

Present Status and Future Prospects of Fruit and Nut Researches in Nepal

I.P. Gautam¹, T.K. Gotame² and S.L. Shrestha¹

¹ Horticulture Research Division, Khumaltar, Lalitpur

² Regional Agricultural Research Station, Parwanipur, Bara

Corresponding email: gotame@gmail.com

Abstract

Fruit in Nepal contributes about 4.8% of national GDP and 15.32% of AGDP. The major public institutions involved in fruits research is primarily Nepal Agricultural Research Council. It has spent about twenty five years of researches in fruit species. Among 62 Stations/Divisions, National Citrus Research Program is only one commodity program while highly dedicated stations in fruit researches are ARS Pakhribas; HRD, Khumaltar; HRS, Malepatan; HRS, Dailekh and HRS, Rajikot, and RARS Tarahara; RARS, Parwanipur; RARS, Lumle and RARS, Nepalgunj. Some good ground work has already been done during past in major fruits particularly in apple, pear, Plum, citrus, kiwifruit, pomegranate, grape, banana, litchi, pineapple, and mango. A major research in the past was focused on genotype collection and evaluation, propagation methods and protocol standardization, plant protection in few commodities and postharvest management. In recent years about 25 technologies have been generated and documented. With long efforts of research in fruits, two varieties of acid lime Sunkagati-1 and Sunkagati-2 have been released while Khoku Local of mandarin and Tehrathum Local of acid lime have been registered so far. Variety registration of banana germplasm particularly, 'William Hybrid', 'G9' and 'Malbhog' has also been proposed for registration by Horticulture Research Division, Khumaltar in collaboration with National Fruit Development Centre and Seed Quality Control Centre. Even though, the researches in fruits and nuts are still lagged behind than that of technological demand from the users. There is still lack of streamline in the fruit research and definite lead centers. To take the momentum in fruit research in NARC, it needs to be restructured with special focus on fruit researches. For example, Horticulture Research Institute as envisaged by ADS should be established. One Fruit and Nut Research Division at each province as leading apex body including Fruit Research Units should be established under NARC. Further upgrading of NCRP along with establishment of Tropical Fruit Research Station at Province 2 and Temperate Fruit Research Station at Province 6 at national level can streamline NARC's fruit researches.

Keywords: Tropical fruits, Temperate fruits, Citrus, Nuts, Commodity Program

1. Introduction

Horticultural crops in Nepal have great potential for creating employment, income generation, food and nutritional security of the people and environment protection. The contribution of agriculture sector in the country's GDP is 29 percent of which horticulture sector contributes about 17% of AGDP. Fruits and spices share about 7.0 percent to agricultural GDP. Among fruits, mango, banana, apple, orange contribute about 1.56 percent, 0.4 percent, 0.42 percent, 0.97 percent, respectively (Pandey *et al.*, 2017). About 5% of the total cultivated area is covered by fruits in Nepal (MoAD, 2015). Nepal has a few decades of systematic research in fruit and nut species. For the first time, germplasm introduction and evaluation was started during 1960s when 13 horticultural farms were established in different agro-ecological conditions with the help of Indian Aid. Most of these public farms established progeny orchards, introduced and evaluated exotic germplasms, produced and distributed planting materials and provided technical backstop in their command areas. Besides these, Pakhribas Agriculture Centre and Lumle Agriculture Centre run by British government during early 90's imported some of germplasm of low chilling apple, peaches and plum and distributed to farmers. Many periodic plans have been implemented, with some priority on research and development activities in fruits in past. At the end of the 7th plan period, government developed a long term plan for horticulture development and a 20-years Master Plan for Horticulture Development (MPHD). To streamline the agriculture research including fruit and nut species, a National Agricultural Research and Services Center (NARSC) was formulated in 1985. The NARSC was given autonomy to exercise its research functions independently and was renamed as Nepal Agricultural Research Council (NARC) in 1991. However, the research in fruits and nut species lagged far behind than the technological demand of the country even though some good ground work has been carried out and research based technologies have been disseminated into farmers' fields. Researches were mainly focused on genotype collection and evaluation, propagation, problem based management, farmers adaptation and postharvest operations. There is still lack of technological packages for successful and transferable technologies (Gotame *et al.*, 2014).

2. List of Institutions Involved in Fruit and Nut Researches

The fruit and nut researches in Nepal is carried out mainly by threes public institutes, NARC, Agriculture and Forestry University (AFU) and Institute of Agriculture and Animal Science under Tribhuvan University (TU). Under NARC, National Citrus Research Program is only one commodity program whereas Horticulture Research Stations (HRS) namely HRS, Rajikot; HRS, Dailekh; HRS, Malepatan and Horticulture Research Division, Khumaltar are the research stations dedicated to fruit and nut researches (Table 1). A NGO LI-BIRD and ICIMOD are also doing research in very small scale such as home garden and technology demonstration activities. However, varieties release and registration is only done by NARC.

Table 1. Lists of offices involved in fruit researches

S.N.	Name of public institutes	Province	Ecological domain
1	Agricultural Research Station, Pakhribas	1	Mid-Hills
2	Agriculture and Forest University	3	Terai

3	Agricultural Research Station, Surkhet	6	River basin
4	Biotechnology Division, Khumaltar	3	Mid-hills
5	Food Research Division, Khumaltar	3	Mid-hills
6	Horticulture Research Station ,Malepatan	4	Mid-hills
7	Horticulture Research Station, Rajikot	6	High hills
8	Horticulture Research Station, Dailekh	6	Mid-hills
9	Horticulture Research Division, Khumaltar	3	Mid-hills
10	National Citrus Research Program, Paripattle	1	Mid-hills
11	Regional Agricultural Research Station, Khajura	5	Terai
12	Regional Agricultural Research Station, Lumle	4	Mid-hills
13	Regional Agricultural Research Station, Parwanipur	2	Terai
14	Regional Agricultural Research Station, Tarahara	1	Terai
15	Tribhuvan University	3	Mid hill/Terai
16	Li-BIRD	4	Mid-hills
17	ICIMOD	3	Mid-hills

Among them, there are only 5 research stations under NARC which are dedicated to fruit and nut researches in the country. They are National Citrus Research Program, Paripattle; Horticulture Research Division, Khumaltar; Horticulture Research Station, Malepatan; Horticulture Research Station, Dailekh; Horticulture Research Station, Rajikot. Other NARC stations involve in fruit research are four RARS and Food Research Division, Khumaltar. After a long research and investigations, some of the prominent technologies on propagation, post-harvest, plant protection and processing have been developed and available at Communication Publication and Documentation Division, Khumaltar and or respective disciplinary divisions of NARC (Table 2).

Table 2. Recently developed technologies in Nepal		
S.N.	Technology	Discipline
1	Macadamia nut vegetative propagation technology	Propagation
2	Splice grafting of Kiwi	Propagation
3	Walnut grafting technology	Propagation
4	Apple transportation cartoon box	Postharvest
5	Apple transportation technology	Postharvest
6	Asian pear post-harvest technology	Postharvest
7	Banana nectar production technology	Postharvest
8	Kiwi Jam and wine making technology	Postharvest
9	Orange grader machine	Postharvest

10	Pear Wine preparation technology	Postharvest
11	Post-harvest technology of mango	Postharvest
12	Alley cropping of Banana and Barseem	Production technology
13	INM in Citrus	Production technology
14	Improved production technology of lime	Production technology
15	Kiwi fruit varieties in Nepal	Production technology
16	Macadamia nut production technology	Production technology
17	Fruit fly management technology	Protection
18	IPM of mango stem borer	Protection
19	Mango mealy bug management technology	Protection
20	Woolly aphids management in apple	Protection
21	Mandarin cv. Khoku Local and acid lime cv. Tehrathum Local production technology	Production technology
22	Citrus fruit fly management technology	Protection
23	Hardwood cutting in pomegranate	Propagation

Source: Acharya, 2018

3. Present Status of Researches in Temperate Fruits

Evaluation of Spur Type Apple Cultivars and Variety Selection

To evaluate the spur type apple, germplasm were collected from RHRS, Mashobra, Simla and HTS, Kandaghat Solon ; and Canadian cultivars were imported from Canada and planted in HRS, Jumla, 2011. The recent result showed that three Indian spur cultivars 'Oregon Spur II', 'Starkrimson Delicious' and 'Red Spur' are found promising for good fruit quality, storability and disease pest resistant up to now and therefore proposals are being developed for registration by the year 2019. While characterization and evaluation is continued for registration of promising Canadian cultivars of apple germplasms.

Table 3. Apple germplasms introduced during 2010/11 in Nepal

S.N.	Indian cultivars	No of transplanted apple saplings	Canadian cultivars	No of transplanted apple saplings
1	Oregon Spur II	35	Ambrosia	3
2	Red Chief	35	Blushing Susan	3
3	Bright N Early	20	Honey Crisp	3
4	Red Gold	20	Gala	3
5	Vance Delicious	20	Red Gravenstein	3

6	Top Red	20	Jonagold (P)	3
7	Starkrimson Delicious	15	Jubile Fuji	3
8	Well Spur	15	Pristine	3
9	Red Spur	15	Redfree	3
10	Stark Spur Gold	15	Robinete	4
11			Sinta	3
12			Sunrise	4
13			Tsagaru	3
14			Zestar	3
15			Jim	4
Total		210		48

Source: ARS, Jumla, 2012

Introduction of New Temperate Fruit Germplasms

Some promising fruit germplasm of temperate fruits such as apple, pear, walnut and cherries were introduced by Horticulture Research Division, Khumaltar with the support of *Association Du Bessin Au Nepal*, France and *Kam For Sud*, Switzerland (HRD, 2018) (Table 4.)

Table 4: Recently introduced temperate fruit germplasms in Nepal, 2016/17

Fruit	Cultivars	Remarks	Importing institution	Year
Apple	Canada Gris, Baskoop, Malrose, Idared, Cox Orange, Belchard, Akane, Judaine, Reine des, Reinettes	Grafted sapling	Association Du Bessin Au Nepal	2016
	Boskoop, Florina, Mutterapfel, Prime Red Schneider Apfel, Sparton, Beauty of Kent, King of Pippin,	Grafted sapling	Kam for Sud	2017
	MM111, MM106	Clonal rootstock	Kam for Sud	2017
Walnut	Franquette	Grafted sapling	Association Du Bessin Au Nepal	2017
Hazelnut	Coutard	Grafted sapling	Association Du Bessin Au Nepal	2017
Black Currant	Neva, Andega	Grafted sapling	Association Du Bessin Au Nepal	2017
Himlayan Goji	GT8, 100/130 3L	Grafted sapling	Association Du Bessin Au Nepal	2017
Raspberry	Zeva	Rooted cutting	Association Du Bessin Au Nepal	2017

Peach	Benedite, Surprise	Grafted sapling	Association Du Bessin Au Nepal	2017
Plum	Mirabelle	Grafted sapling	Association Du Bessin Au Nepal	2017
Nectarin	Big Van, Burlat	Grafted sapling	Association Du Bessin Au Nepal	2017
Apricot	Hargrand, Bergeron	Grafted sapling	Association Du Bessin Au Nepal	2017

In this year three plants of each four walnut cultivars namely Xinjiang, Yanyuam, Chuanzhan and Xianglin were introduced from China and planted for variety evaluation in HRD, Khumaltar.

Standardization of Vegetative Methods of Walnut Propagation

To standardize the vegetative propagation methods in walnut, research was carried out and the result showed that third week of March (mid-March) was found to be highest success time for grafting walnut cv Hartley. The appropriate method of grafting was tongue grafting and success rate was more than 80% when wrapped with grafting tape covering the whole graft for a month. While the success rate of tongue grafting in old method was less than 50%.

Researches in Citrus and Subtropical Fruits

Recently two acid lime cv. Sun Kagati 1 and Sun Kagati 2 has been released so far and cv. Tehrathul Local has been registered. In case of mandarin orange, Khoku Local is registered (Table 5).

Name of fruit	Name of variety	Year of release	Registered/ released	Yield potential (t/ha)	Recommendation domain
Acid lime	Sun Kagati 1	2071	Released	34.5	Terai, inner terai and Mid hills
	Sun Kagati 2	2071	Released	26.9	Terai, inner terai and Mid hills
	Tehrathul Local	2075	Registered		Terai, inner terai and Mid hills
Mandarin orange	Khoku Local	2075	Registered	16-24	Terai, inner terai and Mid hills

Source: NCRP, 2013

Collection and Conservation of Citrus Germplasm in Field Gene Bank, NCRP, Dhankuta

Several germplasm of mandarin, sweet orange, grapefruit, tangor, and tangelo have been collected from local and exotic sources since the establishment of NCRP. A total of 130 germplasms of different cultivars of citrus were collected from exotic and local source and maintained at NCRP,

Paripatle. Collected germplasm have been preserved and being evaluated in field gene bank of NCRP, Dhankuta (NCRP, 2018).

Species	No of germplasms	Source
Mandarin Oranges	32	France, Japan and Local
Sweet Orange	34	India and France
Tangelo	3	France and Japan
Tan gore	4	France and Japan
Acid Lime	21	Local
Lime	6	Local
Grape fruit	8	France and Vietnam
Muntala	3	India
Rootstocks	19	Local and France
Total	130	

Source: NCRP, 2018

Among them cv Washington Navel and Valencia Late of sweet orange has been tested and recommended for commercial cultivation. Washington Navel is suitable for low altitude, seedless, matures in October-November. Valencia Late is seedless, matures in March-April and is a leading variety of the world.

Efficacy Study of Protein Baits against *B. Minax* and Monitoring of Occurrence

In 2012, NCRP, Paripatle assessed the effectiveness of commercially available proteins (i.e., autolysed protein) in field conditions. The commercial protein bait currently used is imported from Australia and United Kingdom which costs more than NRs 15000 per litre. Research was carried out to study on comparative efficacy of commercial and locally prepared protein baits in attracting fruit flies. Five treatments were compared; 1. Autolysed Protein from Australia @ 20 ml/L; 2. Sofri Protein from Vietnam @ 20 ml/L; 3. Beer supernatant; 4. Beer supernatant and debris (1:1); 5. Beer supernatant and debris (1:1) plus honey @ 5 g/L. It was found that that the locally produced protein bait was promising lure to monitor and manage fruit fly in citrus orchards when used in spot sprays. Though autolysed protein was the most attractive lure to both sexes of *B. minax* in Mc Phail traps, the beer supernatant and debris (1:1) plus honey showed a better result in spot sprays. Similarly, survey was carried out to find out the most occurrence period of fruit fly. It was found that the highest fruit fly species ensnared in methyl eugenol trap was from second week of June to second week of August in citrus orchard at NCRP, Dhankuta. Fruit fly species captured in cue lure trap was found to be the highest in mid-May to mid-September at NCRP, Dhankuta conditions. Similarly, fruit flies caught in McPhail trap using autolysed protein was the highest in third week of April to second week of August.

Rootstocks Evaluation

Percentage germination of trifoliate orange seeds was evaluated and found that seeds sown on 3rd week of September gave the highest germination percentage (68.7%) than 1st week of October and 1st week of September. Similarly fruit harvested at half yellow stage gave the highest germination percentage (70%). The effect of rootstocks on mandarin Khoku Local was evaluated and found that yield was higher in rootstock Citrumelo 4475 (7.54 kg/tree) followed by Citrange C-35 (7.5 kg/tree). Citrumelo 4475 and Volkamerina was found to be the promising rootstock for sweet orange cv. Washington Navel and Citrumelo 4475 was promising rootstock for acid lime cv. Terhathum Local.

High Density Planting in Citrus

A high density planting study in citrus was carried out and found that 2.5 m x 3 m and 3.5 m x 2.5 m spacing in mandarin orange produced the highest fruit weight and fruit diameter. But fruit yield was not significantly different. The highest yield was produced when planted in 3 m x 3 m (27 t/ha) as compared with 1.5 m x 3.0 m (7.5 t/ha), 1.75 m x 3.0 m (13 t/ha), 2.25 m x 3.0 m (13 t/ha), 2.5 m x 3.0 m (22 t/ha) and 3.5 m x 3 m (16 t/ha) respectively.

Chemical Application in Grape

The effect of different chemical application in grape production was studied at RARS, Nepalgunj and found that application of potassium nitrate (40 g/L water) produced the highest yield (89 kg/plant) while it was only 77.5 and 55.0 kg per plant when thiourea (thiourea (45 g/L water) and etherel (etherel 20 ppm, etherel 40 ppm) were applied respectively. Similarly, when nitrogen was applied at 300 g/plant, the number of bunch was the highest (28) and weight of bunch was 321 g per plant. A study on effect of GA application on yield attributes in grape was carried out. GA was applied at 20 ppm dipping at 10-14 days after bud break and again GA 20 ppm applied at flower opening time (March last week), cluster dipping in 40 ppm GA at 3-4 mm fruit size, dipping 40 ppm GA at 7-8 mm fruit size, and cluster dipping in 40 ppm GA at 3-4 mm fruit size plus 40 ppm GA at 7-8 mm fruit size. Result showed that cluster dipping in 40 ppm GA at 3-4 mm fruit size plus 40 ppm GA at 7-8 mm fruit size has promising on higher weight of individual bunch (g), breadth of bunch (cm), and weights of 20 fruits (g).

Researches in Kiwifruit

Owing to its delicacy, precocity, high economic return and high nutritional as well as medicinal values, kiwifruit has recently introduced in Nepal. Studies on basic knowledge and skill development, market information collection, germplasm cataloguing, standardization of propagation techniques, soil and water management and insect and disease monitoring were initiated in the fiscal year 2011/2012 in Nepal (HRD, 2013). The fruit characteristics of the eight kiwifruit cultivars including Red Kiwi were done following the Test Guidelines for Actinidia (www.upov.int) developed by International Union for the protection of New varieties of Plants, Geneva, Switzerland and HRD, Khumaltar recommended three promising varieties central mid-hill conditions of Nepal (HRD, 2014). Six varieties of kiwifruit (Hayward, Monte, Abott, Brun, Allison and Red Kiwi) were planted in 2012 for *in-situ* characterization and evaluation at ARS, Pakhribas, Dhankuta. Horticulture Research Division under NARC has imported three Chinese varieties (*Actinidia chinensis*) of kiwifruit and distributed to ARS, Pakhribas; ARS, Dailekh and ARS (Horticulture), Jumla for multi-location evaluation

and found that the performance was poor as compared with established cultivars. Application of compost from hedgerows clipping and/ or vermi-compost @ 80 kg per vine per year produced the highest fruit yield in kiwifruit. A study was carried out at Surya Kiwi fruit Farm, Patleket, Kavre to assess the yellow fleshed fruits from exiting vines. About 75 vines in the orchard were selected for study and found that 17 vines of cv. Hayward showed slight pale green yellow colour at ripen stage. Southern canopy showed higher pale green yellow fleshed fruits compared to fruits from Northern canopy. The result of pale green yellow color fleshed fruits from the orchard reflected varietal characters of kiwifruit (HRD, 2015). In one of the studies at ARS, Pakhribas, ascorbic acid content (ARS, Pakhribas) was found highest in Allision (41.8 mg/100 g fruit) followed by Abbott (36.1 mg/100 g fruit).

Collection and Evaluation of Pomegranate Germplasms

Realizing the scanty production of pomegranate in Nepal, and dependency on imports from India, HRD, Khumaltar is recently collected cutting of 10 exotic pomegranate cultivars (HRDPOM01, HRDPOM02, HRDPOM03, HRDPOM04, HRDPOM04M, HRDPOM05, HRDPOM07, HRDPOM10, HRDPOM11, HRDPOM12) and planted in well managed mother stock block aimed for multiplication, evaluation and selection. Among them, 5 of the germplasm (HRDPOM01, HRDPOM03, HRDPOM04, HRDPOM04M, HRDPOM05) has also been under multiplication evaluation at different stations of NARC (Malepatan, Salyan, Khajura, Surkhet, Dailekh) including horticulture farm of DOA, Trisuli.

Studies on effect of IBA on hardwood cuttings of pomegranate showed that success rate was highest in IBA 9000 ppm (68%) while it was 58% in IBA 12000 ppm and 52% in IBA 6000 ppm.

Identification of effective pomegranate butterfly and fruit drop management

A research was carried out with 5 treatments at HRD, Khumaltar to identification of effective pomegranate butterfly and fruit drop management practices. The treatments were 1. Bagging of individual fruits with Taiwani butter paper bags, 2. Bagging of individual fruits with mustard oil soaked newspapers, 3. Netting of pomegranate tree with insect proof nylon net, 4. Spraying of margo neem insecticide (azadirachtin 0.15% EC) @ 3 ml/L of water for five times at 15 days interval and compared with no spray, no bagged fruits. Evaluation is ongoing on fruit set, fruit drop & yield of pomegranate HRDPOM 004. Results showed that covering of individual fruits with Taiwani butter paper bag after fruit set may be a viable option to minimize pomegranate butter fly infestation and to improve the quality of fruits.

Collection and *In-situ* Evaluation of Avocado

Thirteen accessions of avocado (ARS P A-01, ARS P A-02, ARS P A-03, ARS P A-04, ARSP A-05, ARSP A-06, ARSP A-07, ARSP A-08, ARSP A-09, ARSP A-10, ARSP A-11, ARSP A-12, ARSP A-13) were collected from different locations of Dhankuta and evaluation process is ongoing based on fruits characters such as fruit weight (g), fruit length (cm), fruit diameter (cm), ripe fruit wt (g), seed weight (g), seed length (cm), seed diameter (cm), wt. of flesh (g) and weight of peel (g). The highest fruit weight was found in ARS PA-09 (399 g) followed by ARS PA-10 (338 g). The highest weight of flesh after ripe was found in ARS PA-10 (200 g) followed by ARS PA-09 (196 g). Therefore these two lines would be the potential germplasms for further evaluation and selection at Pakhribas conditions.

Researches in Tropical Fruits

For identification of planting time of tissue cultured banana plants at Parwanipur condition, three cultivars Malbhog, G9 and William Hybrid were planted in RCRD design with 3 replication. The planting time is started from mid March- to mid June at 30 days interval. Based on visual observation mid March planting time has better performance up to now. The collaboration with NFDD and SQCC, HRD, Khumaltar has developed and submitted proposal for variety registration of following three cultivars of banana.

1. William Hybrid
2. Malbhog
3. G-9

High density planting (HDP) experiment in three mango cultivars (Amrapali, Mallika and Neelum) established at RARS, Parwanipur in 2018. There are 4 levels of spacing (7m x 7m, 6m x 6m, 5m x 5m, and 4m x 4m). Similarly, a project on collection, characterization and evaluation of new emerging commercial fruits (dragon fruit, avocado, cherry and blueberry) in Nepal has proposed and started to work from 2018.

4. Future Prospect and Opportunities

Fruits have high comparative advantage over other crops such as kiwifruit, Himalayan berries, citrus, apple, mango, banana dragon fruits, blueberries etc. They are comparatively expensive fruits in domestic as well as international market. There is high opportunities in fruit research and development.

- Collection and utilization of existing wide range of genetic resources in the country
- Fruit value chain study and possibility of extension of production season and supply of fresh is high in Nepal. It can be possible by production enhancement during lean-season through variety diversification, modification of cultural practices and protected cultivation
- Nepal has diversity in micro-climate, niche climate and rich in horticulture biodiversity
- Fruit production is highly technology responsive enterprise.
- High scope of import substitution and export promotion to international market
- Interest of international companies in emerging and innovative fruits
- Linkage of main roads with agri-roads/feeder roads to big cities like Kathmandu/Pokhara
- Scope of high density planting of banana, citrus, apple and mango is high and is emerging technology

5. Constraints and Challenges

Despite of greater scope and potentiality there are various constraints in fruit researches in Nepal. The past research scenarios showed that production oriented and farmers problem solving adaptive research were given priority. These researches were limited to introduction of new germplasms. Except intensive research in citrus species, other commodities are far neglected and shadowed for research prioritization. Because of lack of external support, perennial in nature, long gestation period, long time need for research results, fruit researches except citrus is in extreme dearth. Following constraints and challenges are still existing in fruit research in Nepal.

- Lack of motivation of pomologist to work and continue their career in fruit research
- Poor of coordination with national /international institutions
- Lack of laboratory and infrastructures
- Uptake and dissemination of technologies –R and D gaps is wide
- Poor of effective coordination and linkages between stakeholders
- Poor policy support in fruit research and development
- Global climate change situation- huge effect in fruit biology and physiology
- Long gestation period for the commercial production of most of these fruits

6. Way Forwards

Considering the importance and constraints in fruit researches in Nepal, a five-year plan is proposed to increase the production and productivity of horticultural crops.

I. Organizational Reform

Establishment of Horticulture Research Institute (HRI) under NARC

The technological demands on horticultural crops are ever increasing and entrepreneurs from all across the country are contacting for commercial horticultural enterprises with strong commitment of significant financial investment. Paradoxically horticultural research – the fuel of subsector's development engine, has been struggling with many challenges to cater the technological need of the clientele. To make fruit research more effective and efficient in a coordinated manner, Horticulture Research Institute shall be established as per envisaged by Agriculture Development Strategy (ADS) within the five years. To take the momentum in fruit research in NARC, it needs to be restructured with special focus on fruit researches. For example, Horticulture Research Institute as envisaged by ADS should be established. Fruit and Nut Research Division should be assigned as leading apex body including Fruit Research Units, one at each province under NARC should be established.

II. Collaboration and Linkage Development

Collaboration and linkage shall be established with new and changed structure of MoALD such as Agriculture Knowledge Centre and private companies for outreach research program. Private companies shall be monitored and guided for by Horticulture Research Institute (HRI) for fruit research activities. A strong linkage shall be established with Universities such as Agriculture and Forestry University (AFU) and Tribhuvan University (TU). Similarly, international organizations such as IPGRI, ICIMOD, CGIAR shall be extended to exchange the valuable fruit germplasms.

III. Upgrading and Establishment of Fruit Commodity Program

At least five commodity research program shall be established or upgraded the existing program to streamline the fruit research program in Nepal. Further upgrading of NPCR along with establishment of Tropical Fruit Research Station at Province 2 and Temperate Fruit Research Station at Province 5 at national level can streamline NARC's fruit researches.

S.N.	Name of commodity research	Location	Remarks
1	Temperate horticulture research program	Jumla	Upgrading
2	Tropical horticulture research program	Parwanipur or Tarhara	Proposed
3	National citrus research program	Dhankuta	Existing
4	Coffee research program	Gulmi	Upgrading
5	Commercial crop research program	Eastern region	Proposed/upgrading

Similarly, Faculty of Horticulture will be established under Deemed to be University and research study on M.Sc. and PhD shall be done.

- i. Technology registration/release shall be adopted as being followed for variety release
- ii. Provision of patent incentives for technology inventor
- iii. Research investment shall be increased in proportionate to its contribution in AGDP
- iv. Public- private partnership shall be strengthened
- v. Need of basket fund development and utilization by all stakeholders for research and development
- vi. More vibrant and output oriented research by commodity based consolidated planning with specified role and responsibility shall urgently needed
- vii. Increase number of fruit researcher
- viii. Stability of posting and positive discrimination to fruit researcher
- ix. Climate smart technology generation
- x. Post-harvest technologies generation linked with business
- xi. Fruit germplasms available in public and private farms should be characterized, evaluated, multiplied and selected for wider geographical recommendation based on yield performance, export quality and market niche from the single door.
- xii. NARC should define lead center for each fruit commodity and focus on variety improvement and other production technologies on national level. *In-situ* evaluation of these genotypes using a common protocol could be a worth at initial step whether they are under public or private description.

Most of the varieties of major fruit crops growing in Nepal are exotic and hardly a few of these fruits are of local or wild varieties. Therefore, it is prerequisite for the cultivation of wild fruit trees/shrubs under improved practices and screening for high yielding/quality performing varieties. These germplasms should be utilized in fruit industry by domestication of elite lines/varieties or using as rootstocks. For this, characterization, evaluation and utilization should be the priority program by public research institutions.

7. Conclusions

Except intensive research in citrus species, other commodities are far neglected and shadowed for research prioritization. Because of no external support, perennial in nature, long gestation period, long time needed to conduct research for results, fruit research except citrus is in extreme dearth. To streamline the fruit research, a dedicated entity has to be identify by public sector research

organization with clear mandate for national coordination and command. Streamlining of fruit research in public sector is a pressing need of time and private sector could be boarded to hasten the process of evaluation. NARC should define lead center for each fruit commodity and focus on variety improvement and other production technologies on national level. However, the research in fruits and nut species still is lagging far behind than the technological demand of the country despite some good ground work has been carried out and research based technologies have been disseminated into farmers' fields.

References

- Acharya, UK. 2017. Present and Future Research Status and Development Strategies of Fruit in Nepal. *In: Gautam, IP., Shrestha, SL., Subedi, GD., Bhatpara, DR. and Gotame, TP. (Eds). 2017. Proceedings of Ninth National Horticulture Workshop, 31st May - 1st June, 2017 (Jestha 17 -18, 2074), NARC, HRD, Khumaltar, Lalitpur, Nepal.*
- ARS. 2012. Annual Report - 2069/2070 (2012/2013). Agricultural Research Station (Horticulture), Rajikot, Jumla.
- HRD. 2018. Annual Report 2074/75 (2017/18). Horticulture Research Division, NARC, Khumaltar, Lalitpur, Nepal.
- Gotame, TP, KP Paudyal and PP Khatiwada. 2014. Status of fruit and nut genetic resources in Nepal, indigenus and exotic varietal inventory. Horticulture Research Division, Nepal Agricultural Research Council, Khumaltar, Lalitpur. NARC Publication Serial No. 0090-12 (2013/14).
- MoAD. 2014. Statistical information on Nepalese agriculture, Ministry of Agricultural Development; Agri-Business Promotion and Statistics Division, Singh Durbar Kathmandu, Nepal.
- MoAD. 2015. Statistical information on Nepalese agriculture, Ministry of Agricultural Development; Agri-Business Promotion and Statistics Division, Singh Durbar Kathmandu, Nepal.
- NCRP. 2013. Annual Report 2069/70 (2012/13). National Citrus Research Programme, Paripatle, Dhankuta.
- NCRP. 2018. Annual Report 2074/75 (2017/18). National Citrus Research Programme, Paripatle, Dhankuta.
- Pandey, G, S Basnet, B Pant and K Bhattarai, B Gyawali and A Tiwari. 2017. An analysis of vegetables and fruits production scenario in Nepal. *Asian Research Journal of Agriculture* 6(3): 1-10.