# CHARACTERIZATION AND VARIETY SELECTION OF KIWIFRUIT (*Actinidia spp*) IN NEPAL

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## ABSTRACT

*Kiwifruit is a perennial deciduous vine plant. Actinidia deliciosa and A. chinensis are the two cultivated species of kiwifruit. Although kiwifruit was originated in China its commercial cultivation was started in New Zealand from 1930s. From 1960s kiwifruit cultivation spread to other countries of the world where suitable climate is available. Several varieties of kiwifruit were introduced in Nepal during 1990s by International Centre for Integrated Mountain Development Centre (ICIMOD) and other individuals. In recent years, popularity of this crop has been increasing among the growers of Nepal. But research based information about type of varieties and their suitability in the agro-climatic condition of Nepal is not available. Therefore, this study was carried out to examine the fruit characteristics of kiwifruit varieties available in Nepal and select the suitable ones for commercial production. Location of different varieties was identified through survey and individual contact. During harvesting season of 2010 and 2011 fruit samples were collected and characterized following the Test Guidelines for Actinidia developed by International Union for the Protection of New varieties of Plants. Hayward, Bruno, Monty, Abbot and Allison are female varieties of A. delicious available in Nepal. Two variants of Hayward variety – round and oblong fruits and one unknown variety were also found in ICIMOD farm. Single variety of A. chinensis, Soyou, was found being grown in Nepal. Soyou had red stripe on its pulp while all other varieties had light green flesh. The varieties varied in fruit shape, size, length, width, shape of stylar end, shape of shoulder, hairiness on the fruit and maturity time. Based on maturity time, fruit size and shape Soyou, Bruno and Hayward (round) were selected for early (second week of September), mid (first week of December) and late (second week of December) season harvesting.*

## INTRODUCTION

Kiwifruit or Chinese gooseberry is known as 'China's miracle fruit, and 'the horticultural wonder of New Zealand'. There are more than 70 species of kiwifruit (Ferguson, 1984). Among them *Actinidia deliciosa* and *A. chinensis* are commercially cultivated species (Ferguson and Huang, 2007). Although the cultivated species of kiwifruit were originated in China their commercial cultivation was initiated in New Zealand. The first kiwifruit seeds were planted in New Zealand in 1910 with seeds brought from China. The most commonly used standard variety at present, 'Hayward' of the genus *Actinidia deliciosa*, was developed from these seeds by Hayward Wright around 1924. Kiwifruit moved towards commercial production in New Zealand by the 1930's (Burnie, 2009).

In recent years, popularity of kiwifruit is increasing in many countries because of its delicacy, precocity, high economic return, and health benefits. In 2010, global production excluding China came around 1.35 million metric tons from a harvest of about 90,000 hectares (FAO, 2011). According to World Kiwifruit Review 2006 China's kiwifruit production volume was 341,000 tons in 2005. So, when the potential contribution of China is considered the total world production is expected to be significantly higher than FAO's estimate. Except China the top five kiwifruit producing countries (Italy, New Zealand, Chile, Greece and France) contributed over 86 percent of the world production (FAO, 2011)

Two species of kiwifruit, *A. strigosa* and *Callosa var. callosa,* which were cataloged by Nathaniel Wallich in 1821 are found in wild form in Nepal and are called *Theki Phall* or *Jhuse Phall* in Nepali Language. However, cultivated species of kiwifruit are new introduction in Nepal. International Centre for Integrated Mountain Development (ICIMOD) introduced some kiwifruit varieties from India and established a demonstration production plot at Godavary, Lalitpur during 1990s (Sherpa, 2013). In the same time, some Japanese volunteers working in Nepal also introduced some varieties and planted in a private farm at Kakani. Success of kiwifruit production in those orchards attracted several enthusiastic farmers and entrepreneurs towards this crop initially around Kathmandu valley and later in other districts. However, the introduced varieties have not been properly evaluated in the agro-ecological conditions of Nepal. Therefore, this study was carried out to evaluate the introduced kiwifruit varieties *in situ* and recommend the suitable types for Nepalese farmers.

## MATERIALS AND METHODS

Information on kiwifruit varieties maintained/grown in public organization and private farms were collected. A total of eight exotic varieties were evaluated for their fruit characters. Among the evaluated varieties seven viz. Hayward (round), Hayward (oblong), Bruno, Monty, Abbot, Allisan, ICIMOD Oblong were from Technology Demonstration Centre of ICIMOD at Godavary, Lalitpur (1400 m). Two varieties with distinct fruit shape were named as Hayward in the centre. Based on the shape of the fruit these varieties were named as Hayward (round) and Hayward (oblong) for identification purpose in this paper. One unidentified variety was also found in the centre. It was named as ICIMOD Oblong during evaluation. Soyou variety evaluated in this study was from Surya Organic Kiwi farm, Patlekhet, Kavre (1600 m).

Fruit samples were collected periodically (Table 3) and evaluated their characteristics following the Test Guidelines for *Actinidia* developed by International Union for the Protection of New varieties of Plants, Geneva, Switzerland (UPOV, 2012). In each sampling date 10 random fruits from all sides of the plant were used for the evaluation of quantitative characters (Table 1 and 3) and mean and standard deviation values were calculated. Ten fruit samples from last harvest were used to evaluate qualitative characters (Table 2).

## RESULTS AND DISCUSSION

### Source of introduction

International Centre for Integrated Mountain Development (ICIMOD) has been found as the main repository of kiwifruit varieties in Nepal. ICIMOD introduced five female varieties (Abbott, Allison, Bruno, Hayward and Monty) and two male varieties (Tomuri and Matuwa) from India in late 1980s. In addition to these varieties one unknown genotype (female) introduced from India was also found in ICIMOD farm which was named as 'ICIMOD oblong' for the purpose of evaluation. In 1995, Hayward variety was also introduced from Japan. The fruit shape of Hayward from Japan was oblong and that of Indian was slightly round. Hayward is a very old variety and several other breeding lines have been developed from the seedling or sport selection of Hayward (Zhu and Ding, 2003). Two distinct strains of Hayward as noted at present study could therefore be the result of selection pressure given in original Hayward in different countries. The above mentioned varieties have green color pulp. A variety which has red striped pulp, commonly known as red kiwi, was found during survey. The red kiwifruit varieties viz Soyou (female) and Khohi (male) were introduced from Japan by Karma Lama with the help of Japanese volunteer in mid 1990s and established as mother plant in his own nursery (T.H.S.K.B. Nursery, Subba Ghaun-2, Kavre). Fruit characters clearly revel that botanically Soyou is *A. chinensis* and other varieties are from *A. deliciosa.*

### Fruit characters

***Qualitative Characters:*** The qualitative fruit characteristics of the evaluated varieties are presented in table 1. Among the evaluated varieties Soyou has red stripes in its pulp and all other varieties have light green pulp. Because of pulp color Soyou is commonly known by 'Red Kiwi' rather than its variety name in Nepal. All varieties except Soyou had brown hairs on the outer surface of the fruit skin ranging from medium to high in density. Varieties differed on fruit shape in cross section, stylar end shape and shape of shoulder but they were alike on color of core, degree of pointed protrusion and color of fruit skin.

***Quantitative characters:*** The size of the fruit differed among the varieties. Hayward (round) had the biggest sized fruit (81.4 ±22.1 gm) and Soyou had the smallest sized fruits (39.3 ±9 gm). The size of other varieties was medium ranging from 48 to 65 gm. ICIMOD (oblong) had the longest fruits (69.0 ±5.2 mm) followed by Bruno (66.6±5.7mm) and Monty (66.6±2.5). Similarly, there was variation among genotypes on width of fruit, length of fruit stalk and width of fruit core. Fruit length and width ratio determines the shape of the fruit. Soyou and Hayward (round) had less fruit length to width ratio meaning that these varieties are slightly round or egg shaped whereas other varieties were oblong or elliptical in shape (Table 2).

**Table 1:** Fruit characteristics of different kiwifruit varieties introduced in Nepal

| Trait | Variety | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Red Kiwi** | **Hayward round** | **Hayward Oblong** | **Bruno** | **Monte** | **Abbott** | **Allisan** | **ICIMOD Oblong** |
| Color of outer pericarp | Cream | Light green | L. green | Light green | Light green | Light green | Light green | Light green |
| Color of locule | Red | Light green | L. Green | Light green | Light green | Light green | Light green | Light green |
| Intensity of reddish color in locule | Medium | No | No | No | No | No | No | No |
| Shape of core in cross section | Transverse elliptical | Oblate, transverse elliptic | Oblate & Transverse elliptic | Oblate | Oblate | Transverse elliptic | Circular & oblate | Circular & oblate |
| Color of core | White | White | White | White | White | White | White | White |
| Shape of fruit | Oblong and circular | Elliptic | oblong & obovate | Oblong + obovate | Oblong | Elliptic | Oblong | Obovate |
| Fruit shape in cross section | Oblate | Oblate | ovate & transverse elliptic | Transverse elliptical | Oblate and transverse elliptic | Oblate | Oblate | Circular & oblate |
| Stylar end | Weakly depressed | Flat | Flat | Round | Rounded | Rounded | Rounded | Flat |
| Shape of shoulder at Stalk end | Truncate | Truncate | weakly sloping | Weakly sloping | Truncate | Strong sloping | Truncate | Strongly slopping |
| Degree of pointed protrusion | No | No | No | No | No | No | No | No |
| Presence of calyx ring | Medium | Medium | Strong | Strong | Medium | Medium | Medium | Weak |
| Hairiness of skin | Absent | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Density of hairs | - | Medium | High | High | Medium | Medium | High | High |
| Color of hairs | - | Brown | Brown | Brown | Brown | Brown | Brown | Brown |
| Color of Skin | Light green | Light green | L. green | Light green | Greenish brown | Light green | Light green | Light green |

**Table 2.** Quantitative fruit characteristics of kiwifruit varieties

| Variety | Fruit Weight (gm) | Fruit Length (mm) | Fruit width (mm) | Length of stalk (mm) | Width of core (mm) |
|---|---|---|---|---|---|
| Soyou | 39.3 ±9.6 | 45.9 ±5.1 | 40.3 ±2.9 | 34.9 ±6.8 | 11.2 ±1.3 |
| Hayward(round) | 81.4 ±22.1 | 59.2 ±6.4 | 48.7 ±2.9 | 51.4 ±7.6 | 15.0 ±2.9 |
| Hayward (oblong) | 65.0 ±17.7 | 63.0 ±8.6 | 39.9 ±2.6 | 33.6 ±10.8 | 15.1 ±2.4 |
| Bruno | 63.9 ±12.4 | 66.6±5.7 | 40.9 ±2.3 | 54.5 ±11.0 | 14.2±2.2 |
| Monty | 63.7 ±6.5 | 66.6±2.5 | 41.6 ±1.8 | 36.9 ±5.3 | 16.4±1.9 |
| Abbot | 48.5 ±7.1 | 60.6±4.8 | 37.1 ±0.8 | 44.4 ±3.9 | 14.8±2.0 |
| Allison | 51.7 ±9.0 | 59.7±4.7 | 38.8 ±1.7 | 36.0 ±7.3 | 12.5±1.4 |
| ICIMOD Oblong | 50.4 ±9.2 | 69.0 ±5.2 | 34.1 ±2.2 | 31.6 ±4.8 | 16.4 ±2.9 |

**Maturity Period**

In kiwifruit, with advancing maturity, the accumulation of carbohydrate slows, yet the sugar content continues to increase due to the conversion of stored carbohydrates (mainly starch) to sugars. At the peak of carbohydrate accumulation, fruits achieve their best potential eating quality and further delays in harvest will not improve flavor. Soluble solids (sugar) content (°Brix) is the most commonly used maturity index for kiwifruit harvest. Kiwifruit are harvested when fruits are firm with appropriate percent soluble solids standard (°Brix) and continue to attain ripening and quality improvement in storage (Hopkirt and Beever, 1986).

Maturity index in kiwifruit is standardized to determine the appropriate period for harvesting. It varies for different varieties and production environment. For example, in New Zealand and California, TSS of 6.5 $^0$Brix is considered as the maturity index for Hayward variety (Crisosto and Crisosto, 2001). Nepalese consumers prefer fruits with sweeter taste. Thus, TSS value of 7.0 $^0$Brix has been considered as maturity index of kiwifruit for Nepal. To determine appropriate maturity period for different varieties TSS was measured periodically (Table 3). Soyou (red kiwi) was the earliest (third week of Bhadra) to mature which can fetch high price in Dashain and Tihar festivals. Furthermore, red kiwi fruits were sweeter than green fleshed varieties and it is favorable attribute for Nepalese consumers. Among the green fleshed varieties Bruno was ready for harvest in second week of Kartik with about 7.0 $^0$Brix TSS. All other green fleshed varieties were about a week late in maturity than Bruno.

**Table 3:** Change in TSS of fruit juice over different harvesting date in different varieties.

| Variety | TSS | | | | | | |
|---|---|---|---|---|---|---|---|
| | Sept. 2 | Sept. 12 | Sept. 20 | Oct. 15 | Oct. 31 | Nov. 10 | Nov. 20 |
| Soyou | 6.7 ±0.76 | 8.1±0.73 | 10.2±1.14 | - | - | - | - |
| Hayward (round) | - | - | - | 5.2±0.33 | 6.5±0.41 | 8.3±0.56 | 11.9±0.82 |
| Hayward (oblong) | - | - | - | 4.6±0.87 | 5.2±0.80 | 7.6±1.29 | 11.7±1.06 |
| Bruno | - | - | - | 5.3±0.37 | 6.9±0.76 | 11.2±1.29 | 12.1±1.32 |
| Monty | - | - | - | 5.8±0.44 | 6.1±0.68 | 9.5±1.72 | 13.2±1.29 |
| Abbot | - | - | - | 4.6±0.66 | 5.6±0.54 | 8.3±0.94 | 10.5±0.91 |
| Allisan | - | - | - | 5.9±0.72 | 6.6±0.84 | 8.7±1.19 | 11.2±1.08 |
| ICIMOD Oblong | - | - | - | | 6.1±0.54 | 6.8±0.81 | 10.3±0.92 |

**Variety Recommendation**

Based on fruit size, shape, maturity period and TSS content four varieties were selected for commercial cultivation in Nepal. These varieties are:

**Soyou:** Red fleshed early variety maturing from third week of Bhadra (second week of September). Requires less chilling hours and does not have hairs on skin.

**Bruno:** Medium sized green fleshed fruit with oblong shape. It matures in second week of Kartik (First week of December). It can be stored for about three months in room temperature. Earliest in maturity among green fleshed varieties.

**Hayward (round):** It has big sized nearly round in shape fruits. It matures from fourth week of Kartik (Second week of December) and can be stored about three months in room temperature. Because of its round shape and big sized fruit this variety can fetch better price than the oblong type varieties.

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