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Farming Practices, Knowledge, and Constraints in Apple Production in Ladakh: A Survey

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Abstract: This study outlines the survey results from 500 participants to gather information on farming practices, knowledge, constraints and source of information on apple production in Leh Ladakh. Despite having a huge potential for quality apple production, the apple industry in the region is at a nascent stage. Of the growers surveyed, 76.6% of respondents were having less than 20 apple trees. Apple growers do not follow the standard growing practices. Only 11.4% of the respondents were growing apple trees in the orchard system. The majority (88.4%) of the growers were not applying chemical fertilizer. A majority of the surveyed respondents reported that they do not use mulching (93.4%) and drip irrigation systems (97.6%). There was poor knowledge about the importance of pollinizing cultivars. Knowledge about the insect-pest and disease was poor in the region. When asked to select the biggest constraints in apple production from among five options, 32.6% of the respondents selected lack of marketing opportunity, followed by high insect-pest infestation (24.8%), insufficient water for irrigation purpose (21.1%), non-availability of nursery plants (12.4%) and lack of fencing around the field (9%). The findings will help researchers, extension personnel, administrators and policy makers to bring reforms in the apple industry.

Keywords: horticulture, Leh Ladakh, *Malus domestica*, organic, trans-Himalaya

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1. Introduction

Apple is a traditional fruit crop of high altitude trans-Himalayan Ladakh region. The region represents a great wealth of indigenous apple germplasm that vary in colour, size, flavour and texture (Angmo *et al*. 2018). Ladakh

produced approximately 3992.4 tonnes of apples in the year 2019. It is the second most important fruit crop of the region, after apricot. A number of native cultivars are grown in the region, and *Thra, Mongol* and *Karkechu* are the three most popular cultivars (Dolker *et al*. 2021). The local cultivars ripe in August but do not store well. However, fruit of exotic Delicious cultivars ripe in late October and stored well for 4-5 months by traditional method of storage. In view of late ripening and prolonged fruit storage quality, there is an increasing demand for Delicious cultivars in the region (Angmo *et al.* 2018).

Ladakh has many natural advantages for apple production. The region experiences long day hours with high light intensity and relatively warm days with cool nights and low relative humidity from May to October, thus making apple cultivation favourable in the region. However, apples are being grown in the region either as individual trees or small groups of trees in the traditional way without the use of chemical fertilizer and pesticides. Standard cultural practices such as pruning, training, manuring, spacing are not being followed by the majority of the growers. Despite having a huge potential for quality apple production, the apple industry in the region is at a nascent stage. Advances in horticultural production technology are often hindered by slow grower adoption. A number of factors can hamper adoption, including overly complex systems, cost, risk aversion, and perceived negative return on investment (Ellis *et al*. 2010).

The status of any agricultural industry cannot be better determined than by making a field survey of the subject. Such a survey is generally quite detailed and shows the present condition of the industry. Survey results are expected to help extension personnel understand the critical management concerns of production with diverse growing practices and identify opportunities to address concerns through education and training (Piñero and Keay, 2018). The purpose of the present survey was to learn about: (1) number and types of apple trees grown in the region, (2) adoption of standard growing practices by apple growers, (3) knowledge about insect-pest and diseases, (4) interest and preferences in planting fruit trees, (5) biggest challenges growers face in their production system, and (6) source of information and trainings on management of apple trees in Leh Ladakh. With the data at hand our goal was to present the factual position of the apple industry in Leh Ladakh to enable the researchers, extension personnel, administrators and policy makers to bring reforms in the apple industry. To the best of our knowledge, no such survey was conducted in the region.

2. Methodology

The study was carried through personal interviews with apple growers in Leh district of Union Territory of Ladakh. A total of 25 questions were structured. Leh district is administratively divided into 16 Blocks and the present survey was conducted in eight major fruit growing Blocks and the Leh town. The surveyed Blocks and number of respondents were Skurbuchan (n=43), Khalsi (n=65), Saspol (n=32), Nimoo (n=44), Chuchot (n=23), Thiksey (n=44), Diskit (n=45), and Leh (n=143). From Leh town 61 respondents participated in the survey.

The authors visited the villages and face-to-face interviews with the growers were held. The survey was initiated on 6 July 2021, and it closed on 28 September 2021, at which time 500 apple growers had responded. The survey respondents included 310 female and 190 male. The age of the respondents ranged from 26 to 79 years with an average age of 49.2±15.4 years.

3. Results and Discussion

3.1. Number and Types of Apple Trees

Of the growers surveyed, 76.6% of respondents were having less than 20 apple trees. Growers having more than 50 apple trees constitute 10.4% of the respondents and the remaining 13% were having 21 to 50 trees. Apple growers in Nimoo Block were having comparatively more number of trees, 29.5% were having 21 to 50 trees and 27.2% had more than 50 trees. Therefore, the majority of the farmers in the region were small apple growers (Table 1).

Majority (63.8%) of the respondents were growing both native and introduced apple cultivars. Farmers growing only native cultivars represent 18.4% of the growers surveyed, while 17.4% of the respondents were growing only introduced apple cultivars.

3.2. Purpose of Growing Apples and Income Generation

A vast majority (66.6%) of the survey respondents were growing apples for self-consumption, while the remaining 33.4% respondents reported that their main purpose of growing apples was for income generation (Table 1). However, a majority (61.4%) of the respondents in Nimoo Block reported that their main purpose of growing apples was for income generation.

Due to harsh winter months, availability of fresh fruits and vegetables is a major challenge in Ladakh (Stobdan *et al.* 2018). In view of the same, the majority of the growers (64.4%) stored apples for use in winter months. The

Table 1: Number and type of trees, purpose of growing and income from apple cultivation in Leh Ladakh (% respondent)

Question/ Information sought	*Options*	*Administrative Block*								*Leh Town*	*Total*
		Skurbuchan	*Khalsi*	*Saspol*	*Nimoo*	*Chuchot*	*Thiksey*	*Diskit*	*Leh*		
Number of apple trees	<5	46.5	24.6	15.6	13.6	65.21	50.0	24.4	29.3	36.0	31.8
	6-20	34.8	41.5	62.5	29.5	34.78	36.3	40.0	51.0	54.0	44.8
	21-50	11.6	20.0	9.4	29.5	0.0	6.8	20.0	9.09	9.8	13.0
	>50	6.9	13.8	12.5	27.2	0.0	6.8	15.5	10.4	0.0	10.4
Types of apple cultivars	Native	23.8	12.3	37.5	9.0	21.7	31.8	8.8	20.9	9.8	18.4
	Introduced	30.9	12.3	3.1	6.8	30.4	11.3	24.0	18.1	26.2	17.4
	Both	45.2	75.3	59.3	84.0	47.8	56.8	66.6	60.8	63.9	63.8
Main purpose of growing apples	Self-consumption	62.8	61.5	56.3	38.6	86.9	84.0	57.8	66.4	78.7	66.6
	For sale	37.2	38.5	43.7	61.4	13.0	15.9	42.2	33.6	21.3	33.4
Storage of apples for winter consumption	Yes	58.1	61.5	62.5	79.5	65.3	50.0	86.7	58.7	75.4	64.4
	No	41.9	38.5	37.5	20.5	34.7	50.0	13.3	41.3	24.5	35.6
Income generation from sale of apples	Rs per year	1187	15720	7037	45407	3750	5000	20000	7653	15692	13487

average income from the sale of apples was Rs 13,487 per year. Low income from apple cultivation may be attributed to less number of apple trees per grower, and use of the fruit for self-consumption.

3.3. Adoption of Standard Growing Practices

Practices such as training, pruning, manuring, mulching, growing pollinizing cultivars are widely followed in all apple growing regions in the world. However, the majority of the apple growers in the present study do not follow the standard growing practices (Table 2). Only 11.4% of the respondents were growing apple trees in the orchard system. Training and pruning are very important activities in apple tree production, which is highly dependent on human labour. However, 68.8% of the respondents reported that they do not undertake training and pruning regularly. Manuring was not done by 17% of the respondents. The majority (88.4%) of the growers were not applying chemical fertilizer, which may be due to poor knowledge about importance

of tree nutrition and the ongoing organic farming movement in the region. A majority of the surveyed respondents reported that they do not use mulching (93.4%) and drip irrigation systems (97.6%). Most apple cultivars require cross-pollination with a compatible pollinizer to increase apple tree productivity (Ramírez and Davenport, 2013). However, there was poor knowledge about the importance of pollinizing cultivars and only 6.6% of the respondents reported that they were having pollinizer in their orchard. As compared to other fruit growing Blocks, majority of the apple growers in Nimoo Block were growing apple trees in the orchard system (54.5%) and regularly undertaking training and pruning of apple trees (61.4%).

Table 2: Adoption of standard growing practices in Leh Ladakh (% respondent)

Question/ Information sought	*Options*	*Administrative Block*								*Leh Town*	*Total*
		Skurbuchan	*Khalsi*	*Saspol*	*Nimoo*	*Chuchot*	*Thiksey*	*Diskit*	*Leh*		
Do you grow apple in orchard system?	Yes	11.6	15.3	15.6	54.5	13.0	20.5	31.1	23.7	21.3	11.4
	No	88.3	84.6	84.3	45.5	86.9	79.5	68.8	76.2	78.7	88.6
Are you applying manure every year?	Yes	76.7	84.6	75.0	90.1	82.6	77.2	73.3	87.4	75.4	83.0
	No	23.2	15.3	25	9.9	17.3	22.7	26.6	12.5	24.5	17.0
Are you applying chemical fertilizer?	Yes	6.9	13.8	6.3	9.0	4.3	18.1	6.6	11.8	18.0	11.6
	No	93.0	86.1	93.7	90.9	95.6	81.8	93.3	88.1	81.9	88.4
Are you regularly doing training and pruning of apple trees?	Yes	20.9	27.7	21.9	61.4	8.7	29.5	44.5	29.4	37.7	31.2
	No	79.1	72.3	78.1	38.6	91.3	70.5	55.5	70.6	62.3	68.8
Do you have pollinizing variety in the orchard?	Yes	2.30	7.7	3.1	15.9	8.7	4.5	2.2	5.6	9.8	6.6
	No	97.6	92.3	96.9	84.0	91.3	95.4	97.8	94.4	90.2	93.4
Are you using mulching in the orchard?	Yes	6.9	0.0	9.4	0.0	4.3	11.4	4.4	1.4	1.6	6.6
	No	93.0	100	90.6	100	95.7	88.6	95.6	98.6	98.4	93.4
Are you using drip irrigation system in the orchard?	Yes	0.0	1.5	6.3	0.0	0.0	0.0	0.0	2.0	4.9	2.4
	No	100	98.5	93.7	100	100	100	100	97.9	95.0	97.6

3.4. Damage and Pest Management Knowledge

Codling moth (*Cydia pomenella*) is a major insect-pest of apples in Ladakh region. The pest is reported to infest 42.2-76.8% of the apple trees in the region

(Hussain *et al.* 2015). Growers were asked if they knew the name of any insect-pest and disease of apple trees. Over 90% of the respondents were not able to mention the name of a single insect-pest and disease of apples (Table 3). Therefore, knowledge about the insect-pest and disease was poor in the region. The growers (82.6%) felt that insect-pest infestation is increasing in recent years. When the growers were asked what percent of apple fruits were damaged due to infest-pest infestation, 36.8% respondents reported less than 10% damage. Majority of the growers from Chuchot (56.5%) and Leh (67.8%) Block responded that the damage was less than 10%. Chuchot and Leh are not traditional fruit growing areas and thus less incidence of insect-pest could be due to presence of low initial inoculum. However, 33.6% of the growers surveyed reported 11-30% damage, and 23.2% of the respondents said the damage was 31-50%. A significant (5.6%) number of respondents said the damage was 51-70%. Over 70% damage was also reported by the growers in Saspol (6.3%) and Nimoo (2.3%) Blocks.

Table 3: Knowledge, damage and management of insect-pest and diseases in Leh Ladakh (% respondent)

Question/ Information sought	*Options*	*Administrative Block*								*Leh Town*	*Total*
		Skurbuchan	*Khalsi*	*Saspol*	*Nimoo*	*Chuchot*	*Thiksey*	*Diskit*	*Leh*		
Do you know name of any insect-pest of apple trees?	Yes	4.7	18.5	9.4	9.0	0	4.5	13.4	3.0	6.5	8.2
	No	95.3	81.5	90.6	90.9	100	95.5	86.6	97.0	93.4	91.8
Do you feel that insect infestation is increasing in recent years?	Yes	88.4	92.3	84.4	93.2	78.3	77.3	82.2	72.0	88.5	82.6
	No	11.6	7.7	15.6	6.8	21.7	22.7	17.8	28.0	11.5	17.4
How much apple fruit get damaged due to insect infestation?	<10%	7.5	16.9	18.8	20.5	56.5	27.3	20.0	67.8	41.0	36.8
	11-30%	37.5	30.8	37.5	18.2	26.1	47.7	60.0	25.9	34.4	33.6
	31-50%	55.0	36.9	31.3	38.6	17.4	18.2	15.6	6.3	21.3	23.2
	51-70%	0.0	15.4	6.3	20.5	0.0	6.8	4.4	0.0	3.3	5.6
	>70%	0.0	0.0	6.3	2.3	0.0	0.0	0.0	0.0	0.0	0.8
Do you know name of any disease on apple?	Yes	2.3	7.7	3.1	9.3	0.0	0.0	11.1	7.7	9.8	6.4
	No	97.7	92.3	96.9	90.7	100	100	88.9	92.3	90.2	93.6
Do you regularly undertake orchard sanitation?	Yes	55.8	52.3	43.8	9.3	78.3	65.9	42.3	7.7	62.3	62.2
	No	44.2	47.7	56.2	90.7	21.7	34.0	57.7	92.3	37.7	37.8
Are you spraying pesticide in your orchard?	Yes	4.6	38.5	21.8	61.4	0.0	9.0	15.5	7.7	93.4	17.4
	No	95.4	61.5	78.1	38.6	100	90.9	84.4	92.3	6.5	82.6

Orchard sanitation is an effective method of managing insect-pest and diseases. Sanitation practices aimed at reducing the initial inoculum causing insect infestation and diseases. When growers were asked questions about orchard sanitation, the majority (62.2%) of the surveyed respondents said they regularly undertake orchard sanitation. However, 90.7% of the respondents from Nimoo Block were not doing regular orchard sanitation, which may be a key factor for significantly higher fruit damage in the area. A majority of the growers (81.6%) do not use chemical pesticide for management of insect-pest.

3.5. Interest and Preferences in Planting Fruit Trees

Growers were asked a series of questions about their interest and preferences in growing fruit crops (Table 4). Majority (88.4%) of the growers wanted to plant more apple trees. For fresh consumption, the majority (72.4%) of the respondents preferred native apple cultivars. *Thra* was preferred the most (42.6%) followed by Delicious cultivars (27.6%), *Karkechu* (18.2%) and *Mongol* (11.6%). However, when asked which apple cultivars they preferred to grow, the majority of the respondents said they prefer Delicious cultivars (50.8%), followed by *Karkechu* (27.2%), *Thra* (17.0%) and *Mongol* (5.0%) cultivars. Preference for Delicious cultivars may be because of its late ripening and good keeping quality. *Karkechu* is also a late ripening cultivar and has good keeping quality (Dolker *et al.* 2020). Majority (77.2%) of the surveyed respondents felt that farmers were having less preference for native apple cultivars. Poor fruit storage quality was cited as the main reason for low preference for native cultivars.

When asked which fruit tree they preferred to grow, the majority of the respondents showed preference for apple (64.4%), followed by apricot (24.6%), cherry (3.0%), pear (3.0%), peach (2.6%) and grapes (2.0%). Apricot is the main fruit crop of Ladakh and known for its quality. However, low preference for the fruit crop may be because of short fruit shelf life and poor processing facilities in the region (Stobdan *et al.* 2021).

3.6. Constraints in Growing Apples

Growers were asked to identify one major constraint in growing apples (Table 5). Surveyed respondents (32.6%) reported lack of marketing opportunity as the major challenge. Of the growers surveyed, 24.8% of the respondents reported high insect-pest infestation as the major constraint. Insufficient water for irrigation purposes was cited as the major challenge by 21.1% respondents. Non-availability of nursery plants was cited as the major constraints by 12.4% growers, and the remaining 9% respondents cited lack of fencing around the

Table 4: Interest and preferences in planting fruit trees in Leh Ladakh (% respondent)

Question/ Information sought	*Options*	*Administrative Block*								*Leh Town*	*Total*
		Skurbuchan	*Khalsi*	*Saspol*	*Nimoo*	*Chuchot*	*Thiksey*	*Diskit*	*Leh*		
Do you want to plant more apple trees?	Yes	90.7	95.3	93.7	95.4	86.9	86.3	31.1	23.7	80.3	88.4
	No	9.3	4.6	6.2	4.5	13.0	13.6	68.8	76.2	19.6	11.6
Which apple variety you like the most for fresh consumption?	*Thra*	62.8	42.9	59.4	58.1	47.8	31.8	20	42.4	34.4	42.6
	Mongol	4.7	9.5	15.6	7.0	13.0	29.6	53.3	11.5	11.5	11.6
	Karkechu	11.6	23.8	18.7	11.6	8.7	11.4	8.9	14.6	19.7	18.2
	Delicious	20.9	23.8	6.3	23.3	30.4	27.2	17.8	31.5	34.4	27.6
	Others	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0
Which apple cultivar you prefer to grow?	*Thra*	20.9	16.8	34.4	13.6	13.0	27.3	15.5	17.4	11.5	17.0
	Mongol	9.3	6.2	0.0	0	0.0	9.0	6.7	5.8	4.9	5.0
	Karkechu	20.9	29.1	25.0	29.5	21.7	18.2	15.6	33.9	27.9	27.2
	Delicious	48.8	47.9	40.6	56.8	65.2	45.5	62.2	42.9	55.7	50.8
Do you think farmers have less preference to grow native cultivars?	Yes	74.4	67.7	71.9	84.1	82.6	72.7	77.8	85.0	81.9	77.2
	No	25.6	32.3	28.1	15.9	17.4	27.3	22.2	15.0	18.0	22.8
What are the reasons for less preference to grow native cultivars?	Fruit less tasty as compared to Delicious	6.3	0.0	8.7	8.1	21.1	15.6	8.6	17.2	14.0	8.0
	Fruit do not store well	75.0	63.6	73.9	64.9	68.4	65.6	57.1	69.7	48.0	68.1
	High insect infestation	18.7	29.5	17.4	10.8	10.5	15.6	34.3	9.8	28.0	19.2
	Others	0.0	6.8	0.0	16.2	0.0	3.1	0.0	3.3	10.0	4.7
Which fruit tree you prefer to grow on your land?	Apricot	74.4	50.8	40.6	18.3	26.1	15.9	40.0	15.4	14.8	24.6
	Apple	25.6	36.9	59.4	59.2	73.9	65.9	60.0	72.7	80.3	64.8
	Peach	0.0	6.1	0.0	4.6	0.0	0.0	0.0	0.0	0	2.6
	Cherry	0.0	6.2	0.0	6.9	0.0	0.0	0.0	4.2	4.9	3.0
	Grapes	0.0	0.0	0.0	2.0	0.0	9.1	0.0	2.0	0	2.0
	Pear	0.0	0.0	0.0	9.0	0.0	9.1	0.0	5.7	0.0	3.0
	Others	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0	0

field as the major constraint. Therefore, upcoming research and outreach objectives should emphasize on the major constraints being faced by the apple growers. If marketing opportunities, incidence of insect-pest and availability of nursery plants are addressed, its impact would be keenly felt by the growers.

Table 5: Major constraints in growing apples in Leh Ladakh (% respondent)

Question/ Information sought	*Options*	*Administrative Block*								*Leh Town*	*Total*
		Skurbuchan	*Khalsi*	*Saspol*	*Nimoo*	*Chuchot*	*Thiksey*	*Diskit*	*Leh*		
Major constraints in growing apples	Nursery plant not available	7.0	9.2	15.6	13.6	21.7	20.5	8.9	12.6	14.8	12.4
	High insect infestation	53.5	40.0	50.0	34.1	13.0	13.6	28.9	8.4	21.3	24.8
	Insufficient water for irrigation	0.0	12.3	15.6	18.2	8.7	6.8	28.9	36.4	27.9	21.1
	Lack of marketing opportunity	39.5	27.7	18.8	34.1	43.5	29.6	28.9	33.6	36.0	32.6
	Lack of fencing around field	0.0	10.8	0.0	0.0	13.1	29.5	4.4	9.0	0	9.0

3.7. Source of Nursery Plant, Information and Training

Growers were given a list of five sources of apple nursery plants and asked which was the main source for them (Table 6). The Government Horticulture Department was the main source of nursery plants for 26% respondent. Twenty-four per cent responded that they raise their own nursery plants. Friends and relatives were the main source of plants for 24.2% growers. Nursery plants are not readily available in the region and only 13.4% of the surveyed respondents cited the local market as the main source of nursery plants. Therefore, the establishment of nurseries needs to be promoted in the region.

On-farm training needs to be conducted frequently. Eighty-two per cent of the survey respondents did not receive any formal training on managing apple trees during the last five years. Growers were given a list of four resources Extension personnel typically use and asked which source was the main

source of information on management of apple trees. Overall, growers seemed to be open to a wide variety of sources of information with the most commonly selected response being television (36.4%) and friends/ relatives (32.2%).

Table 6: Source of nursery plant, information and training on growing apples in Leh Ladakh (% respondent)

Question/ Information sought	*Options*	*Administrative Block*								*Leh Town*	*Total*
		Skurbuchan	*Khalsi*	*Saspol*	*Nimoo*	*Chuchot*	*Thiksey*	*Diskit*	*Leh*		
Main source of apple nursery plants	Own raised	34.8	20	37.5	18.6	13.0	34.0	11.1	26.6	29.5	24.4
	Friends/ relatives	9.3	24.6	28.1	18.6	30.4	34.0	17.8	23.8	34.4	24.2
	Govt Hort Deptt	23.3	36.9	15.6	53.5	39.1	15.9	62.2	18.2	21.3	26.0
	Local market	16.3	7.7	12.5	9.3	17.4	11.4	8.9	24.5	8.2	13.4
	Other States	16.3	10.8	6.3	0	0	4.5	0	6.9	6.6	12.0
Do you get training on growing apple during the last five years?	Yes	20.9	23.0	21.8	25	4.3	15.9	20	18.9	8.2	18.0
	No	79.0	76.9	78.2	75	95.7	84.0	80	81.8	91.8	82.0
What is the main source of information on management of apples trees?	Radio	41.9	20.0	18.8	11.4	17.4	15.90	8.9	23.8	16.4	19.0
	Television	25.8	21.5	3.1	34.0	60.9	27.3	46.7	41.3	45.9	36.4
	Friends and relatives	18.6	47.7	25.0	25.0	13.0	43.2	42.2	23.8	32.8	32.2
	Training &awareness camps	13.95	10.8	21.9	29.5	8.7	13.6	2.2	11.2	4.91	12.4

4. Conclusion

Ladakh has many natural advantages for apple production. Despite having a huge potential for quality fruit production, the apple industry in the region is at a nascent stage. Majority of the farmers in the region were small apple growers, and 76.6% of respondents were having less than 20 apple trees. Knowledge and adoption of standard growing practices such as training, pruning, manuring,

mulching and management of insect-pest was poor among the apple growers. The biggest constraints in apple production were lack of marketing opportunity, followed by high insect-pest infestation, insufficient water for irrigation purpose, non-availability of nursery plants and lack of fencing around the field. Most growers do not always keep accurate accounts so the figures are only estimates. However, the findings will help researchers, extension personnel, administrators and policy makers to bring reforms in the apple industry.

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Conflict of Interest: None

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