 0.00               | Decrease cost      | 0.00               |
| Total (USD $)     | 14837              |                    | 17931              |

Net change (US $) 3094.00.
well facility for which extending of soft loans by the local government over a longer period of time is proposed. This will facilitate the drip pattern of irrigation required for increasing productivity of high-density apple. The role of institutions has to go a long way with the provision of financial assistance and development subsidy on the establishment of high-density orchards.

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### Annexure A1. Distribution of Apple growing areas.

| State              | Growing belts                                                      |
|--------------------|--------------------------------------------------------------------|
| Jammu & Kashmir    | Srinagar (Ganderbal), Budgam, Pulwama, Anantnag, Baramullah, Kupwara Shopian |
| Himachal Pradesh   | Shimla, Kullu, Sirmour, Mandi, Chamba, Kinnaur                     |
| Uttarakhand        | Almora, Pithoragarh, Tehri Garhwal, Uttarkashi, Chamoli, Dehradun, Nainital |
| Arunachal Pradesh  | Tawang, West Kanneng, Lower Subansiri                               |

Most important commercially grown apple varieties are.

### Annexure A2. Varieties of apple cultivated in India.

| Category                 | Varieties                                                                 |
|--------------------------|---------------------------------------------------------------------------|
| Clonal rootstocks        | M 9, M 26, M7, MM 106, MM 11                                              |
| Commercial Varieties     | Hazratbali, Razakvari, Gala Mast, Kesari, Red Delicious, Royal Delicious, American Apirouge, Golden Delicious, Maharaj, Coxs Orange pippin, Chamura |
| Newly introduced varieties | Red Velox, Starkrimson, Cooper 4, Gala Redlum, Oregon spur, Silver spur, Wells spur, Fuji Zehn Aztec, Coe Red Fuji, Gala Brookfield, Mitch Gala, Elstar, Elrosa, Wiltons Star, Red Braeburn, Jona gold, Golden Clone B, Golden Reinders |
| Scab resistant           | Prima, Priscilla, Sir Prize, Jonafree, Florina, Macfree, Nova Easy Grow, Coop 12, Coop 13 (Redfree), Nova Mac, Liberty, Freedom, Firdous, Shireen |
| Hybrids                  | Lal Ambri (Red Delicious x Ambri), Sunehari (Ambri x Golden Delicious), Chaubattia Princess, Chaubattia Anupam (Early Shanbury x Red Delicious), Ambred (Red Delicious x Ambri), Ambrich (Richared x Ambri), Ambroyal (Starking Delicious x Ambri) |
| Low Chilling varieties   | Michal, Schlomit, Anna, Tamma, Vered, Neomi, Tropical Beauty, Parlin’s Beauty |
| Pollinizers              | Tydeman’s Early, Red Gold, Golden Delicious, Mc Intosh, Lord Lambourne, Winter Banana, Granny Smith, Starkspur Golden, Golden Spur |