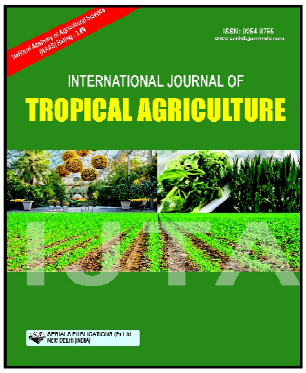

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Climate Change and Temperate Fruits - Exploring Adaptation and Mitigation Strategies for Biotic and Abiotic Stress – A Case Study of Apple in Himachal Pradesh

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INTRODUCTION

Apple is an important temperate fruit which has been cultivated in Europe for over two thousand years. It originated in the Caucasus mountains of Southern Asia, where its natural forests with pears and nuts are still covering millions of acres, and from where it was first domesticated in Europe. From Europe its seeds and grafted trees were spread westward by Indians, traders and Missionaries. From these scattered seedlings, several of the leading apple cultivars were eventually selected, such as Red Delicious, Golden Delicious, Rome and Ginger Gold. The USA apple breeders have contributed a great deal to today's large wealth of the Delicious Apple.

The world production of apples is rapidly approaching 60 million Mt/yr, which makes them by far the most important of temperate tree fruits. It is the premier table fruit, which has been under cultivation from time immemorial. 'An Apple a day keeps the doctor away"- this old adage focuses man's attention on the importance of apples in the daily diet. It has long been the staple fresh fruit in temperate parts of the world. Apples are a rich source of carbohydrates, proteins, mineral such as Ca, P, Fe, K, sugar, amine and vitamin B6. It has also been found to contain an appreciable amount of sorbitol, malic and citric acids. Eating apples is believed to reduce the incidence of dental caries, help control obesity and supply extra energy for heavy exercise. Apples arc also used in the making of jams, jellies, preserves, slice, juices, sauces, apple hutter, apple chips, apple rings, wine and cider. The apple is fetching high price ill

the international market, thus it is successfully used for export.

Apple is tolerant to an exceptionally wide range of summer and winter temperatures so it can be grown in many different soils and in suitable micro climates from the Arctic to the Equator. With this wide range of conditions, apple at present is grown in about 62 countries, which makes it, with possible exception of grapes, the most cosmopolitan fruit in the world (Luckwill 1983).

A notable feature of post world war II happenings has been the great increase in apple growing in warmer countries of the world. India, which was previously associated more with II1angos and other tropical fruits, now grows early thrice the number of apples as in the UK, mainly in hill regions of Jammu and Kashmir, Himachal Pradesh, Uttaranchal and NEH region states, where apple trees are typically planted on terraced hills or in river valleys. Bhutan and Nepal are rapidly expanding apple production areas as well.

SCENARIO OF GLOBAL CLIMATE CHANGE

The last two decades have been the warmest in the past 100 years. Sea levels are rising. Rainfall patterns are changing. Arctic ice is thinning, and the frequency and intensity of EI Nino events appear to be increasing. In many parts of the world, major heat-waves, floods, droughts and extreme weather patterns have led to significant loss of life. Associated economic losses totaled US$ 40 billion in 1990; one-forth of the losses occurred in developing countries. The question is no longer whether the earth's climate will change, but rather how much it will change how fast and where. The earth's average surface temperature could rise by as much as 5.8°C (10.4 degrees Fahrenheit) over the next 100 years. This warming, the most rapid climate change in 10,000 years, would be more than 60 per cent higher than that predicted by scientists just five years ago (IPCC, 2000).

While an increase of less than 2 degrees Celsius in the average global temperature in the next 100 years would bring some benefits to the technically advanced countries with temperate climates in the form of milder winters, extended growing seasons, and higher yields of some crops, the ability to deal with warming depends heavily on economic resources and access to technology. In developing countries, even a modest warming will mean net losses. In the tropics and subtropics like India, where some crops are near their maximum temperature tolerance, and where dryland, non-irrigated agriculture dominates, yields are likely to decrease with even small increases in atmospheric temperature.

In recent Inter Governmental Panel on Climate Change United Nations (IPCC, 2011) and Hydrabad based Central Research Institute for dry land agriculture (CRIDA) have warned reduction in crop production with just one degree change in average temperature could bring down production of 2 cereal crops namely rice and wheat by 6 million tones and with rise of temperature by 5 degree the loss is likely to increase to 27.5 million tones.

Scientists working with the Kathmandu based International Center for Integrated Mountain Development (ICIMOD) have recently termed Himalayan region a global warming hot spot, changes in temperature can lead to rapid shrinkage of glaciers and increase in river water flow. Based on data collected by Snow and Avalanches Study Establishment of DRDO Chandigarh, the report says that average winter temperature in the Indian part of Himalayas have increased by 0.6 to 1.3 degree Celsius between 1975 and 2006. The ICIMOD report also spelt out complex struggle for 25000 species of flora and fauna habitat in the Hindu Kush Himalayas suggesting that rise in temperature will push tree species to higher altitudes towards cooler locations. Perhaps that may be the reason why apple from valley and mid-hills of sub-temperate zone

vanished and shifted to higher areas of "Cold Desert Zone"(!) as envisioned by author in ICAR sponsored Brain Storming session of CPRI, Shimla 2008.

APPLE PRODUCTION STATUS

International vis-à-vis National Scenario

Apple production of the world is confined to areas within latitudes 30^{0}C and 50^{o}C. It extended into lower latitudes in India by cooling influence of higher altitudes of Himalayas. Thus, apple is the predominant temperate fruit crop of hilly areas of India and it accounts for about three per cent of the total fruit production of the country. India stands eighth in apple production in the world (FAO, 2011), however, in productivity in stands at fifty third position. The rapid expansion in area in the last five decades has not kept pace with the productivity of apple fruits due to various problems. In India, the average productivity of apple is nearly 6-7 tonns per ha, which is much lower than the average yield obtained in advanced countries of the world viz., Belgium (46.87 tons per ha), Denmark (41.87 tons per ha) and Netherlands (40.40 tons per ha).

Table 1
Area production and productivity of ten major apple producing countries

Sr. No.	*Country*	*Production Million MT*	*Area Million ha*	*Productivity MT/ha*
1.	China	22.88	2.30	9.95
2.	USA	4.84	0.18	26.89
3.	Turkey	2.50	0.10	25.00
4.	Iran	2.20	0.16	13.75
5.	Italy	2.15	0.06	35.83
6.	France	2.14	0.08	27.44
7.	Germany	1.80	0.07	25.71
8.	India	1.58	0.23	6.89
9.	Poland	1.40	0.16	8.75
10.	Ukraine	1.32	0.25	5.28

Table 2
Where India Stands in apple productivity at international level?

Ranking	*Country*	*Productivity MT/ha*
1.	Belgium	46.22
2.	Denmark	41.87
3.	Netherlands	40.49
4.	New Zealand	40.13
5.	Brazil	38.62
…..	…….	…….
53	India	6.89
	World	10.82

Table 3
National Scenario: Area, production and productivity of apple producing Indian Himalayan States

States	*Area (000 ha)*	*Production (000 ha)*	*Productivity (MT/ha)*	*Leading share in production (%)*
Jammu and Kashmir	126.4	1268.5	10.0	63.80
Himachal Pradesh	94.5	592.6	6.3	26.61
Uttarakhand	32.2	130.5	4.0	6.52
Arunachal Pradesh	10.8	9.8	0.9	0.49
Nagaland	0.40	0.5	1.43	-
Total	263.9	2001.5	7.6	-

Apple productivity in Himachal Pradesh –An analysis

The production of apple in Himachal Pradesh has increased from 12,000 tonnes in 1960-61 to 4.59 Lakh tones in 2003-2004. The production of the state crossed the 5.92 lakh tones mark in 2007-2008 with an average productivity of 10.84 t/ha. The highest ever yield in the state was recorded in 2007-2008 (5.92 lakh tones) which was nearly touched for the first time in ten year in 2005-2006 (5.40 lakh tones). A gradual decline in apple productivity from 10.84 t/ha in 1981-82 to only 0.88 t/ha during 1999-2000 with the exception of 2010-2011 (11.57 t/ha) has

been reported by Department of Horticulture, Govtnment of HP, Shimla (2011-12) and National Horticulture Board data base (2008).

Table 4
Apple Scenario in Himachal Pradesh (at a glance)

Grown from 1524 to 2472 m amsl
Average productivity in last 24 years -5.82 t/ha
Total apple production (2003-04)-459492 t located in three agroclimatic zone II to IV.
Districts wise distribution

District	*Production (t)*	*% Share*
Shimla	294402	64.1
Kullu	98781	21.5
Kinnaur	33074	7.2
Mandi	23261	5.1
Other (Chamba, Lahaul Spiti, Kangra and Solan District	9974	2.1

Adapted from NATP/World Bank Report, 2005

LOW PRODUCTIVITY OF APPLE IN HP – WHY SUCH A SITUATION?

Causes of low productivity analyzed through various technical reports followed by brain storming session with scientists and subject Mater Specialists were accessed in the farmer's field and in the experimental research stations of the different apple growing areas of state. The below mentioned biotic and abiotic factors such as climatic and varietal biodiversity causes were identified on the basis of various inputs as most important factors for the low productivity in apple.

Varietal Biodiversity: In Himachal Pradesh, Delicious group of varieties constitute about 83 per cent of the total production of apples. The predominant varieties being Starking Delicious, Red Delicious and Richared. These varieties are self unfruitful and require cross pollination for fruitfulness. Moreover, these varieties have strong tendency of alternate bearing after a few years of commercial fruit production which is also one of the reasons which account for low production during the off-years. These varieties are highly susceptible to low temperature and frost and hail injury during flowering which also accounts for low production.

Table 5
Productivity scenarios of apple in Himachal Pradesh mainly influenced by climatic factors

District	*Good Crop*	*Poor Crop*
Shimla	10.86	4.52
Mandi	2.16	0.88
Chamba	2.26	0.76
Solan	0.42	0.20
Sirmour	1.70	0.68
Kullu	6.94	2.82
Kangra	0.06	0.09
Kinnaur	7.10	4.50

Climatic Constraints: Irregular bearing behaviour of Starking Delicious is largely influenced by climatic conditions. The rains and hails during flowering adversely affects the fruit-set whereas moderate temperature of 20°C with relatively low rains during flowering results in good fruit-set. Low temperature during pre-bloom or bloom stage can cause sublethal injury to buds or flowers resulting in poor fruit-set and crop load. Early flower anthesis and full bloom were observed in good crop years. Long flowering period is also indication of good crop prospects.

Impact of Changing Climatic Conditions on Chilling Units, Physiological Attributes and Productivity of Apple in Himachal Himalayas – Backward linkage

At the university of Horticulture and Forestry Solan comparative investigations have been undertaken to study the influence of winter temperatures below 7°C on effective chill units (ECU), growing degree hours Celsius (GDH°C) requirements and

physiological changes associated with the bud dormancy of Starking Delicious apple under two locations viz., location A (ideal apple growing conditions with an altitude of 2286 in amsl) and location B (marginal apple growing conditions with an altitude of 1375 m amsl). Using the Utah Model, the effective chill unit requirements for location A and B were 1208 and 1130, respectively, whereas, the GDH°C requirements from rest completion to full bloom for the respective locations were 8893 and 9376. The quantitative analysis of physiological components indicated varying pattern during the course of dormancy. The effects of various chilling units on budbreak and biochemical attributes in young potted apple plants were studied under controlled conditions. It has been observed that with the increase in chilling exposure, the days required for bud break were reduced. Further, the impact of climatic conditions during winter, spring and summer are being assessed for studying the relationship with fruiting parameters of Delicious apple.

Table 6
Annual variation in chilling units (below 7°C) at IARI station Shimla

Months	*2006-07*	*2007-08*	*2008-09*	*2009-10*
August	0	0	0	0
September	0	0	0	0
October	32.5	1.5	13	9
November	219	124	64.5	112.5
December	464.5	449	226.5	496
January	430.5	525	403.5	459
February	446.5	431.5	325.5	438
March	299.5	28	96.5	14
April	0	0	44	0
Total Chill Units	1892.5	1559	1173.5	1519.5

Climatic Constraints from flowering to fruit growth/harvesting

The productivity and quality apple is influenced by i) winter conditions (December to February), ii) spring conditions during flowering (April) and iii) post-bloom summer conditions (May-June). The important climatic components affecting the productivity and quality parameters are temperature, rainfall, hails and frost.

1. **Temperature**: Low temperature during early fall and completion of chilling requirement before February results in good flowering. If the chilling is not met the flowering shall be sparse, staggered and poor. Temperature during the flowering should be around 20°C for proper anthesis, cross pollination and fruit-set. High temperature above 26°C or very low temperature below 15°C during flowering especially around full bloom has adversely affected the fruit-set and productivity. The dry and hot summers affect the fruit development and quality, as the fruit size remains small. The optimal temperature during summer for proper growth and development is 20-24°C.

2. **Rainfall**: Winter precipitation especially in the form of snow helps in providing winter chilling. Early snowfall before January and well distributed rains during the winters (above 150 mm) are most beneficial for ensuring optimal flowering and good fruit-set. The cloudy and rainy weather during flowering especially at the time of bloom restricts the pollination and deteriorate fruit-set. The post-bloom rains are most advantageous for sustaining the fruit-set and fruit development. Dry summers with extended drought spells impair the fruit quality especially fruit size and colour.

3. **Frost**: Usually the frost can occur any time during winters and spring but the spring frost coinciding the flowering flushes especially the full bloom affects the fruit-set adversely.

4. **Hails**: The bud break to petal fall is the most sensitive stage when hail can reduce the prospective good crop year to almost 'off ' year. It does not only inflict direct injury to buds, flowers and leaves but can causes sublethal injury to the developing fruits and spurs as well. Hails during the fruit development have more serious effects, however, the frequent occurrence of hailstorms in Himachal Pradesh has created havoc in fruit setting in apple (Table 7). It is feared heavy crop loss for the last 3-4 years may be due to hails as computed below.

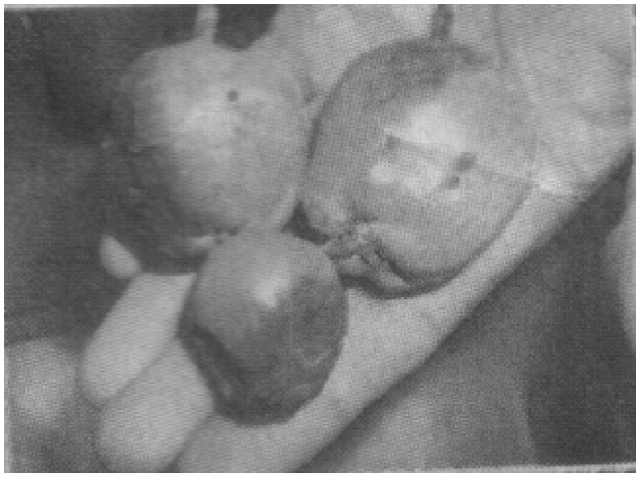
Table 7
Actual losses to fruit crops due to various natural calamities in HP

Sr. No.	*Year*	*Major calamities*	*Area affected (in ha)*	*Value of losses (in Lakh)*
1.	2009-2010	Drought, hail storm, excessive rain/ windstorm and delayed monsoon	32244	24834.25
2.	2010-2011	Drought, Hailstorm, Excessive rain, windstorm and delayed monsoon	106467	23640.99
3.	2011-2012	Hail storm, heavy rains and wind storm	166207	35695.24
4.	Till 15th April, 2012	Severer bouts of hail storms and unseasonal rain	24358	15400.00

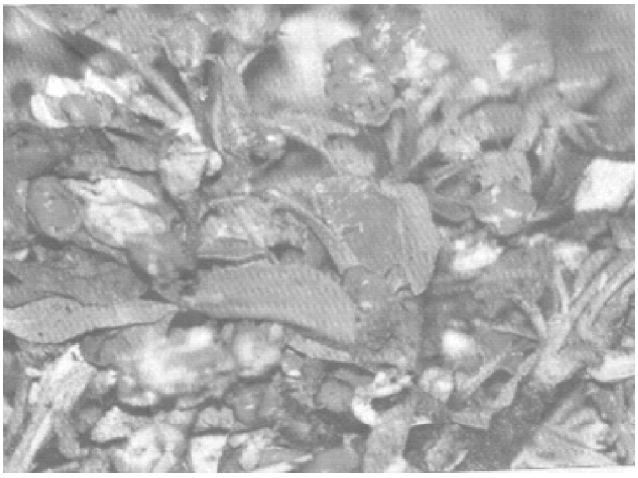
Data computed from technical cell of state Department of Horticulture repots 2009 – 15 April, 2012

Physiological basis of hail injury

The release of chemicals, probably auxins, cytokinins, gibberellins and ethylene, from the damaged cells provoke the formation of new tissues. Wound healing is shown to be more rapid in young fruits of cv. Golden Delicious than in the older fruit because in older fruits the time between the damage and harvest is short, and also because cell regeneration is slow owing to the advanced stage of cell differentiation. Leaves are more severely damaged followed by twigs and fruits.



Recent Hail Damage young apple fruits



Hail damage flower and foliage (April, 2012)

Mid season corrections to mitigate loss due to hail storms

1. **Plastic netting**: Hail netting though fool proof method has not been readily adopted by fruit growers, mainly because of high cost, and partly because of concerns relating to tree growth and fruit quality under the plastic nets. It has been shown that shading from some netting materials decrease photosynthesis especially black may interfere with the development of red colour in apple. White nets reduce radiation by 4-8 per cent and black net by 33-37 per cent. Hence, fruit colouring may was less extensive under black net and little affected under white nets. The studies are in progress.
2. **Training system**: Central leader trees suffer the most total hail damage, while the modified central leader suffering the least as observed in RHRS, Shimla.
3. Bagging of fruits also reduce hail damage. However, it is very laborious.
4. The spray of urea immediately after the hail storm helps in the repairing process of hail injury.
5. The injury caused by hail damage makes the fruits susceptible to attack of disease causing organisms. These diseases can be controlled effectively by using mild fungicides so as to reduce the loss of fruit quality on experiencing hail storm.
6. In order to heal the damage of hail on leaves and fruits and improve the size of quality fruits two plant hormones namely CPPU (a cytokinin derivative) and 30 to 60 ppm promalin (mixture of BA and GA 4+7) at different growth stages have been laid at Regional Research Station, Shimla. The Sprays will be repeated. The impacts will be known after the harvesting of fruits in coming season.

OTHER SPECIAL BIOTIC AND ABIOTIC PRODUCTION PROBLEMS

Pollination Problems

With continuous change in the climate and an increase in the excessive use of insecticides and pesticides, the problem of inadequate pollination has become acute. More than 75 per cent of orchards have less than twenty per cent pollinizers whereas a minimum proportion of 25 per cent is required. The natural population of pollinating insects has drastically reduced with the deterioration ecosystem and excessive use of insecticides. Honeybees are the only insect under man's control and we require at least four to six beegive/ha of orchards, hut our government as well as private bee keepers supply only 0.5 beehive/ha. Moreover, the predominant pollinizers, like Golden delicious Red Gold, have a biennial bearing tendency and the crops fail in their off year sequence. This whole problem can be solved by providing temporary pollination aids, such as pollen inserts, bouquets, pollen dusting and with branch top working with pollinizers.

Fruit Drop

Though an apple tree may bloom profusely, only a relatively small percentage of flowers will mature into fruit. Only five per cent setting is required for a good commercial crop. Most blossoms fall soon after full bloom with a for a good few dropping later on. Generally three drops are experienced in apple that is first drop of less pollinated fruits after petal fall to three weeks later, the second is a bigger drop in June which causes concern to growers due to the dropping of larger fruits and the third is the preharvest drop.

The first drop cannot be checked until effective pollination is assured. The second drop (June drop) can be minimized if orchard management practices, such as moisture conservation and irrigation, are given due attention. Judiciolls fertilization with nitrogen and pruning also have a helpful influence

in the checking of fruit drop. Preharvest fruit drop can be checked with a spray of NAA (10 ppm) before the drop starts.

Thinning Apple Frnits and Alternate Bearing

Thinning is done to improve fruit quality and to reduce any alternate bearing tendency. Excessive fruiting in one year, in cu1tivars like Golden Delicious, Red Gold, McIntosh, Jonathan, Rome Beauty and some other English varieties, leads to the failure of trees to bloom the next year. This causes serious concern to the fruit growers due to their pollination needs. Though hand thinning is the best method to regulate flowering, it is laborious and is only possible as supplementary to chemical thinners. NAA is an effective thinner for Golden Delicious in 20 ppm concentration at petal fall stage. NAA is, of course, an excellent thinning agent without any side effects (50 ppm) but it is not commercially available in India. Carbaryl (Sevin) is one of the safest and most widely used chemical thinners currently available. This in a 0.15 per cent dose with NAA (10 ppm) spray is excellent for thinning Red Gold after petal fall.

Colour Problem

Colour development in Delicious is greatly hampered in low lying apple growing areas due to the warmer conditions. Such fruits fetch very low prices. In higher elevations maturity is delayed causing a glut in the market due to late arrival and over colour development. Application of ethrel (2-chloroethyl phosphonic acid) at 1,000 to 1,200 ppm (2.5-3.0 ml ethrel/l of water) combined with NAA at 20 ppm (0.5 ml/l ethophon) improves the colour in mid and low hills and enhances l1Iallll'ity ill the high hills, Use of ethrel spray is advised about ten days before expected harvest and when there is nearly 20 to 25 per cent nalural colour development; such ethrel treated fruit has a short storage life, hence it is suitable only for the fresh market.

Replant Problem

The apple replant problem arises which suppresses the initial growth of young trees, when planted on old apple orchard sites. The causes of this problem all: considered to be soil borne, biotic and abiotic factors which vary from location to location. When biotic factors are involved, it is known as apple replant disease (ARD), and when abiotic causes are responsible it is known as replant problem (ARP). Several management methods, such as fumigation or soil solarization, biomanagement methods by employing antagonistic microorganism have been suggested to check replant disease. Corrected or modified soil nutrition (particularly P based) combined with micorrhizal inoculation also improves the growth of freshly planted apple trees. However, the prospects of the management of orchard replant problem are difficult owing to the absence of efficient diagnosing methods to identify even the primary causal agent and that, too, with the background of complex interacting factors. Fumigants are easy and safe to use. Rootstock like Merton 793 are also reported to be suitable for overcoming this problem. Diagnosis of this problem is vitally necessary to decide the management practices for successful apple cultivation.

Plant Protection Problems

The apple is infected with number of insect pests and diseases, but San Jose scale and Woolly aphids are still the dominant insects, though two-spotted spider mite and European Red mite had been of minor importance until the eighties in apple orchards, but with the increasing use of pesticides (mainly insecticide) outbreaks have hardly been witnessed in recent years. Infected nursery plants are the main source of Woolly aphid, and San Jose scale spread. Malling Merton rootstock are resistant to aphid. All other insects can be managed with correct spraying of insecticides. All these insect problems should be managed with the Integrated Management Approach

(IPM). Apple diseases, such as premature leaf fall, root rot, collar rot, powdery mildew and scab, arc the problems of ill-managed orchards and can be minimized if efficient management practices are followed.

OUTLOOK

Climate change per se will have impact on economically important species like apple but livelihoods of farmers are being threant treatment due to incomplete chilling, longer GDH, iritic irruptive rainfall, and snow in winter, more frequent hail storms and enhanced abiotic and biotic stresses. However, measure to adapt to these climate changes is critical for sustainable production. Increased temperature and weather vagaries will have more effect on reproductive biology. The strategies has been identified and addressed to mitigate the adverse effects of weather and development of climate resilient plants species, like low chilling crops, culture practices and efficient use of water. Concerted and integrated efforts can convert challenges into opportunity.

FUTURE STRATEGIES FOR ENHANCING PRODUCTIVITY

Delineation of Areas for Apple Cultivation

In the changing climate outlook, apple cultivation is profitable only above 6,000 ft (amsl) elevation. Therefore, all the efforts and facilities for apple cultivation should be extended only to suitable areas. Lower elevation areas should be diversified with pears, nectarines, kiwi fruit and nut crops.

Diversification in Apple Cultivars

Different apple growing areas face different problems, such as low spur formation and poor colour at lower elevations and valley areas (below 5,500 ft), colour problem at middle height (5,500-6,500 ft) an delayed maturity at higher elevations. With the availability of a large diversity in apple cultivars various self-pollinating Spur types and colour sports need to be adopted according to the problem faced in a particular area. Lower altitudes and valley areas should be restricted to fifty per cent Delicious type cultivars preferably Spur type and remaining should be pollinizers and selfcompatible cultivars, such as Scarlet Gala, Red Fuji, Gloster and Florina. Spur type cultivars are suitable where problems of spur formation and poor colour exist. Colour sports, such as Vance Delicious, Top Red, Hardiman and Skyline Supreme, are suitable for these areas where spur formation is adequate, but the problem of poor colour persists at elevations above 7,000 ft (amsl) and there one must use standard Delicious cultivars.

Sricntitic Nursery Production Programme

Nearly seven to eight lac nursery plants are required each year in the different apple growing areas of India. This demand is being met by nearly olle thousand government, as well as private, nursery growers. For this huge planting material, only seedling rootstock are being used at large, which results ill lot of variabilities in grafted plants, since the seed sources are quite variable in different areas. To improve upon this problem there is an urgent need for rouging of nursery stock and strengthening the clonal multiplication programme of selected rootstock. Private nursery growers should be encouraged to take part and it will be useful to establish and promote large nurseries for this purpose as is done in various overseas countries.

Development of Budwood Banks

Variation in scion source is another problem in the apple nursery programme. There is urgent need to set up wood banks for mass scale supply of elite material for multiplication by nurserymen. Due to the vast seed and budwood variations, we get hardly a handful of nursery plants for our orchards.

Diversification in Pollinizers

The trend in apple plantation has recently shifted to Spur type cultivars but, except for Golden Spur, we do not have any Spur type pollinizers for these plantations. Therefore, Spur type pollinizing varieties, such as Gran Spur, Lys Golden, Spure Rome, Sundale Spur Golden and Spur Winter Banana, need to be introduced and multiplied, otherwise pollinizers in such plantations must hl' planted on semi-dwarfing clonal rootstock (MMI06, M7), or interstock (M9) advocated on seedling rootstock. An adequate pollinizer proportion (25-33%) should be made available to growers as well, since commercial nurserymen and government agencies grow only commercial cultivars so that the orchardists can not obtain their required pollinizers and are obliged to opt for top working. Beekeeping entrepreneurs should be encouraged to increase the availability or beehives for pollination.

Developing High Density Plantations

By using this technology, the per unit production can be increased. There are instances when a high density orchard at RHRS, Mashobra had productivity of over 70.0 t in some 'on' years. At present most apple orchards in the USA, Europe, Australia and New Zealand are under the intensive system of fruit production.

Improvement in Orchard Management Technology

Practices like weed control, fertigation, organic manuring and scientific training and pruning systems are needed to increase the productivity of apples.

Need for a Sound Postharvest Management System

There is an urgent need for uniform maturity standards in all commercial cultivars, diversification in value added products, utilization of factory waste and efficient marketing system for apples.

CONCLUSION AND SUMMARY

The low productivity of apple has become a serious concern for the farmers, research workers and development agencies at national and state level for the last two decades. Several factors can be attributed to the declining trend in productivity like expansion of apple cultivation to marginal areas, monoculture of Delicious varieties, declining standards of orchard management and the fluctuating abnormal climatic conditions.

The Indian Himalayas comprises of more than one eight of total land area of the country and extends from Jammu and Kashmir in the north west to Arunachal Pradesh in the east. The geographical difficulties and inaccessibility in many areas adversely affect the developmental processes. However, progress has been made in temperate horticulture especially in the north west Himalayas covering the states of Himachal Pradesh and Jammu and Kashmir. The state of Himachal Pradesh has been named "Apple State of India" which will achieve the distinction of "Fruit Bowl of India" in the near future.

The productivity of temperate fruits especially apple in Himachal Pradesh is declining at a faster rate. Average yield of apple in India has been estimated at about 6 tonnes per hectare which is far below the level of 30 tonnes per hectare in most of advanced countries. The productivity has also not kept pace with the expansion in area under temperate fruits due to various biotic and abiotic problems faced by the farmers in the Himalayas. This has caused a serious concern not only to the hill farmer community but also to researchers, development agencies and policy planners. With the global warming, the decline in productivity is being attributed to changing climatic scenario. Keeping this in view, University Grants Commission Ministry of Human Resources Development Govt. of India has awarded as special gesture Emeritus fellowship in Life Sciences at Shoolini Institute of life science and

Business Management affiliated to Himachal Pradesh University, Shimla in Collaboration with Dr. Y.S. Parmar University of Horticulture and Forestry Nauni-Solan with participatory approach of Regional Research Station of Indian Agriculture Research Institute Amartara Cottage Shimla. The co-operation of scientists, subject matter specialists and concern farming community who provided valuable inputs are gratefully acknowledged.

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REFERENCES

Abbott DL (1970). The role of bud scales in the morphogenesis and dormancy of apple fruit bud. In: LC Luckwill and CV Cutings (Eds) Physiology of Tree crops. Aladormic Press Lord.

Free JB (1964). Comparison of the importance of insect and wind pollination of apple trees. Nature 201: 726-727.

ICIMOD reports 2012

IPCC Reports 2000-2005 and 2012

Janick J (1974). The apple in Java. I-Iort Sci 9 (1) : 13-15.

Janick J and Moore IN (1975). Advances in fruit breeding. Purdae\Uni Press West laf\tyettc, Indiana.

Kronenberg HG (1979). Apple growing potential in Europe. I : The fulfilment of the cold requirement of the apple trees. Netherland J Agric Sci 27: 131-135.

Luckwill LC (1983). Apple growing around the world: Problems and Prospects. Apples and Pears Rep RHRS Conference.

Mayer DF, Johansen CA and Lunden JD (1985). Bee pollination of tree fruits.In:Pollination and fruit set. Proc. Short cause, good fruit grower,Yakima Washington.

Nadda AL (2001). Marketmg management of apples. In: KK Jindal and DR Gautam (Eds) Productivity of Temperate Fruits Dept Pomology UHF Solan.

Notodimedjo S. Sastrosumarto Sand Danoesastro S (1981). Shoot growth, flower initiation and dormancy of apple in tropics. Acta Hort 120:179-186.