Recent Technology Development and Research Status of Fruit Crops: Role of Nepal Agriculture Research Council in Nepal

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Abstract

Nepal Agriculture Research Council has made an effort to streamline six thematic areas of fruit research such as varietal improvement, production technologies, plant protection, post-harvest management, germplasm collection and its evaluation and propagation methods. In recent years, some promising technologies have been developed in some fruit crops; mango, citrus, papaya, banana, pomegranate, apple, walnut, kiwi fruit, litchi, pineapple, and mecademia nut are given here. Different pre and post-harvest management technologies are developed in mandarine, sweet orange, acid lime, papaya, kiwi, banana and pineapple and fruit fly management in citrus, borer management in litchi fruit and delay ripening technique in banana fruit and early ripening in pineapple fruit. Application of cytokinin and micronutrient decreased the fruit drop in macadamia nut. Pre harvest treatment with Borax on lime improved freshness and postharvest longevity of lime and appropriate packaging, coating material and storage technique for acid lime. Among varietal development research, G9, Willium hybrid and Malbhog varieties of banana have been registered. Washington navel proposed for varietal release due to its fruit quality, yield, off-season production. Bedana pomegranate has been found as the promising variety for the mild hill (Pakhribas area) of eastern Nepal. One of the best suitable Pomegranate genotype ewill be proposed for variety registration. HRS-02 guava had shown maximum TSS and total sugar content. Some Canadian and French apple cultivars are showing good performance. Beside this, research on new emerging fruit crops like dragon fruit, avocado, berries being studied and will get some output within few years.

Keywords: *Cultivars, fruit crops, NARC, Post-harvest management, Registration, Recent technology*

INTRODUCTION

The total cultivated area is around three million hectares, of which around 4.79% is covered by fruit crops. The contribution of the horticulture sector amounts to 15% of Agriculture GDP, of which almost half is constituted by fruits (MOALD, 2018).During the last 15 years, productive area of fruits has been increased by about 117% from 51,016 in 2002-03 to 110,502 ha in 2016-17 whereas the production has gone up by about 96% from 518,864 mt in 2002-03 to 1,018,307 mt in 2016-17. Even though area and production of fruits have doubled during last 15 years (2001 to 2015) but fruit productivity is not increased (Table 1).

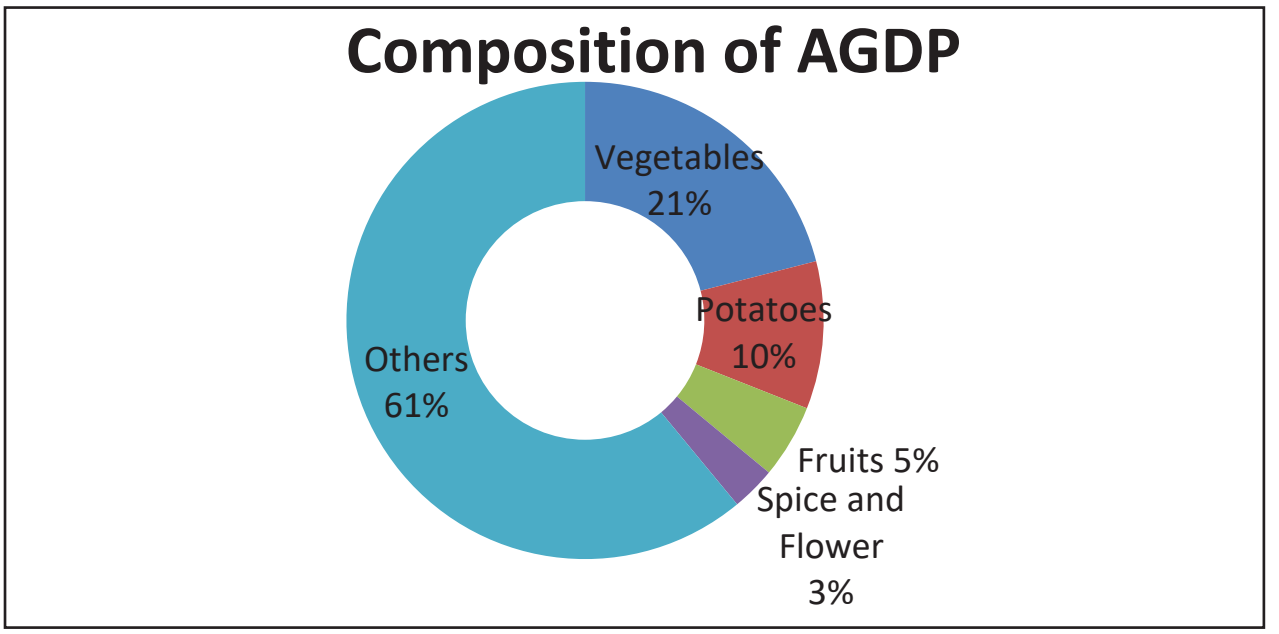

Figure 1: Contribution of horticultural commodity to AGDP

Table 1: Area, Production and Productivity of Fruits in Nepal

Year	Area (ha)	Production (mt)	Productivity (mt/ha)
2002/03	80426	51016	10.17
2006/07	94901	57595	9.99
2010/11	117932	79184	10.03
2014/15	150387	110802	8.96
2016/17	162660	110502	9.22

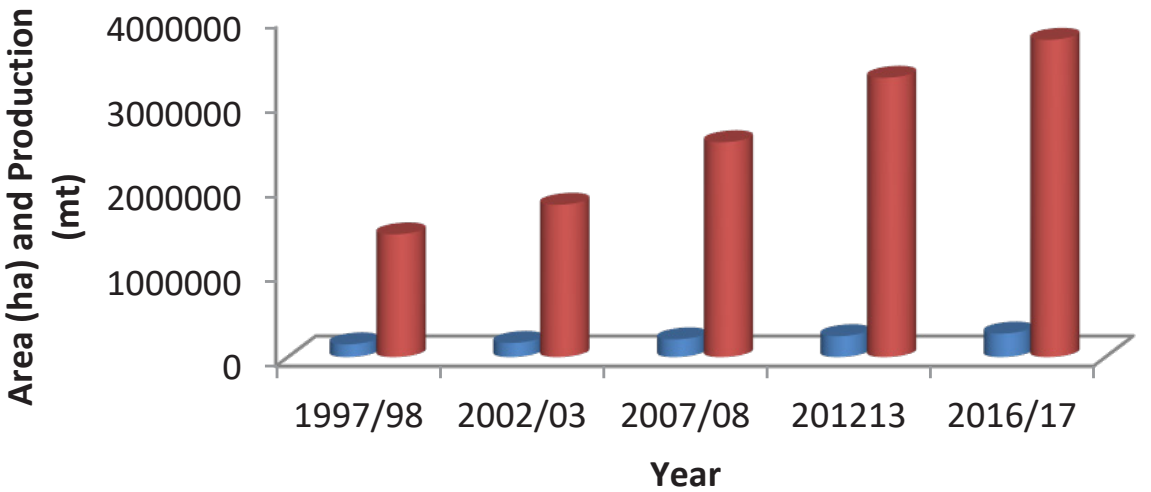

Figure 2: Area and Production status of fruit crops during 2002/03 to 2016/17

Owing to its greatly varied geographical and climatic conditions, altitude ranging from 70 m (Kechana Kalan in Jhapa) to 8848 masl (Mt. Everest), Nepal accommodates wider biodiversity, and this applies to the growing of diverse biotypes of fruit species as well. There are 45 species belonging to 37 genera of wild edible fruits (Kaini 2004, 2012; Kainiet al. 2016). Seasonal fruits harvested from the forests can be seen in many local markets even today. Southern Terai regions are suitable for cultivation of tropical fruits while mid-hills and

high-hills towards north are suitable for sub-tropical to warm and cold temperate fruit and nut species (Atreya and Manandhar 2016).

Fruit research in NARC in general is struggling to deliver the technological need of clients despite vegetable is in better position than that of fruits. Because of no external support from international organization, perennial in nature, long time need for research results and unclear policy, fruit research except citrus is in extreme dearth. In this context, NARC has made an effort to streamline six thematic areas of fruit research such as varietal improvement, production technologies, plant protection, post-harvest management, germplasm collection and its evaluation and propagation methods. Horticulture Research Division (HRD) under NARC has been working with goal of contributing horticulture development through the use of modern technologies. HRD coordinates at national level with various research stations for horticultural research, germplasm conservation, breeder and foundation seed production and variety maintenance. It establishes linkage with national and international horticultural research organizations and provide technical support to horticulture researchers. It has taken strategies; collection and utilization of genetic resources from local and exotic sources, varietal improvement through conventional and hybrid breeding and productivity enhancement through proper utilization of natural resources and spaces, production enhancement during lean-season through variety diversification, modification of cultural practices and protected cultivation, protecting consumers' health by safe food production, post-harvest loss reduction, high quality source seed and mother stock production, public-private partnership in horticulture research, expand international collaboration, improvement of technical capacity of researchers and develop necessary research infrastructure and national network.

In recent years, some promising technologies have been developed in some fruit crops; mango, citrus, papaya, banana, pomegranate, apple, walnut, kiwi fruit, litchi, pineapple, and mecademia nut are given here. Different pre and post-harvest management technologies were developed in citrus, papaya, kiwi, banana and pineapple and fruit fly management in citrus, borer management in litchi fruit and delay ripening technique in banana fruit and early ripening in pineapple fruit has been tried to include in this paper.

Export and Import Scenario of Fruits

Table 2 and 3 illustrate the situation of fruits trade in three years. Among the exported fruits category, the shares of summer fruits and citrus are high in comparison to winter fruit by volume and values except in the year 2015-16 where winter fruit share 36% and 7% by volume and values. However, in import, summer fruit and winter fruit share much more than citrus fruit by volume and values. In terms of volume and values, the export of fruit has been decreased almost 100% while import of fruits has been increased by 4% and 7% respectively in comparison to 2014-15 (MOALD, 2016).

Table 2: Export of Fruits

Fruits	**2014/15**		**2015/16**		**2016/17**	
	Volume (mt)	Values (NRs.'000)	Volume (mt)	Values (NRs.'000)	Volume (mt)	Values (NRs.'000)
Summer fruits	15824	2841629	991	170639	84	6991
Citrus fruits	452	5273	19	1097	830	16995
Winter fruits	146	3502	577	13657	27	5205
Total	16422	2850404	1588	185393	940	29191

Source: MOALD,2016-2018

Table 3: Impor t of Fruits						
Fruits	**2014/15**		**2015/16**		**2016/17**	
	Volume (mt)	Values (NRs.'000)	Volume (mt)	Values (NRs.'000)	Volume (mt)	Values (NRs.'000)
Summer fruits	110765	6879595	72261	3927867	73788	3672570
Citrus fruits	30242	1406894	27994	1321125	29456	1370177
Winter fruits	48151	2243149	90724	5570237	93029	6196588
Total	189158	10529639	190979	10819229	196273	1239336

Source: MOALD,2016-2018

1. Varietal Development

1.1 Characterization of Different Cultivars of kiwifruit (Actinidia species) at Mid-hills, kavre, Nepal

It Nepal As the climatic requirements for the production of kiwifruit in mid hills have been considered much favorable (Paudyal 2013) it has been cultivating in the range of 1200-2500 masl. As a result the area under the cultivation of kiwifruit is 52 hectare and its production is about 368.1 metric tonnes in Nepal (FDD, 2015).

The goal of this research was to examine the morphological, pomological and physio-chemical characteristics of six different kiwifruit cultivars grown in the mid-hills region of Kavre district, and to select the most appropriate cultivar for mid-hills to sustain commercial cultivation (Table 4).

Table 4: Morphological characters of different cultivars of kiwifruit from Kavre District of Nepal					
Morphological Characters	**Cultivars**				
	Actinidia chinensis	**Actinidia deliciosa**			
	Red Kiwi	Hayward Long	Hayward Round	Bruno	Allison
Plant vigor	Medium	Medium	Medium	Medium	Medium
Density of hairs on young shoot	Very sparse	Medium	Medium	Sparse	Medium
Present of anthocyanin on young shoot	Weak	Weak	Medium	Absent	Absent
Texture of bark on stem	Smooth	Very rough	Very rough	Very rough	Very rough
Density of hairson stem	Absent	Medium	Medium	Medium	Medium
Leaf blade: shape of apex	Acute	Acute	Acute	Emarginate with cuspidate	Emarginate with cuspidate
Leaf blade: basal lobes	Slightly apart	Slightly overlapping	Slightly overlapping	Slightly overlapping	Emarginate with uspidate
Leaf blade: number of ciliate serrations	Few	Few	Few	Few	Few

Leaf blade: density of hairs on upper side	Absent	Absent	Absent	Absent	Absent
Leaf blade: density of hairs on lower side	Sparse	Medium	Medium	Medium	Medium
Leaf blade: intensity of green colour on upper side	Medium	Medium	Medium	Medium	Dark medium
Leaf blade: intensity of green color on lower side	Medium green	Yellow green	Medium green	Yellow green	Light green
Leaf blade: variegation	Absent	Absent	Absent	Absent	Absent
Leaf blade: color of variegation	Absent	Absent	Absent	Absent	Absent
Petiole: anthocyanin coloration of upper side	Absent	Medium	Medium	Weak	Medium
Inflorescence: type	Solitary	Dichasium	Solitary	Solitary	Dichasium

Source:Dhakal, 2017

Varietal Evaluation in Kiwifruit

Six cultivars; Hayward long, Hayward round, Bruno, Allison, Red kiwi and Golden kiwi are under varietal evaluation process at HRD Khumaltar. HRD has plan to register one of the best variety in near future.

1.2 Varietal Development in Banana

In Nepal local varieties (Malbhog) and Dwarf Cavendish are being grown up to 1630 m from sea level. These two varieties are resistant to drought(Thapa and Karmaccharya 1990, Singh 1995). Since long time no any released variety, three varieties of Banana (G9, William hybrid and Malbhog) have been registered by Horticulture Research Division in collaboration with Fruit Development Program and SQCC.

Table 5. Banana varieties recommended and registered for Terai region:

	William Hybrid	**Malbhog**	**Grand Nain- G9**
Fruit color at ripening	Attractive yellowish green	Light yellow	Attractive yellowish green
Plant height	6-8 ft	2.5 m	2-2.5 m
Days from flowering to harvest	2.5 months	3.0 months	2.5 months
Average yield	40-50 t/ha	15-20 t/ha	50-55 t/ha
Number of fingers/plants	140 (130-200)	90-150	175-225
Weight of fruit/plant	15-25 kg	12-15 kg	30 kg

1.3 Evaluation of Pomegranate Cultivars

A multilocation evaluation trial on pomegranate germplasms has been established at Khumaltar, Nuwakot, Nepalgunj, Surkhet, Dailekh and Malepatan. Ten germplasms of pomegranate were evaluated for their vegetative and pomological characteristics at HRD Khumaltar. The preliminary result revealed that HRDPOM002 was the dwarf genotype and HRDPOM001 was grown upright. The highest numbers of fruits were harvested from HRDPOM002 but produced negligible marketable yield. The highest fruit yield was produced in HRDPOM005 (3.8 kg/plant) followed by HRDPOM011 (3.2 kg/plant). The genotypes HRDPOM004, HRDPOM005, HRDPOM007 and

HRDPOM011 showed better performance. Therefore, among these one of the best has developed and submitted proposal for variety registration.

Bedana pomegranate has been found as the promising variety for the mid hills of eastern Nepal. During varietal trial at Pakhribas, Bedana had the biggest fruit (293.5 g) and the highest TSS (12.3) where TA was higher in local variety (1.5%) (Pakhribas, 2017).

1.4 Guava Germplasm

Guava cultivars collected and grown in Horticulture Research Station, Pokhara were evaluated for its physical and chemical quality of leaf and fruits. The preliminary result revealed that leaf size was largest in Allahabad Safeda (88.37 sq cm) whereas fruit volume was recorded highest in cv. KG-1 (17 ml) (Table 5). The fruits of HRS02 had maximum TSS (11.72 0B) total sugar whereas cv. L-49 had the maximum moisture percentage (86.6 %). Ascorbic acid was recorded 10.57 mg/100g in cultivar KG-1 and minimum in HRS-04 (4.86 mg/100g) (Table 7).

Table 6 : Physical quality parameter of Leaf and fruit of Guava

Genotypes	Leaf (L)	Leaf (B)	Leaf size (sq.cm)	Weight (gm)	Fruit L (mm)	Fruit B (mm)	Volume (ml)
KG-1	11.08	5.59	62.224	176.2	66.896	67.026	178
Dudhiya	10.83	6.52	71.687	74.2	48.454	48.78	71
HRS-01	12.39	5.3	66.068	74.8	46.096	52.131	75
HRS-02	6.61	3.16	21.23	58.6	43.162	45.274	68.4
HRS-03	13.08	4.81	63.507	70.7	46.41	49.772	67
HRS-04	10.68	4.78	51.393	33.4	35.924	36.966	34.6
L-49	11.93	5.3	63.898	74.8	46.096	52.131	75
Allahabad Safeda	13.53	6.48	88.37	125.8	54.614	60.159	100
Gorkha							
Selection	-	-	-	51	44.29	41.4	69
Allahabad							
rato	11.58	4.37	50.535	-	-	-	-

Source : HRD, 2016/17

Table 7 : Proximate composition of Guava fruit

Cultivar	Moisture (%)	Acidity (%)	Total Sugar (mg/100g)	Reducing Sugar (mg/100g)	Non reducing Sugar (mg/100g)	TSS (o B)	Ascorbic acid (mg/100g)
KG-1	78.41	0.28	213.53	112.29	101.24		10.57
Dudhiya	85.82	0.25	198.33	104.53	94.13	8.54	5.63
HRS-01	83.99	0.24	215.23	136.53	78.7	7.28	4.89
HRS-02	83.00	0.52	330.46	68.07	262.39	11.72	
HRS-03	75.26	0.39	146.42	126.74	19.68	5.6	6.19
HRS-04	74.1	1.03	103.5	89.54	13.96	9.62	4.86
L-49	86.6	0.57	65.12	21.48	43.64	6.8	
Allahabad Safeda	79.31	0.23	160.15	51.05	109.1	7.988	7.65

Source : HRD, 2016/17

Eight different guava germplasms were collected and the fruits of HRS-02 had maximum TSS and total sugar whereas cultivar L-49 had maximum moisture percentage followed by Dudhiya whereas higher ascorbic acid was recorded (10.57 mg/100 mg) in KG-1 and minimum in HRS-04.

1.5 Varietal Evaluation in Guava

Six cultivars; Bangalor, Pear-shaped, Apple guava, Bari, KG-1 and Ilam selection are under varietal evaluation process at HRD, Khumaltar.

1.6 Varietal Development in Walnut

In recent years, thirty different germplasms of walnut were collected from Mustang district and its phenological characters were identified (Lumle, 2018).

1.7 Varietal Development in Citrus

Washington navel has been proposed for varietal release due to its fruit quality, yield, off-season production and it is suitable for off-season production. Among the tested cultivars, Malta blood red, Delicious seed less, Sucari, Dhankuta local have shown higher yield. Washington navel is in the process of being proposed for varietal release.

1.8 Varietal Development in Apple

Germplasm evaluation and selection on Canadian and French apple cultivars being on process at HRS Jumla, Rajikot, some cultivars showing good performance.

2. Post-Harvest

2.1 Development of appropriate postharvest handling technologies in papaya

Researches on fruit composition determination and self-life determination of papaya are ongoing in HRD, Khumaltar.

Identification of appropriate cushioning and packaging materials during transportation to distant markets

Harvested fruits in different stages were wrapped and transported to Kathmandu from Chitwan and stored for one week in ambient room condition. The preliminary study done by HRD revealed that physiological weight loss (%) of cv. Red Lady of Papaya had the lowest PWL% (29.1 %) followed by using newspaper in 1/4th ripen papaya treatment (48.1%) and straw in 1/4th ripen treatment (48.9 %) respectively (Table 8).

Table 8: Physiological weight loss (%) of Papaya (Red Lady) from farm to one week of storage.

Treatments	Weight loss 1 (%)	Weight loss 2 (%)
A.Wrapping materials		
Newspaper	7.06	67.3
Straw	7.66	59.5
Control	10.34	74.7
F-Value	ns	ns

B. Stage		
Fully matured	5.96	51.5
1/4 th ripen	9.12	49.9
½ ndripem	9.98	100
F-Value	ns	**
LSD		12.11
Interaction (A * B)		
Newspaper * fully matured	5.23	53.7
Newspaper * ¼ th ripen	8.72	48.1
Newspaper * 1/2 th ripen	7.23	100
Straw * fully matured	6	29.5
Straw * ¼ th matured	7.64	48.9
Straw * 1/2 th matured	9.35	100
Straw * fully matured	6.66	71.4
Straw * ¼ th matured	10.99	52.8
Straw * 1/2 th matured	13.37	100
Grand Mean	8.35	67.2
F - Test	ns	ns

Source :HRD, 2016/17

Study on effect of calcium chloride on shelf life of papaya under different storage condition

Stage second (50% ripening) of papaya fruits were selected for the research. A unit samples of four fruits of each experimental units were dip in 0.5 %, 1%, 1.5%, 2%, 2.5 % and 3% for five minutes in calcium chloride solution and replicated three times. The treated fruits were stored in ambient and coolbot storage for further postharvest evaluation. Data compilation is ongoing.

2.2 Study on the post-harvest loss of acid lime in different packaging container from Syangja district to Pokhara transportation

Preliminary study showed that higher transportation losses were recorded in polythene packaging while lower in plastic crate. In contrast to transportation loss, storage loss was recorded higher from jute sac packed fruits while it was found less in Polythene bag packed fruits.

2.3 Nutrient Management in sweet orange for improving shelf life

NCRP,Dhankuta is planning to conduct an experiment on foliar spray of multi-nutrients, soil application of nutrients, combination of both and farmers practice on sweet orange at 15 days after flushing and 15 days after fruit formation and evaluating its shelf life period.

2.4 Study on post-harvest disease management technology for citrus fruit

Experiment will be carried out to assess the decay loss of mandarin and sweet orange

due to blue mold in cellar, Zero energy, Cool bot and normal room condition with dipping in different solutions; Ginger extract 10%, Calcium carbonate 6.25 g/lt, Potassium carbonate (2000 ppm), Fludioxonil (1500 ppm), Potassium sorbate (2000ppm).). Shelf-life will be assessed on the basis of chemical changes (acidity, TSS, vitamin C) and microbiological changes (mold infestation) and PLW during storage. Sensory evaluation will be carried out for acceptability.

2.5 Banana postharvest practices: control on disease spreading and measures to improve shelf life

Preliminary study showed that banana bunch treated with SNP 2.5 mM single and in combination with ethylene treatment (1000 ppm) after water cooling at 15-180C and this treatment has given the encouraging result to delay ripening.

2.6 Post harvest management in acid lime

The technology in acid lime revealed that treated with castor oil was found better and packaged in MAP had the uniform color development and good appealing and marketing characters during storage condition at HRD Kumaltar. Likewise, at RARS Lumle; among the different pre harvest treatment, the sprayed of Borax @0.6 % shows better result with freshness and longevity, post-harvest study of lime was continued for 45 days on the basis of freshness of fruits. Study conducted by HRS Malepatan showed that in acid lime transportation losses were assessed higher in polythene packaging than plastic crates in contrast to transportation loss, storage loss was recorded higher in jute sac packed fruits while it was found less in polythene bag packed fruit. Beside this, NCRP Dhankuta reported that nutrient management also showed improving shelf life in sweet orange and NCRP identified maturity indices of mandarin and sweet orange at different altitude of Sindhuli district as well.

A study on coating and packaging effect on postharvest quality of acid lime at HRD Khumaltar revealed that the fruit coated with coconut and castor oil was found better quality while the fruit packaged in modified atmosphere packaging had the uniform color development and good appealing and marketing characters with longer shelf life during storage under ambient lab condition for one month.

2.7 Kiwifruit Trial

2.7.1 Physio-chemical characters

The Physio-chemical characteristics of six cultivars of Kiwifruit are presented in Figure 1, 2 and 3. The result showed that the total soluble solid content differed between the cultivars. Total soluble solid content was maximum in the variety Red Kiwi (17.9 °Brix). In the present study, the total soluble solid (TSS) content of the fruits ranged from 8.3 - 17.9 °Brix. The maximum total soluble solid content in the fruits was measured from Red Kiwi (17.9 °Brix) followed by Monty (15.4°Brix) and the minimum from Bruno (8.3°Brix). Likewise, Allison showed the highest titrable acidity (0.94%) followed by Hayward Round (0.92%) and the lowest from Red Kiwi (0.28%). Similarly, the vitamin C content ranged from 27.44 to 41.80 mg ascorbic acid/100 g fruit weight. The vitamin C content was highest in Allison (41.80) followed by Abbott (36.1) and was least in Red Kiwi 27.44 mg.

2.8.2 Post-harvest characterization of different cultivars of Kiwi fruit

Significant difference on weight loss was observed on five cultivars in the first week of storage. Afterwards, no any significant difference in percent weight loss was recorded. Maximum weight loss was recorded in Bruno whereas percent weight loss was minimum in Hayward

long. Long storage and minimal weight loss in Hayward might be because of lowest respiration and less ethylene production than other varieties as reported by Manolopoulou and Papadopoulou, 1998. Thus, it can be concluded that for immediate marketing Bruno can be a good selection whereas Hayward Long can be stored for longer duration compared to other three varieties.

Total soluble solids content of fruits during storage is considered an index of fruit ripening and increase in TSS corresponds to a conversion of starch to soluble sugars. The TSS of different kiwifruit cultivar was increased with some level of storage period and then remain constant afterwards (Table 9).

Table 9. Changes in Total Soluble Solids during storage under ambient room condition during two years at HRD, Khumaltar

Cultivars	TSS ºBrix (At harvest)	TSS ºBrix (wk1)	TSS ºBrix (wk2)	TSS ºBrix (wk3)	TSS ºBrix (wk4)	TSS ºBrix (wk5)	TSS ºBrix (wk6)	TSS ºBrix (wk7)
Hayward Long	8.17	10.77	11.73	11.22	13.38	14.48	14.48	14.54
Hayward Round	9.66	11.46	11.46	12.44	12.87	13.32	13.32	13.56
Allison	9.55	10.88	11.58	11.95	12.32	12.44	12.44	12.55
Bruno	8.33	9.66	11.79	12.14	12.91	13.54	13.50	13.66
Monty	10.67	12.67	12.99	13.23	13.77	14.36	14.43	14.67
Grand Mean	9.28	11.90	11.79	12.14	12.91	13.54	13.63	13.79
F-test	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
LSD (0.05)	0.42	0.19	0.07	0.09	0.08	0.12	0.11	0.21
CV%	3.4	1.3	0.4	0.6	0.5	0.7	0.6	1.2

Source: HRD, 2016/17

Titrable Acidity decreased with time upto 4th week of storage and then showed constant effect afterwards on both the years. Thus, the decrease of Titrable acidity was more pronounced until 28 days and after that period it was almost stable during storage (Table 10).

Table 10. Changes in Titrable acidity during storage under ambient room condition during two years at HRD, Khumaltar

Cultivars	TA% (At harvest)	TA% (wk1)	TA% (wk2)	TA% (wk3)	TA% (wk4)	TA % (wk5)	TA% (wk6)	TA% (wk7)
Hayward Long	0.55	0.54	0.47	0.41	0.36	0.30	0.29	0.29
Hayward Round	0.66	0.52	0.48	0.37	0.34	0.33	0.33	0.32
Allison	0.68	0.54	0.49	0.47	0.42	0.38	0.38	0.37
Bruno	0.70	0.66	0.54	0.51	0.49	0.38	0.37	0.33
Monty	0.60	0.52	0.39	0.37	0.35	0.35	0.34	0.34
Grand Mean	0.63	0.55	0.47	0.42	0.39	0.34	0.34	0.33
F-test	0.11	<.001	<.001	<.001	<.001	<.001	<.001	<.001
LSD (0.05)	0.12	0.01	0.02	0.01	0.01	0.005	0.03	0.03
CV%	14.1	2.3	3.9	3.3	3.9	1.1	7.0	7.6

Source: HRD, 2016/17

3. Nutrient Management

3.1 Integrated plant nutrient system management (IPNS) in (citrus)

IPNS management is one of the major key to revive declined citrus orchards. It is resulted by the both biotic (mainly diseases and insects) and abiotic factors (soil, nutrition, water etc) (Thakur et al. 2017). The inconsistent manuring practice is the most serious problems in citrus growing pockets in central and western development region of Nepal (Gurung 1998). In some citrus pocket areas of Nepal, more than 100 years old trees are still in fruiting condition, which indicates proper nutrient management for longer the life of trees. Major cultivated varieties of mandarin orange in Nepal are Pokhara local, Dailekh local and Dhankuta local (NCDP 2016). Considering poor nutrient management as one of the major problem in citrus decline, on station research work on integrated nutrient management in citrus genotype Khoku local was carried out at National Citrus Research Program, Dhankuta for two consecutive year i.e. from December 2010 to December 2012 and the results revealed that number of fruit and fruit yield observed to be highest with 500g N+ 250gP+ 500gK+75gCUSO4+20g H3BO3+ 150gZnSo4+75gm MnSO4/tree. But fruit weight was observed to be highest with 500gN+250gP+ 500K/tree (Thakur et al., 2017). Thus, Nitrogen and potassium are two most important nutrients for citrus tree growth, fruit yield in adequate amount especially at critical growth stages i.e. fruit initiation and development (Obreza and Morgan 2008).

3.2 Effect of plant growth regulators and micronutrients to control fruit drop in macadamia nut

Macadamia trees usually produce numerous flowers borne on axillary racemes and a mature tree can produce more than 10,000 racemes each consisting of 100 – 300 flowers. However less than 10% of flowers can be successfully fertilized and set young fruit in 2 weeks after anthesis, and 80% of the premature fruits are abscised in the following 8 weeks. This is presumably caused by a shortage of carbohydrates for rapid fruit development. The excessive fruit drop is a common problem in the macadamia orchards across the production regions of western mid hills in Nepal. Thus, this phenomenon has posed a major challenge to the cultivation and expansion of Macadamia Nut Orchard.

Macadamia Nut fruit drop trends in the interval of 15 days (both treatments and counting of fruits) spraying and counting from IstJestha 2076 to 22nd Bhadra 2076 (9 times; 4 times spray and 9 times counting).

According to the graph, the fruit drop slow down with the application of 6BAP (200 ppm) + Micronutrient (2.5 ml/lit. water) with sticker (2.5 ml/lit water) than the other treatments. Finally, fruit no was highest in the record date than the other treatments recorded.

Application of cytokinin @ 200 PPM and micronutrient @ 2.5 ml/litre water help to decrease the fruit drop in macadamia nut.

3.3 Soil drench with hexconazole and chloropyriphos controlled the foot rot/wilt in betal nut

Soil drench with Titan (hexconazole)@ 1 ml/L + Super killer (chloropyriphos) 1ml/L) controlled the foot rot/wilt in betal nut.

3.4 Sigatoka leaf spot disease management

Sigatoka leaf spot of banana is effectively controlled by the application of Pinnacle@1ml/L.

4. Plant Propagation

4.1 Grafting technology in Walnut

Grafting time and success rate in walnut showed better performance in Chaitra 1-22 with in-situ than bench grafting situation. Further research work is going on to understand the suitability of the rootstock.

5. Cultivation Practices

5.1 Identification of maturity indices of mandarin and sweet orange at different altitude of Sindhuli

Five orchards have been chosen at Sindhuli district to establish the sweet orange and mandarin maturity trail at four altitude ranges 1000, 1100, 1200, 1300 masl. The data were taken on skin chlorophyll loss (with DA meter), TSS, TA, fruit wt. and juice percent. Data analysis is the process.

6. Insect Pest Management

6.1 Litchi fruit borer (Conopo-morphasinensis) management on Litchi

Study at Regional Agriculture Research Station, Tarahara, Sunsari showed that Mean percentage damage caused by Conopomorphasinensis on Litchi was significantly reduced by the application of either chlorantranilpronil or flubendiamide just after fruit setting period (RARS, 2018).

CONCLUSION

Except intensive research work in citrus species, other commodities are neglected and shadowed for research prioritization. Because of no international support, perennial in nature, long time need for research results and unclear policy, fruit research except citrus is in extreme dearth. However, in recent years, some promising technologies have been developed in some fruit crops; mango, citrus, papaya, banana, pomegranate, apple, walnut, kiwi fruit, litchi, pineapple, and mecademia nut. Different pre and post-harvest management technologies are developed in mandarin, sweet orange, acid lime, papaya, kiwi, banana and pineapple and fruit fly management in citrus, borer management in litchi fruit and delay ripening technique in banana fruit and early ripening in pineapple fruit, some of which have been presented in this paper. As lot of works to be done in fruit research within different constraints situation, research priority areas should be listed and research works should be done phase by phase according to the priority fixed.

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REFERENCES

ARS. 2017. Annual Report 2074/75. Agriculture Research Station, Pakhribas, Dhankuta

Atreya, P.M. and R. Manandhar 2016. Fruit crop Development in Nepal, In: Proceeding of the first International Horticulture Conference. Nepal Horticulture Society, pp 36-49.

Dhakal, M., T.P. Gotame, S. Sapkota, I.P. Gautam and P. Adhikari. 2017. Characterization of Different Cultivars of Kiwifruit(Actinidia species) of Mid-hills at Central Region,

Nepal.In: Proceedings of the Ninth National Horticulture Workshop, May 31-June 01, 2017; NARC, HRD, Khumaltar, Lalitpur, Nepal, pp.131-137.

FDD. 2015. Year Book. Fruit Development Directorate, Kirtipur, Kathamandu, Nepal.

Gurung, H.P. 1998. Improvement of post-harvest handling of major horticultural crops, In: Proceeding of the national seminar on fruit and vegetable marketing in Nepal.

HRD, 2017. Annual Report 2073/74(2016/17). Horticulture Research Division, NARC, Khumaltar, Lalitpur,Nepal.

HRS, 2019. Annual Report 2073/74 (2017/18). Horticulture Research Station, Malepatan, Pokhara

Kaini, B.R. 2004. Horticulture Development in Nepal-An Overview. Paper presented in Third National Horticulture Seminar. Nepal Horticulture Society, Kathmandu, Nepal.

Kaini, B.R. 2012. Management of Government Owned Horticulture Farms. Nepalese Horticulture, 9:110-115.

Kaini, B.R, G.P. Shrestha and R. Manandhar. 2016. Six Decades of Fruit Development in Nepal. In: Six Decades of Horticulture Development in Nepal (Silver Jubilee Special). Nepal Horticulture Society, Lalitpur, Nepal.

MOALD. 2016. Statistical Information of Nepalese Agriculture 2014/15. Government of Nepal, ministry of Agriculture Development, Agri-Business promotion and Statistics Division, Singhadarbar, Kathamndu.

MOALD. 2017. Statistical Information of Nepalese Agriculture 2016/17. Government of Nepal, ministry of Agriculture Development, Agri-Business promotion and Statistics Division, Singhadarbar, Kathamndu.

MOALD. 2018. Statistical Information of Nepalese Agriculture 2017/18. Government of Nepal, ministry of Agriculture Development, Agri-Business promotion and Statistics Division, Singhadarbar, Kathamndu.

Manolopoulou, H., P. Papadopoulou. 1998. A study of respiratory and physico-chemical changes of four kiwi fruit cultivars during cool-storage. Science Direct, 63: 529-534.

NCRP. 2018. Annual Report 2074/75. National Citrus Research Programme, Paripatle, Dhankuta

NCDP. 2016 National Citrus Development Program (NCDP). 2016. Annual Report (2015/16). Retrievedfromhttp://nkcs.org.np/narc/pmb/opac_cs s/index.php?lvl=publisher_see&id=3518.

Paudyal, K.P. 2013. Characterization and Variety Selection of Kiwifruit (Actinidia Spp.) in Nepal. In: Proc. Eighth National Horticulture Seminar on Horticulture Development towards the Pace of National Economic Growth, Khumaltar, Kathmandu, 18-20 March 2013. Nepal Horticulture Society, pp.16-19

Popovic, R., T. Milosevic, A. Veljovic. 2002. Pomological traits of the most significant cultivars of kiwifruit (Actinidiachinensis) in the conditions of Bar. Acta Agric. Serbica, 7(13):17-25

RARS. 2018. Annual Report- 2074/75. Regional Agricultural Research Station, Tarahara, Sunsari.

RARS. 2019. Annual Report- 2076/77. Regional Agricultural Research Station, Lumle.

Shrestha, C.M. 2015. Kiwifruit Cultivation in Nepal (In Nepali). Siddartha Printing Press, Lalitpur.

Thakur, M.K., K.B.Thapa, K.Bhandari. 2017. Integrated plant nutrient management to revive declined mandarin Orchard. In: Proceedings of the Ninth National Horticulture Workshop, May 31-June 01,

2017; NARC, HRD, Khumaltar, Lalitpur, Nepal, pp.131-137.

Thapa, S.K., B.B. Karmaccharya. 1990. Trainers manual No. 10 Tropical fruits. Department of Agriculture, Agriculture training and manpower development programme; Manpower development agriculture project. Pp., 407.

Obreza, T.A., K.T. Morgan. 2008. Nutrition of Florida Citrus trees SL 253. University of Florida Lake Alfred. FL.

Wang, H.S., J.L. Zhang. 1994. The biodiversity and character of spermatophytic genera endemic to China. Acta Botanica Yunnanica, 16(3): 209-220