

INTRODUCTION AND EVALUATION OF SPUR TYPE APPLE VARIETIES IN THE KARNALI REGION OF NEPAL

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ABSTRACT

Experiments were conducted at ARS, Jumla for two consecutive years (2011-2012) to identify appropriate apple varieties for Karnali region of Nepal. Ten varieties from HRS, Solon and RHRS, Mashobra; and fifteen from Canada were collected and planted in RCBD with 7 and 3-4 replications respectively. Preliminary characterization of Indian apple indicates that earlier bud swelling (3rd April) was observed in Starkinson Delicious and Red Spur whereas late in Stark Spur Gold (14th April). Earlier bud breaking (8th April) was observed in Well Spur, Red Spur and Red Chief-22 whereas late in Stark Spur Gold (21st April). Earlier defoliation (18th Nov) was observed in Well Spur whereas late in Oregon Spur 22 (30th Nov). The thickest stem diameter was observed in Red Gold (26 mm) whereas the thinnest in Red Chief-22 (14 mm). The tallest plants were observed in Starkinson Delicious (1.14 m) whereas the dwarfest in Stark Spur Gold (0.68 m). More branches were developed in Red Chief-21 and Starkinson Delicious (3.4) whereas the least in Oregon Spur-22 and Red Chief-22 (2.4). The highest canopy volume was observed in Red Chief-21 (0.97 m³) whereas the lowest in Red Chief-22 (0.12 m³). Earlier bud swelling (2nd April) in Canadian varieties was observed in Ambrosia and Redfree whereas late in Jim and Gala (8th April). Earlier bud breaking (6th April) was observed in Ambrosia and Redfree whereas late in Jim and Robinata (12th April). Earlier defoliation (18th Nov) was observed in Ambrosia whereas late in Jonagold and Sinta (28th Nov). The tallest plants (1.64 m) were observed in Pristine whereas the dwarfest in Honey Crisp (0.41 m). The thickest stem (11 mm) was observed in Red Gravestain whereas the thinnest in Honey Crisp and Zerstar (4 mm). Varietal selection through phenological characterization and evaluation is a long term task, thus needs to be continued for several years to achieve desired outputs.

Key Words: *Malus domestica* Borkh, germplasm, variety, spur, standard, phenology, characterization, *in situ* evaluation and descriptors.

INTRODUCTION

Nepal is predominantly an agrarian society. Agricultural sector provides employment opportunities to 66 percent of total population and contributes about 33 percent to national GDP. Out of total AGDP, horticulture sector contributes about 21% and apple contributes 0.91%. Apple (*Malus domestica* Borkh) is an important deciduous fruit in terms of area, production and household economy in remote mountain areas from east to far west of Nepal. A total of 54 districts grow apple in Nepal; however, there are only 12 major apple producing districts mainly from high mountainous regions (MOAC, 2008). Out of these, five districts of the Karnali region are major apple growing districts with a production of 19,067 mt in an area of 1,953 ha (Subedi et al., 2012). Jumla ranked first among the apple producing districts of Nepal in terms of area (538 ha) and production (3,500 mt).

Deciduous type of commercial fruit growing is not traditional in Nepal. After establishment of DOA in 1925, temperate fruits were introduced to Balaju and Godavari farms whereas several improved cultivars were introduced to Singh Durbar and Kakani farms after the establishment of HDS in 1955. Six Temperate Horticulture Stations were established and many new cultivars were introduced during 1960 to 1973 with support from ICMP and key Horticulture Stations were strengthened during 1977 to 1980 under HADP. Later on, introduction of 20 million saplings of 14 apple varieties from Himanchal Pradesh to farmers' field directly was done by Karnali Special Project without performance study and recommendation. Thus, apple cultivars grown in Jumla are high chilling requiring and non-spur types viz. Red Delicious, Royal Delicious, Golden Delicious and Rich a Red, Jonathan, Masadi, Kullu, Torikulu, Sweet Ambri, Ambri, Cox Orange Pippin and Mc

Intosh. Despite high potentiality of apple cultivation, apple growers of the Karnali region have not been able to obtain optimum benefit due to low productivity of existing standard varieties (6.6 mt/ha) which is less than national productivity (9.3 mt/ha) as well as high losses in quality and quantity (30%) during post harvest handling period. Nepal produced 41,755 mt apples fruits in 2009/2010; however, small, isolated and inaccessible production pockets where infrastructures such as collection centers, roads, irrigation, transportation, storage facilities, and appropriate post harvest handling technology are inadequate. Thus the produce is mostly used for local consumption. As a consequence, 92% of apple fruits (37,400 mt) were imported after November to meet domestic demand in urban markets: 65% from China, 22% from India and 5% from developed countries (*Subedi et al., 2012*).

Spur-type apple varieties viz. Red Spur, Top Red, Red Chief, Oregon Spur, Golden Spur, Starkrimson Delicious, etc. are more compact and profitable than existing non-spur varieties cultivated in Himanchal Pradesh that have characteristics of regular bearing, early maturity, dwarf trees suitable for high density planting, attractive fruit color, true to type, good quality fruits, less pruning requiring and greater hardiness. Spur-type trees tend to grow in an upright manner with narrow crotches, sparse branching, smaller than standard trees even when grown on seedling rootstock. They spread out somewhat as they approach 5 and 6 years of age, but they may be generally upright throughout their life. Trees will develop several leaders with no predominant central leader. Fruiting occurs on numerous short spurs, which are long lived. The zone of fruiting tends to remain close to trunk. Combinations of dwarfing rootstocks with spur-type varieties will result in much smaller trees than the same rootstock with a non-spur standard variety (*Awasthi, R. P. and Chauhan, P.S. 1997*).

Phenological characterization based on morphological traits such as yield, color, taste and maturity period, which has been adapted by most of apple breeders, are such traits which are easy to observe and measure. In Jumla, only preliminary studies on varietal introduction, performance study, propagation, insect pest management and PRA on post harvest reduction were undertaken and no significant research work on spur type apple germplasm characterization and evaluation was carried out in the past. This project intends to identify appropriate spur type apple varieties suitable for the Karnali region, develop uptake pathways for dissemination of appropriate varieties with a view to improve the socio-economic status of apple growers of this region. Thus, technological intervention carried out in this project falls within the research and development priority of APP, poverty reduction goal of 10th five-year Plan and Three Year Interim Plan of Government of Nepal.

MATERIALS AND METHODS

A series of joint interventions and field experiments were carried out at ARS (Horticulture), Rajikot, Jumla for two consecutive years (2011-2012) in close collaboration with ICIMOD, HRD and IAAS to identify appropriate spur type apple varieties through germplasm collection; establishment and maintenance of varietal evaluation block; phenological characterization and evaluation, and development of uptake pathways for dissemination of the elite varieties with a view to improve the socio-economic status of apple growers of the Karnali region of Nepal. To achieve above objectives, the following research activities were carried out during 2011-2012.

Introduction of spur type of apple varieties from India and abroad

A work-plan between NARC and ICAR was signed for exchange of apple germplasm on February, 2009. A confirmation letter regarding reservation of 20 apple saplings of each variety for 2010/11 was received from Dr. Y. S. Parmar University of Horticulture and Forestry, RHRS, Mashobra, Shimla, HP, India. Unfortunately, NARC had no provision for financial support to this work. ICIMOD was supporting PAR in Jumla and Mustang which was conducted under HIMALI project. Meanwhile, ICIMOD arranged a visit program to RHRS, Mashobra, Shimla, HP, India at the end of December, 2010 for collecting apple germplasm. However, unfavourable climatic conditions especially long drought in Himanchal Pradesh hampered uprooting of apple saplings from the nursery. Dr. M. S. Mankotia from RHRS, Mashobra arranged to collect six varieties of apple germplasm from HRS, Kandaghat, Solon, H.P., India. In this regard, there was an urgent need to collect remaining apple germplasm from RHRS, Mashobra. ICIMOD again arranged 2nd trip to RHRS, Mashobra at 2nd week of January, 2011 for collecting apple germplasm. We were able to collect six varieties including two duplicate varieties (Table 1). Scion woods of 15 apple varieties from Canada were collected during February, 2011 and tongue grafting on edi-mayal rootstocks was performed. Successful grafts were planted on the experimental plot in first week of January, 2012 (Table 2).

Establishment and maintenance of apple germplasm at varietal evaluation block

Field layout was carried out on square system at spacing of 5x5 m² after proper sanitation and leveling of experimental plot located at B Block of ARS (Hort.), Rajikot, Jumla during the winter season of 2011. Pits of 1 m³ were dug out and filled with a mixture of well decomposed compost and top soil supplemented with 20 gm malathion dust per pit. Twelve varieties from Indian source were planted for evaluation in RCBD with seven replications (seven saplings planted in a single row) while 15 varieties from Canadian source were planted with 3-4 replications. Thus, in both experiments, each treatment consisted of one sapling. The saplings were planted at the centre of filled pit in such a way that the graft union remains above the soil level. Mulching was done immediately after planting with dried grasses; staking was performed with bamboo sticks to prevent vibration of newly planted saplings. Watering was done regularly according to requirement of plant until onset of rainy monsoon. Foliar application of 1% Bordeaux mixture was applied in winter after pruning whereas 0.1% Bavistin was sprayed and drenched in June and September in all treatments. Training and pruning, weeding, basin making, composting, intercropping with legumes (Garden pea during autumn and Phaleolus beans during rainy season) were done frequently according to requirement. Strong framework on spur type of apple plants was developed through bending of limbs to a horizontal plane and tying them in that position with the help of nylon rope on mayal sticks. Thus, varietal evaluation block was established to identify appropriate spur type apple varieties suitable for the Karnali region under changing climatic condition.

In situ phenological characterization of apple germplasm based on plant and fruit characters

Penological characters were recorded from *in situ* evaluation block by observing and measuring morphological external characters such as tree age, tree height, stem diameter, tree canopy in four dimension (east-west, north-south), number of primary scaffold branches, bud swelling date, bud breaking date, flowering date, flower color, etc. Canopy volume of apple plants was estimated by using formula developed by Holtzhausen *et al.* (1988), i.e., $V=r^2(\pi h-1.046r)$, where V= Canopy volume, h= tree height, r = radius (1/2 of canopy diameter). However, morphological characters such as girth diameter (30 cm above the soil surface), flower color, fruit lets per branch, fruit retained up to maturity, maturity period and time of flowering will be determined on the basis of visual observation in coming years. Yield efficiency (kg/m³) will be measured on the basis of canopy volume. Plant vigor i. e. height, girth and canopy will be calculated by selecting and measuring apple trees of same age. Similarly, qualitative traits such as fruit shape, leaf shape, base shape, apex shape, surface texture, skin color and pulp color will be studied by using apple descriptors (IPGRI, 1993) in the following years. Other phenological and physiochemical characters will be studied in the following years until the end of experiment.

RESULTS AND DISCUSSIONS

Introduction of spur type of apple varieties from India and abroad

All together 10 varieties of apple germplasm from India with two duplicate entries and 15 varieties of apple germplasm from Canada were collected and planted at spacing of 5x5 m² during the winter season of 2011/12 as follows:

Table 1: Apple varieties introduced from HRS, Solon and RHRS, Mashobra, Shimla during 2010/11

S. N	Varieties	No of transplanted apple saplings					Total	Source
		ARS Jumla	NTHS Marpha	Lowerlorpa Jumla	Upperlorpa Jumla	Mahat Jumla		
1	Oregon Spur II	14	10	4	4	3	35	S & M
2	Red Chief	14	10	4	4	3	35	S & M
3	Bright N Early	7	5	4	4		20	S
4	Red Gold (P)	7	5	4	4		20	S
5	Vance Delicious	7	5	4	4		20	S
6	Top Red	7	5	4	4		20	S
7	Starkrimson Delicious	7	5			3	15	M
8	Well Spur	7	5			3	15	M

9	Red Spur	7	5			3	15	M
10	Stark Spur Gold (P)	7	5			3	15	M
Total		84	60	24	24	18	210	

P=Pollinizer variety; S=HRS, Solon; M=RHRS, Mashobra

Table 2: Scion-wood of apple varieties introduced from Canada on February and planted at ARS (Hort.), Rajikot, Jumla on December, 2011.

S. No	Accession No	Varieties	Transplanted saplings (No)	Varietal Characteristics
1	AMBR	Ambrosia	3	Spur type
2	BLSU	Blushing Susan	3	Mid late
3	CRSP	Honey Crisp	3	Mid
4	GALA	Gala	3	Mid
5	GROS	Red Gravenstein	3	Early
6	JNGL	Jonagold (P)	3	Late
7	JUBL	Jubile Fuji	3	Mid
8	PRST	Pristine	3	Early
9	RERE	Redfree	3	Early
10	ROBN	Robinete	4	Early
11	SNTA	Sinta	3	Late
12	SUNR	Sunrise	4	Early
13	TSAG	Tsagaru	3	Mid early
14	ZEST	Zestar	3	Early
15	JIM	Jim	4	Early
Total			48	

P=Pollinizer variety

Establishment and maintenance of apple germplasm at varietal evaluation block

Eighty four saplings of twelve types of apple germplasm introduced from HRS, Kandaghat and RHRS, Mashobra during January, 2011 and forty-eight saplings of 15 varieties of apple germplasm introduced from Canada were established and maintained at varietal evaluation block of ARS (Hort.), Rajikot, Jumla (Table 1 and Table 2). All the cultural practices were followed as per recommendation.

In situ phenological characterization of apple germplasm based on plant and fruit characters

Phenological characters of apple germplasm were studied by observing and measuring morphological characters such as tree age, tree height, stem diameter, tree canopy in four dimension (east-west, north-south), number of primary scaffold branches, bud swelling, bud breaking, defoliating time and canopy volume of apple plants.

Stem Diameter

The thickest stem diameter was observed in Red Gold (26 mm) followed by Red Chief- 21 and Oregon Spur- 21 (25 mm) whereas the thinnest in Red Chief- 22 (14 mm). The highest growth rate on stem diameter within six month was recorded from Red Gold (31%) followed by Oregon spur-21 (30%) whereas the lowest in Red Chief- 22 (5%) (Table 3).

Table 3: Stem diameter of different apple varieties tested at ARS (Hort.), Rajikot, Jumla during June and December, 2012 (Two year old plants)

S. N.	Varieties	Stem diameter (mm)			Growth rate (%)
		June 2012	December 2012	Difference	
1	Vance delicious	17	21	4	20
2	Red Chief-21	20	25	5	22
3	Red Gold	19	26	6	31
4	Bright N early	17	22	5	27
5	Oregon Spur-21	19	25	6	30

6	Top Red	18	21	3	17
7	Well Spur	16	19	3	18
8	Starkimson delicious	17	19	2	11
9	Red spur	20	22	1	6
10	Stark spur gold	14	16	1	10
11	Oregon Spur-22	15	18	2	15
12	Red Chief-22	13	14	1	5
	Mean	18	21	3	19

Plant Height

The tallest plants were observed in Starkimson Delicious (1.14 m) followed by Red Chief 21 (1.05 mm) whereas the dwarfest in Stark Spur Gold (0.68 m). The highest growth rate on plant height within six month was recorded from Red Chief-21 (36 %) followed by Red Gold and Starkimson Delicious (28 %) whereas the lowest in Oregon Spur-21, Top Red and Red Spur (14 %) (Table 4).

Table 4: Plant height of different apple varieties tested at ARS (Hort.), Rajikot, Jumla during June and December, 2012 (Two year old plants)

S. N.	Varieties	Plant height (m)			Growth rate (%)
		June 2012	December 2012	Difference	
1	Vance delicious	0.88	1.03	0.15	17
2	Red Chief-21	0.77	1.05	0.28	36
3	Red Gold	0.78	0.99	0.21	28
4	Bright N early	0.82	0.94	0.12	15
5	Oregon Spur-21	0.77	0.88	0.11	14
6	Top Red	0.83	0.95	0.12	14
7	Well Spur	0.79	0.91	0.12	15
8	Starkimson delicious	0.89	1.14	0.25	28
9	Red spur	0.82	0.93	0.12	14
10	Stark spur gold	0.58	0.68	0.10	18
11	Oregon Spur-22	0.61	0.71	0.10	17
12	Red Chief-22	0.67	0.78	0.12	17
	Mean	0.76	0.91	0.14	19

Bud Swelling, Bud Breaking and Defoliation time

Earlier bud swelling (3rd April) was observed in Starkimson Delicious and Red Spur followed by Vance Delicious, Red Chief-21, Top Red, Well Spur, Oregon Spur 22 and Red Chief-22 (5th April) whereas late in Stark Spur Gold (14th April). Earlier bud breaking (8th April) was observed in Well Spur, Red Spur and Red Chief-22 followed by Vance Delicious, Red Chief-21 and Starkrimson Delicious (9th April) whereas late in Stark Spur Gold (21st April). Earlier defoliation (18th Nov) was observed in Well Spur followed by Red Gold (20th Nov) and Starkimson Delicious (21st Nov) whereas late in Oregon Spur 22 (30th Nov) (Table 5).

Table 5: Primary scaffold branches on different apple varieties tested at ARS (Hort.), Rajikot, Jumla during December, 2012 (Two year old plants)

S. N.	Varieties	Bud swelling date	Bud breaking date	Leaf shading date	Primary scaffold branches (No)
1	Vance delicious	5-Apr	9-Apr	22-Nov	2.8
2	Red Chief-21	5-Apr	9-Apr	27-Nov	3.4
3	Red Gold	9-Apr	14-Apr	20-Nov	2.9
4	Bright N early	8-Apr	14-Apr	25-Nov	3.2

5	Oregon Spur-21	8-Apr	10-Apr	25-Nov	2.7
6	Top Red	5-Apr	10-Apr	29-Nov	2.9
7	Well Spur	5-Apr	8-Apr	18-Nov	2.7
8	Starkimson delicious	3-Apr	9-Apr	21-Nov	3.4
9	Red spur	3-Apr	8-Apr	24-Nov	3.0
10	Stark spur gold	14-Apr	21-Apr	27-Nov	2.7
11	Oregon Spur-22	5-Apr	10-Apr	30-Nov	2.4
12	Red Chief-22	5-Apr	8-Apr	25-Nov	2.4
	Mean				2.9

Primary Scaffold Branches

More primary scaffold branches were developed in Red Chief-21 and Starkimson Delicious (3.4) followed by Bright N Early (3.2) whereas the least in Oregon Spur-22 and Red Chief-22 (2.4) (Table 5).

Canopy Volume

The highest canopy radius on northern side was observed in Red Gold (0.65 m) followed by Red Chief-21 (0.61 m) whereas the lowest was observed in Red Chief-22 (0.25 m). The highest canopy radius on southern side was observed in Red Chief-21 (0.44 m) followed by Red Gold (0.42 m) whereas the lowest in Oregon Spur-22 (0.20 m). The highest canopy radius on eastern side was observed in Red Chief-21 (0.77 m) followed by Top Red (0.59 m) whereas the lowest in Red Chief-22 (0.28 m). The highest canopy radius on western side was observed in Red Chief-21 (0.6 m) followed by Top Red and Red Spur (0.45 m) whereas the lowest in Red Chief-22 (0.2 m). Thus, the highest mean canopy radius was observed in Red Chief-21 (0.6 m) followed by Red Gold and Top Red (0.5 m) whereas the lowest in Red Chief-22 (0.2 m). The highest canopy volume was observed in Red Chief-21 (0.97 m³) followed by Red Gold (0.56 m³) whereas the lowest in Red Chief-22 (0.12 m³) (Table 6).

Table 6: Canopy radius and Canopy volume of different apple varieties tested at ARS (Hort.), Rajikot, Jumla during December, 2012 (Two year old plants)

S. N.	Varieties	Canopy radius (cm)				Mean canopy radius (m)	Canopy Volume (m ³)
		North	South	East	West		
1	Vance delicious	47	27	41	43	0.4	0.43
2	Red Chief-21	61	44	77	60	0.6	0.97
3	Red Gold	65	42	56	22	0.5	0.56
4	Bright N early	51	32	47	43	0.4	0.47
5	Oregon Spur-21	40	36	45	22	0.4	0.31
6	Top Red	48	30	59	45	0.5	0.52
7	Well Spur	33	23	42	30	0.3	0.26
8	Starkimson delicious	44	31	44	22	0.4	0.40
9	Red spur	49	38	47	45	0.4	0.50
10	Stark spur gold	25	27	32	30	0.3	0.15
11	Oregon Spur-22	26	20	30	33	0.3	0.14
12	Red Chief-22	25	22	28	20	0.2	0.12
	Mean	43	31	46	35	0.4	0.36

Phenological Characteristics of Canadian Apple germplasm

Earlier bud breaking (6th April) was observed in Ambrosia and Red Free followed by Pristine and Sunrise (8th April) whereas later in Jim and Robinate (12th April). Earlier defoliation (18th Nov) was observed in Ambrosia followed by Jubile Fuji and Pristine (20th Nov) whereas later in Jonagold and Sinta (28th Nov). The tallest plants (1.64 m) were observed in Pristine followed by Sinta (1.6 m) whereas the lowest was observed in Honey Crisp (0.41 m). The thickest stem (11 mm) was observed in Red Gravenstein followed by Pristine (10 mm) whereas the lowest was observed in Honey Crisp and Zerstar (4 mm). Only one primary branch among the tested varieties was recorded. Earlier bud swelling (2nd April) was observed in Ambrosia and Red Free followed by Jubile Fuji and Pristine (4th April) whereas later in Jim and Gala (8th April) (Table 7). Collection of 25 varieties of apple germplasm has been accomplished to date and preliminary characterization has been initiated only on vegetative parameters. Thus, morphological characters such as girth diameter, flower color, fruit lets per branch, fruit retained up to maturity, maturity period, time of flowering, etc. will be determined on the basis of visual observation on coming years. Similarly, qualitative traits such as fruit shape, leaf shape, base shape, apex shape, surface texture, skin color, pulp color will be studied by using apple descriptors (IPGRI, 1993). Thus, characterization and varietal selection work need to be continued for several years to select appropriate spur type apple varieties suitable for the Karnali region of Nepal.

Table 7: Phenological characteristics of 15 Canadian apple varieties tested at ARS (Hort.), Rajikot, Jumla during December, 2012 (one year old plants)

S. N.	Varieties	Plant height (cm)	Stem diameter (mm)	Primary branch (No)	Leaf shedding date	Bud swelling date	Bud breaking date
1	Ambrosia	66	6	1	18-Nov	2-Apr	6-Apr
2	Blushing Susan	75	6	1	25-Nov	5-Apr	10-Apr
3	Honey Crisp	41	4	1	22-Nov	7-Apr	12-Apr
4	Gala	71	7	1	27-Nov	8-Apr	12-Apr
5	Red Gravenstein	98	11	1	27-Nov	6-Apr	10-Apr
6	Jonagold	94	8	1	28-Nov	5-Apr	10-Apr
7	Jubile Fuji	89	5	1	20-Nov	4-Apr	10-Apr
8	Pristine	164	10	1	20-Nov	4-Apr	8-Apr
9	Redfree	101	8	1	24-Nov	2-Apr	6-Apr
10	Robinete	100	8	1	25-Nov	6-Apr	12-Apr
11	Sinta	160	9	1	28-Nov	5-Apr	10-Apr
12	Sunrise	68	3	1	25-Nov	5-Apr	8-Apr
13	Tsagaru	91	10	1	27-Nov	5-Apr	9-Apr
14	Zestar	71	4	1	24-Nov	5-Apr	9-Apr
15	Jim	101	9	1	22-Nov	8-Apr	12-Apr
	Mean	93	7	1			

CONCLUSION AND RECOMMENDATIONS

25 apple varieties have been collected and preliminary characterization has been initiated. Other promising varieties such as Silver spur, Scarlet Gala, Red Fuji, Super chief, Gale Gala, Scarlet Spur, Pink Lady, Top Export Fuji, Auvil Early Fuji, Aztec Fuji, Mara Red Fuji, September Wonder, Red Fuji, Sansa and Early Red need to be introduced in coming years from RHRS, Mashobra and abroad to identify appropriate spur type apple varieties with a view to improve the socio-economic status of apple growers of the Karnali region of Nepal. Thus, this project needs to be continued for several years to obtain desired outputs.

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