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An overview of apple cultivation and its challenges: A case study in village Dalash of Distt. Kullu, Himachal Pradesh

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Abstract
The present report includes the analysis of the situation of apple farming in the village of Dalash in Kullu district, Himachal Pradesh. The primary focus of the research was to document the current practices of cultivation, study the morphological and anatomical peculiarities of the domestic apple species, assess the soils fertility, and reveal the key issues that endanger the feasibility of the further development of the apple cultivation in the area. It made use of a mixed methodology, which involved a sequence of comprehensive field surveys, semi structured interviews with the informants and laboratory analyses of plant tissues and soil samples of the various orchards. The experimental timeframe investigated various development phases of apple trees in the period after April 2024 and before June 2025. The study defines production of seven large types of apples. Climate variability (frost, hail), issues within the market and labor shortages were the most common challenges that were raised. The findings emphasize the relevance of certain actions, including bringing farmers to understand how to grow on a climate-resilient scale, improved soil stewardship, and the way of developing post-harvest infrastructures, so that the industry may be viable in the long-term.

Keywords: Morphological, anatomical peculiarities & domestic apple species

Introduction

Malus domestica also referred to as the apple is a popular temperate fruit crop that is greatly appreciated due to its nutritional and economic value. The main driver of economic development in Himachal Pradesh, a state that has established a niche as a horticultural hub, is Agriculture and is popularly referred to as the Fruit Bowl of the Nation. Though the state cultivates almost 34 types of tropical and temperate fruits, apple occupies a leading position covering about 49 percent of the total agricultural land and contributes 79 percent of the total production of fruits in the state. Such disproportional dominance indicates high economic dependence on a single crop, which, although quite profitable, preconditions high risk of crop-specific diseases and climate change. This type of intensive agricultural specialization implies that a systemic shock, like a serious hailstorm or an outbreak of a new disease, can have an economy-wide impact. The same concentration also makes the success of agriculture in the region quite vulnerable to climate changes as evidenced by the reported changes in the altitudes of growth.

Apple farming in India goes as far back as the ancient times when the fruit was observed growing wild in most of the temperate regions of the globe as well as in cooler, high altitude regions of the sub-tropical regions. Captain R. C. Lee established the base of the apple industry in the state by establishing a professional orchard in the year 1870 in Bandrol, Kullu district. This was followed by the introduction of high quality delicious apples in Kotgarh in the Shimla district in 1916 by Samuel Evans Stokes, an American missionary which is said to have given birth to the first apple boom in the state. This created a great boost to the economic and social status of the region. Apple farming has since grown to be a major source of earnings to thousands of farmers in Himachal Pradesh and districts such as Kullu, Shimla, and Kinnaur are home to large scale apple farming.

Materials and Methods

Study Area

The research was carried out in Dalash village of Anni Tehsil of Kullu District, Himachal Pradesh, India. The village lies at a level of about 1,800 to 2,200 meters above sea level. Its latitude is about 31.5026° N and a longitude about 77.3989° E. To carry out the varietal analysis in detail, data had been particularly gathered in different orchards in the sub-localities of Dalash, i.e., Kantwari, Chewa, Tipri and Bhuni.

Map showing Dalash Distt. Kullu

Fig 1

Field Survey and Data Collection

To evaluate cultivation practices, choice of varietal selection, and farmer challenges, the apple cultivation survey was done after April 2024 and before June 2025. Field visits were made regularly at various seasons to record the different phases of apple production which include flowering, development of the fruit as well as harvesting. This was done through a mixed research method that consisted of a structured questionnaire, interviews, and group discussions that were conducted in the local language. In order to have a holistic picture, 30 key informants were well chosen. Such informants were experienced apple growers, horticulture specialists, local government representatives, apple traders, and organic growers. These were chosen according to their level of knowledge, interest, and cooperation in the planned research work, as well as to have a diverse but focused group that has the potential to give reliable information. Out of 30 informants only 15 informants are present in the given data.

Table 1: Profile of Key Informants

Sr. No.	Name	Age	Sex	Occupation
1	Manjeet Kumar	50	Male	Govt officials
2	Geeta Sharma	44	Female	Housewife
3	Anshita Bhardwaj	20	Female	Knowledgeable
4	Udit Chauhan	26	Male	Private Job
5	Dr. Arvind Bhardwaj	38	Male	Agriculture officials
6	Brij Mohan	65	Male	Knowledgeable
7	Aryan	23	Male	Apple trader
8	Hemant Sharma	45	Male	Advocate
9	Ramesh thakur	40	Male	Apple farmer
10	Pramod	40	Male	Organic farming expert
11	Gagan	21	Male	Knowledgeable
12	Ram Bhadur	37	Male	Farmer
13	Pawan	57	Male	Horticulture experts
14	Jeevanand Sharma	70	Male	Agriculture Expert
15	Anita Sharma	38	Female	Knowledgeable

Anatomical Study

The internal structure of apple plants was studied by the collecting of samples of stems, roots and leaves by means of chosen orchards. The plant material was fixed with the help of an FAA solution (Formalin: Acetic Acid: Ethanol in the proportion of 10:5:85) during 24-48 hours in order to maintain the structure of the cells. The roots, stems and leaves were sectioned manually with a sharp razor blade making thin transverse sections (TS) with a potato block to stabilize them. These sections were stained in aqueous safranin 3-4 minutes, washed and counterstained in fast green. These samples were afterwards dried in a series of ethanol, cleared and stained with xylene and placed under a compound microscope using DPX.

Soil Analysis

A soil auger was used to take the sample soils out of the different orchards at a depth of 15-20 cm. Composite samples to be representative were made by mixing subsamples of different locations within each of the selected sites. The samples were then collected in the laboratory where physical and chemical properties were researched.

Physical Properties: Physical qualities that were examined include; soil texture, structure and moisture content that are vital in the determination of the ability of soil to support the apple trees.

Chemical Properties: Chemical analysis had a critical evaluation of the pH of soil, electrical conductivity (EC), organic carbon (OC) and the available amounts of nitrogen (N), phosphorus (P) and potassium (K). The following Standardized procedures that guaranteed scientific rigor and repeatability of the findings were adhered to as follows:

Soil pH: Determined by a method of Jackson (1967), i.e. addition of a soil sample to a volume of distilled water and measurement on a digital pH meter.

Organic Matter: Determined through the Walkley-Black titration procedure using the following reagents: potassium dichromate, diphenylamine indicator.

Nitrogen: Although the analyses were done by alkaline permanganate.

Potassium: Single determination by the flame photometry, with 1N neutral ammonium acetate solution in place.

Phosphorus: Established using the Olsen method with sodium bicarbonate being used as an extractant.

This credibility of the research results because of these standardized approaches renders the results not anecdotal but rather the outcome of a structured, properly conducted and rigorous process.

Results and Discussion

The study documented the cultivation of seven major apple varieties in Dalash village, with each variety possessing distinct morphological and market characteristics. A summary of these varieties is provided below

Table 2: Variety of Apple

Variety	Fruit Color	Maturity time	Taste	Yield Potential
Royal Delicious	Bright red	Mid Season	Sweet – tart	High
Red Golden	Reddish Yellow	Mid to Late	Sweet	Moderate
Golden Delicious	Yellow	Late	Sweet	High
Spur Scarlet II	Dark Red	Early to mid	Sweet	Very High
Tydeman	Light Red	Early	Tart -Sweet	Moderate
Gala	Reddish Pink	Mid Season	Very- Sweet	Moderate
Fuji	Pink Red	Late	Very-Sweet	High

Royal Delicious Borkh: Royal Delicious of the Dalash area are one of the latest varieties that are cultivated at 2,000-2,500 m above sea level. The fruits are large, cones, and bright red, with crunchy firm flesh with a distinctively sweet taste. This type likes well drained loamy soils of pH 5.5-6.5 and require 800-1200 chilling hours. The harvest is usually late in September and goes on through to October. It has great market demand, and this is because of its good keeping property and high consumer preference.

Red Delicious Borkh: Red Golden is a medium to large-skinned and glossy apple of a reddish-golden color. The

fruits are conical in shape, and this contributes to the acidic and sweetness balance. It thrives successfully at 1,500-2,500 m, loamy soils (pH 5.5-6.5) and the chilling hours needed are 800-1,200. It grows in mid-September till the month of October. The diversity is valued due to its stable yields, moderate to good storability and stable market value.

Golden Delicious Borkh: Golden Delicious is characterized by a yellow peel that is smooth and hard crisp with honey-like sweetness in the flesh. It is most ideal in altitudes of 2,000-2,500 m and the loamy soils with slightly higher PH level (6.0- 7.0). It takes approximately 900-1200 chilling time. The harvests are in mid- to late-September. It has a good storage life and is known to be very versatile and can either be eaten as a fresh product or processed.

Scarlet Spur II Borkh: This type is medium to large conical in form and of deep red color. Its solid, sweet body makes it extremely popular among the consumers. It grows well in loamy soils with pH 6.0-7.0, and needs 900-1200 chilling hours. The picking of fruits normally ends in early to mid-September. Scarlet Spur II has a reputation of being very productive, good looking and can be trusted to last long on the shelf.

Tydeman's Early Worcester Borkh: Tydeman's Early Worcester is an early-maturing variety with which bright-red, round, to conical apples are produced. The fruits are sweet and tangy in taste. It thrives very well in loamy soils (PH 6.0-7.0) and it needs 800-1000 chilling hours. Its harvest time begins in early August and extends to the middle of September. It has been favored by farmers as it has been found to reach markets earlier than most varieties.

Gala Borkh: Gala apples are usually medium in size and the red bands are placed in a contrast with the yellow color of the skin. The fruits are sweet and crisp with a juicy and mild taste, which makes them good to eat fresh. The diversity has been found to flourish in an altitude of 1,500-2500 m in well-drained loamy soils in a pH of 6-7. It takes approximately 800-1000 chilling hours and is generally picked at the end of August to the beginning of September. It also has a stable consumer demand, in addition to good storability.

Fuji Borkh: Fuji is characterized by great size, reddish-pink colour, and very sweet and crisp flesh. It grows well on high elevations (1,800-2,500 m) deep loamy soils with pH of 6.0-6.8. The variety takes 1,000-1,200 chilling hours and they are cropped late in the season, between late October and early November. Fuji is renowned for its great quality and has a huge market locally and in the international market.

Morphology

The apple tree has a properly developed root system made up of fibrous and lateral roots that have extensive spread around the surface of the soil. A woody stem or trunk, and this is woody and cylindrical, is developed, on which grow as the tree grows, Rough, scaly bark, a natural defence against any temperature extremities in the country. The leaves are dark green, ovate-elliptical with serried margins and a dark green upper leaf. There is a definite midrib that sustains the definite pinnate venation. Apple trees bear flowers in four to six clusters of about four to six flowers during the flowering season, which are in the form of corymb-type inflorescences. The flowers are radially symmetrical having five white petals and a light fragrance. The main commercial product, the fruit, is medium to large, and the shape differs, round to conical, according to the cultivar. The crunchy hardness of the fruit and the dense covering of the bark are not only features but essential to survival and commercial viability in a rough, hilly area where there are transportation difficulties. The shape and purpose of the tree is a direct answer to the ecological scenario and the needs of people.

Anatomy of Apple

An anatomical study of the parts of the apple tree showed an appearance of normal dicotyledonous structures, which are fundamental to growth and survival of the tree.

Stem: The anatomy of the stem is typified by the presence of an outer epidermis which has lenticels facilitating the exchange of gases. Bundles composed of vascular arrangements are organized in the form of a ring where the xylem is on the inward side and the phloem is on the outward side. The xylem and phloem are separated by a layer named vascular cambium and it is due to the secondary growth that causes thickening of the stem.

Leaves: the apple leaf is dorsiventral, so that the upper and lower surface are different. The epidermis upper is covered by the waxy cuticle to stop the loss of water and the lower is covered by the stomata to exchange gases and transpiration. The mesophyll is separated into a compact layer of palisade which is specialised in photosynthesis and a spongy layer which contains air spaces that allow exchange of gases.

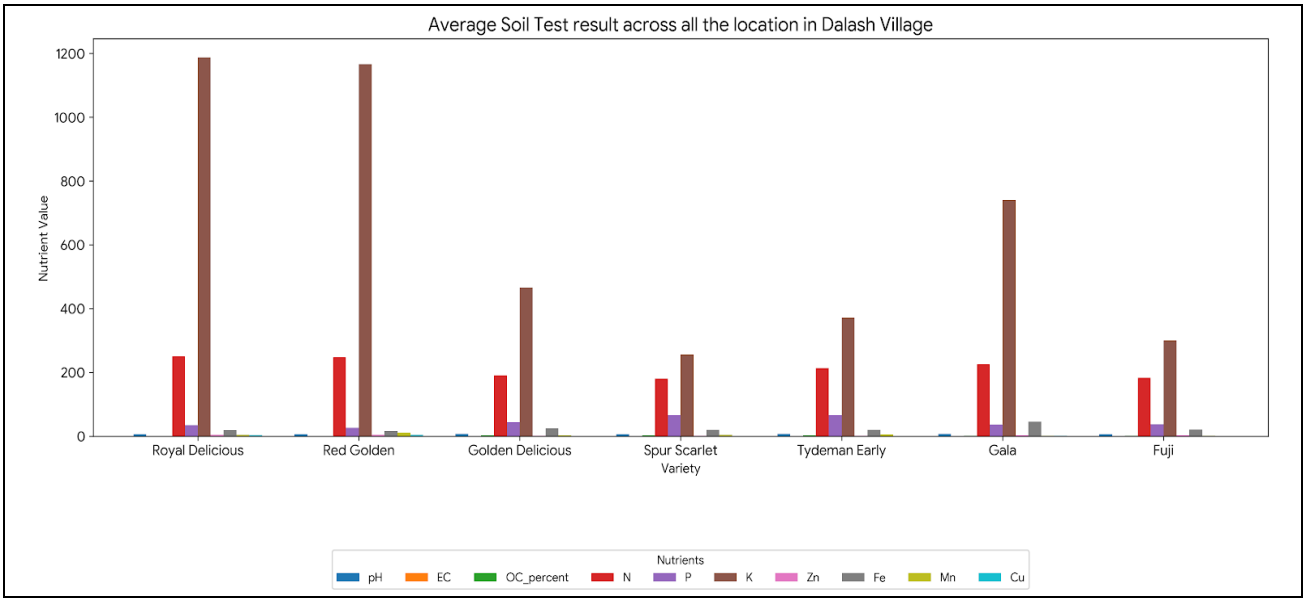
Root: The root consists of an outer epidermis that can become root hairs to absorb. The cortex which is composed of parenchymal cells serves as a storage site of nutrients and water content and the entry of such into the vascular bundle is regulated by the endodermis. A star-shaped xylem (a conductor of water and minerals) and phloem (a carrier of food by the leaves) are found in the vascular cylinder.

Soil Properties and Fertility Status

The research was based on soil analysis to determine the appropriateness of the land to produce apples. Physical examination revealed that the soil of the majority of orchards was loamy-sandy loam, which is most suitable in terms of moisture retention and aeration to grow apples.
Chemical analysis, however, showed there were serious imbalances of nutrients, as shown in the following tables.

Table 3: Average Soil Test Results Across All Locations in Dalash Village

Variety	pH	EC (dS/m)	OC (%)	N (kg/Ha)	P (kg/ha)	K (kg/ha)	Zn (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)
Royal Delicious	6.36	0.604	0.59	250.54	34.68	1187.26	4.321	18.55	4.275	3.702
Red Golden	6.34	0.063	0.61	247.89	26.28	1166.32	4.623	16.56	10.63	4.02
Golden Delicious	7.45	0.025	2.67	190.26	43.52	465.52	1.579	24.71	2.73	0.99
Spur Scarlet	6.34	0.028	2.64	180.36	65.76	255.84	1.3	20.06	4.59	0.933
Tydeman Early	6.62	0.04	2.64	213.38	65.31	371.4	1.411	19.74	5.55	0.665
Gala	6.59	0.06	1.37	225.86	36.0	740.5	2.564	45.94	1.618	1.228
Fuji	6.32	0.195	1.32	182.97	37.24	299.96	2.122	20.33	1.717	0.702



The data reveals a clear nutrient imbalance across most orchard soils. While the pH values were generally within the optimal range (6.5-7.5), and electrical conductivity (EC) was well below the critical limit, nutrient levels were erratic. Organic carbon (OC) content was generally optimal to high, but available nitrogen (N) was often below the recommended range of 280-560 kg/Ha, especially in Royal Delicious and Fuji orchards. In contrast, phosphorus (P) levels frequently exceeded the desired range of 10-25 kg/ha, and potassium (K) levels varied widely, reaching exceptionally high levels in some areas.

This nutrient imbalance, with low nitrogen and high phosphorus and potassium, is a direct consequence of farmers' reliance on traditional fertilization methods, such as the heavy application of farmyard manure (FYM), without conducting proper soil testing. FYM is rich in phosphorus and potassium but may not provide sufficient readily available nitrogen. This non-scientific approach leads to a "feast-or-famine" scenario for plant nutrients, which can compromise long-term productivity and fruit quality.

Observed Cultivation Practices

Varietal Selection: Dalash farmers grow a blend of older varieties of apples such as Royal Delicious with enhanced varieties such as Fuji and Gala. Altitude can also affect the variety used with higher altitude use of traditional varieties and lower altitude use of the early-maturing improved cultivars as they are better able to achieve higher market prices.

Plantation Methods: Traditional and modern plantation methods were observed. The common practice of most farmers is the use of traditional methods with large spacing (15 ft x 15 ft) between trees that carry 200-250 trees per hectare. Nevertheless, some progressive farmers have switched to high-density plantation (HDP) systems with dwarfing clonal rootstocks such as M-9 and MM-106, making it possible to practice even more compact spacing (6 ft x 4 ft) and fruit earlier.

Grafting: Grafting is a frequent horticultural process that is performed to bring together the preferable traits of a scion and a rootstock. The main techniques that were identified include whip and tongue on young plants and cleft grafting on changing varieties on the mature trees and this is usually done during the dormant season.

Soil and Nutrient Management: The mode of soil management in Dalash is hybrid. Organic manure, which mainly entails use of cow dung compost is a customary practice to enhance soil fertility and soil structure. They also use chemical fertilizers such as urea, DAP and potash, but this utilization is usually guided by visual and economic factors as opposed to diligent suggestions of soil testing. Farmers are encountering a growing trend in the use of vermicompost and biofertilizers as an alternative that is more sustainable.

Irrigation: Dalash relies more on natural water and precipitation. In order to divert water flowing in small irrigation channels, which are traditionally used by the farmers, water diversion is done through farm-based systems using the nearby springs or streams. On steep slopes with scarce water supply, rainfed cultivation is usually adopted and dry grass is used to store water in the soil against evaporation. There was little use of drip irrigation systems because of its high costs and the rough terrain.

Pruning and Canopy Management: This is done when in the dormant seasons (usually in December to February) and pruning is largely done to allow exposure to light and increase air-flow. It is however restricted to the scientific pruning techniques thus causing thick canopies in the older orchards resulting in impacts to the quality and size of the fruit.

Pest and Disease Management: There was a general observation of woolly aphids, apple scab and powdery mildew which are the most prevalent. Most farmers are still using the ancient methods of controlling pests such as spraying with garlic extracts and some have also embarked on using chemical pesticides in the control of longer pests.

Flowering and Pollination: The flowering phase usually starts in late March or early April and pollination depends, to a large extent, on honeybees, which are natural. Many farmers carry or hire bee boxes and have plant pollinizer

varieties in addition to commercial cultivars to guarantee a good fruit set.

Harvesting and Post-Harvest Handling: Apple harvest is done by hand in late August, through to September. Farmers take care not to bruise it, because it has an impact on marketability. The apples are also hand-sorted and graded and packed in either wood crates or corrugated cardboard boxes.

Transport and Packaging: Apples transportation is a major problem because of the rugged landscape and inaccessible roads. The produce is transported by mules or small vehicles to road points where it is loaded to larger trucks. Poor infrastructure of cold storage and transport facilities implies that apples should have to be transported as fast as possible to prevent spoilage.

Conclusion

Apple production in the Kullu district of Himachal Pradesh is still the primary activity of the local economy and a key source of revenue to the agricultural communities and particularly in the villages such as Dalash. Good climatic and geographical conditions have over the years contributed to different varieties development of apples in the area. However, there also exists a rising challenge that is posed to the sustainability of apple farming and it is brought about by several environmental and socioeconomic issues. Unpredictable weather, pests infestation, and absence of labor at the most critical stage of the crop production are among the factors contributing to the hardships that the apple growers experience. In addition to that, market challenges, the fluctuation of prices, inadequate storage, and overdependence on middlemen reduce the revenues of farmers and their security.

Recommendations

Based on the field observations and analysis of the data, the following recommendations are proposed to improve apple cultivation and address its challenges in Dalash village and the wider Kullu district:

- Introduce Protective Measures
- Improve Soil Health
- Strengthen Pest and Disease Management
- Enhance Infrastructure
- Promote Knowledge Transfer
- Form Farmer Producer Organizations (FPOs)

Challenges Faced During Field Survey (Fig. 35 - Fig. 41)

During a field survey in Dalash village, I faced multiple challenges. Some of those were unpredictable rainfall, late snowfall, rising temperatures, affecting flowering and fruiting.

- Hailstorm is a major challenge in apple cultivation, as it causes significant damage to developing fruits, reduces marketable yield, and affects overall quality of the product produced.
- Labour shortage especially during pruning and harvesting seasons.
- Irregular and insufficient water supply dependence on natural springs.

Pest and disease pressure increase cases of aphids, canker, root rot and leaf blotch.

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