The selection of onion varieties for off-season production

Wongmetha, O. and Kutrakul, S.
CHIANGMAI ROYAL AGRICULTURAL RESEARCH CENTER (CMRARC), DEPARTMENT OF AGRICULTURE
NONGKUAY, HANGDONG, CHIANGMAI, 50230 THAILAND
agriculture_24@hotmail.com, royala@doa.in.th

Linwattana, G.
HORTICULTURAL RESEARCH INSTITUTE, DEPARTMENT OF AGRICULTURE
LADYAO, CHATUCHAK, BANGKOK 10900 THAILAND
linwattana@chaiyo.com

Panuampai, W. and Kaneythipe, J.
CHIANGMAI AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, DEPARTMENT OF AGRICULTURE
FANG, CHIANGMAI, 50110 THAILAND
jaruchat@hotmail.com

Sookchan, A. and Khuntiyawit, A.
KHONKAEN AGRICULTURAL PRODUCTION SCIENCE RESEARCH AND DEVELOPMENT CENTER,
DEPARTMENT OF AGRICULTURE, MUANG, KHONKAEN 40000 THAILAND
aranbell@hotmail.com

ABSTRACT
This study was conducted on a farmer’s farm located in Chiang Mai and at the Khon Kaen Agricultural Production Science Research and Development Center in Khon Kaen during the off-season 2012-2013. All experiments were laid out using a RCBD, four replications and ten treatments (nine varieties of F1 seed onion imported from Netherlands; Cavalier, Sirius, Minerva, Buccaneer, Colossus, Annika, Sweet Uno, Lucinda and Fernanda, and one variety commonly used by Thai farmers, Superex). Performance variables including growth, yield, physical characteristics and quality attributes were recorded. The productivity of Fernanda, Colossus and Buccaneer (270, 250 and 220 kg/ha) varieties were higher than the other varieties in all locations. The bulb shape of their varieties was different such as rhomboid, broad, globe, broad elliptic and spindle shapes. The bulb diameter and length of Fernanda and Colossus were bigger than other varieties. Number of leaf bases of all varieties were 5-8 scales. The total soluble solid of Lucinda and Minerva (8.70 and 7.88 °Brix) was the highest relatively to other varieties. Further investigation on the selection of onion varieties in season, postharvest handling, the nutritional quality, satisfaction of farmers and consumers, and marketing acceptance should be conducted in the future.

Keywords
Variety, production, quality, off-season, onion

INTRODUCTION
Onion (Allium cepa L.) is classified in the Amaryllidaceae family, monocotyledonous, herbaceous biennial, cool season vegetable crops (Khan et al. 2007), cross-pollinated, and diploid chromosomes number 2n=16 (Dawar et al. 2007). Onion is a source of vitamins and minerals (Condé Nast 2013). In Thailand, onion is a high value vegetable crop. In 2012, onion productivity was 24.6 t/ha, and total production was 39,909 tons. Chiang Mai is the largest onion producer (approximate 34,261 tons), followed by Chiang Rai (3,624 tons), Nakorn Sawan (1,463 tons), and Kanchanaburi (564 tons). Onion varieties are generally classified by day length (short, intermediate,
and long). Most types of onion sold in local markets are short-day varieties that have 5-7% soluble solids and 2-6 moles/kg of pyruvic acid (2-6 moles kg) and high pyruvate ratio, which causes the onion to be sweet (Smith et al. 2011). Superex is the only short-day onion available in Thailand. From 2012 to 2014, Thailand annually imported 3.15 tons (6,944 pounds) of onion seed from Japan under the tariff quota with zero percent tax. In turn, Thailand exports fresh onion back to Japan (Daily News Thailand 2012). Under the tariff quota, the Onion Growers Cooperative of Thailand is the only importer of onion seeds from Japan. Onion seeds are distributed to members to reduce production costs. The tariff for those outside the tariff quota is 218% according to the World Trade Organization (WTO) obligation (Bank of Thailand 2001). Due to limits on onion seed importation, farmers cultivate onion only once a year after rice harvesting from December to April. Onion bulbs are stored from May to October. As a result of import limits, seed from the black market is smuggled to Thailand. This increases onion production costs and leads to decreased prices. The government has tried to reduce excess supply and improve quality to serve consumer demand and increase the onion price.

Although the government has helped farmers obtain higher onion prices, in the early harvesting season onion prices are low. This study analyzed high potential production areas and investigated the onion production system. Results will be used to improve and develop onion production system.

**MATERIAL AND METHODS**

Ten varieties of onion (*Allium cepa*)—nine varieties of F1 seed onion imported from the Netherlands (Cavalier, Sirius, Minerva, Buccaneer, Colossus, Annika, Sweet Uno, Lucinda and Fernanda), and one variety used by Thai farmers, Superex (control). Seedlings of uniform size on visual observation were transplanted on February 7, 2013 on a flat bed system. The plot size was 1 m × 5 m for each treatment. Row-to-row and plant-to-plant spacing were 20 and 15 cm, respectively. Well-rotted field manure at the rate of 6.25 t/ha and lime at 1.25 t/ha were incorporated to the soil 30 days before transplanting the seedlings. The recommended dose of N, P and K fertilizers was applied at the ratio of 62.5-93.75 kg (21-0-0) ha, 68.75 kg (0-46-0) ha and 31.25-62.5 kg (0-0-60) ha. All the fertilizers were applied three times and same dose in 7, 25 and 50 days after transplanting. All the cultural and management practices like hoeing, weeding, irrigation and sprays for insect pests and disease control were carried out uniformly for all treatments. Onions were harvested at maturity, about 90 days after planting (DAP). The plants showed neckfall from three locations in Chiang Mai (MaeWang, Praow, Fang) and one location in Khon Kaen, Thailand during 2012-2013. The onions were then transported to Chiang Mai Royal Agricultural Research Center (CMRARC) within 2 h at 30-32°C. After grading for uniform size and shape, data on the growth, physical characteristics, yield, and quality attributes were recorded. Ten bulbs were selected for physical characteristics evaluation.

**METHODS**

*Bulb yield*

Total yield (kg/ha) was calculated for each variety.

*Physical characteristics*

The bulb weight was measured gravimetrically using a precision balance model Sartorius ELT 2001.3. It was expressed in grams (g).
The bulb diameter and length were measured using a vernier caliper model Mitutuyo Absolute Digimatic CD-12”. It was expressed as centimeters (cm).

The bulb shape was measured on a 1-9 scale of mature onion. The following scale (IPGRI, ECP/GR, AVRDC 2001): 1 = flat oval, 2 = flat globe, 3 = rhomboid, 4 = broad, 5 = globe, 6 = broad elliptic, 7 = ovate (elongated oval), 8 = spindle and 9 = high top.

Number of leaf bases and number of scale leaves were measured for each onion variety.

Peel color was measured using the Royal Horticultural Society (RHS) Color Chart. Readings were taken in three positions of fruit area. Pulp color was determined following the Royal Horticultural Society (RHS) Color Chart.

**Quality attributes**

Bulb firmness was measured using a fruit hardness tester (Nippon Optical Works FHR-5) and a 5 mm-base diameter cylinder. Readings were taken in three positions of bulb area, averaged and recorded in newtons (N).

Total soluble solids (TSS) was measured by direct readings of onion juice using a hand-held digital refractometer (Atago Pocket refractometer PAL-1) with results expressed in °Brix. The measurement was taken in three positions of fruit area.

**Statistical analysis**

The experiments were laid out using a completely randomized design (RCBD). Ten treatments and four replicates per treatment were evaluated for their growth and development. The data were analyzed using Analysis of Variance (ANOVA). Where possible, mean comparisons were made using Duncan’s multiple range tests (DMRT) at p≤0.05. Statistical analysis was carried out using the SAS system.

**RESULTS**

**Bulb yield**

In Praow, the total bulb yield of Fernanda, Colossus and Buccaneer varieties (1689, 1564 and 1320 kg/ha) were significantly higher than the other varieties (Fig. 1). At the Fang site, the variety Fernanda (1368 kg/ha) was observed to have the highest bulb yield. Praow is the most suitable area to cultivate these varieties, followed by Fang.

**Physiological characteristics**

**Bulb weight**

The maximum bulb weight of Fernanda, Colossus and Buccaneer in Praow were 62, 53 and 53 g/bulb, respectively (Fig. 2). The bulb weights of these varieties grown in the Praow site were significantly higher than the same varieties grown in MaeWang, Fang and Khon Kaen.

**Bulb diameter and length**

Measures of bulb diameter and length of the Fernanda and Colossus varieties grown in Praow were larger than the other varieties grown in other areas (Table 1).

**Bulb shape**

All varieties have similar shapes that span from rhomboid, broad, globe, broad elliptic and spindle (Table 1, Fig. 3). However, Fernanda and Buccaneer varieties in
all areas have shapes ranging from globe to broad elliptic, while the Colossus variety is broad ellipse and spindle.

**Number of leaf bases**

Number of leaf bases found in all varieties varied between 6 to 8 scales (Table 1). Varieties grown in Praow including Fernanda, Buccaneer and Colossus have a greater number of leaf scales (8 scales) than onion grown in Mae Wang (7 scales) and Fang (6-7 scales).

**Peel and pulp color**

All varieties showed peels with light colors; however, the pulp color varied from pale orange to pale yellow (Fig. 3). Minerva has white peel and pulp color.

**Quality Attributes**

**Bulb firmness**

The bulb firmness of Sirius, Buccaneer and Colossus in Khon Kaen were 3.54, 3.53 and 3.51 N, respectively, which was higher than MaeWang and Praow (Table 2).

**Total soluble solids (TSS)**

TSS of Lucinda and Minerva in MaeWang (8.70 and 7.88 °Brix, respectively) and Praow (8.13 and 7.63 °Brix, respectively) were higher than all varieties in Khon Kaen (Table 2).

**CONCLUSION**

Total bulb yield of Fernanda and Buccaneer and Colossus varieties in all sites were significantly higher than the yields of other varieties. Varieties such as the Fernanda, Buccaneer and Colossus showed desirable physiological characteristics such as bulb weight, size, shape, fleshy scale leaves, and peel and pulp color. The quality attributes of bulb firmness and TSS in these varieties were better than Superex. However these quality attributes were different in each variety and each area. Our findings suggest that the varieties Fernanda, Buccaneer and Colossus are the most appropriate to grow in all areas.

**Acknowledgement**

The authors would like to express their sincere gratitude to Nipat Sukhvibul, Jorge Fidel Barahona, and Wanwilai Chaluphun for English editing. Our gratitude also goes to all staff of CMRARC, CARDC, KAPSRDC for their kind assistance and help in making this research a success.

**References**

Table 1. The average bulb weight, bulb size (width and length), bulb shape and fleshy scale leaves of each onion variety after harvest at three locations in Chiang Mai (MaeWang, Praow and Fang) and one location in Khon Kaen.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Diameter (mm)</th>
<th>Length (mm)</th>
<th>Number of leaf bases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MaeWang</td>
<td>Praow</td>
<td>Fang</td>
</tr>
<tr>
<td>Cavalier</td>
<td>32 bc</td>
<td>40 c</td>
<td>33 bc</td>
</tr>
<tr>
<td>Sirius</td>
<td>32 bc</td>
<td>41 bc</td>
<td>32 c</td>
</tr>
<tr>
<td>Minerva</td>
<td>37 abc</td>
<td>41 bc</td>
<td>35 b</td>
</tr>
<tr>
<td>Buccaneer</td>
<td>41 a</td>
<td>44 bc</td>
<td>33 bc</td>
</tr>
<tr>
<td>Colosseus</td>
<td>36 abcd</td>
<td>45 ab</td>
<td>32 bc</td>
</tr>
<tr>
<td>Annika</td>
<td>30 d</td>
<td>40 c</td>
<td>32 c</td>
</tr>
<tr>
<td>Sweet Uno</td>
<td>41 a</td>
<td>43 bc</td>
<td>40 a</td>
</tr>
<tr>
<td>Lucinda</td>
<td>34 bcd</td>
<td>41 bc</td>
<td>33 bc</td>
</tr>
<tr>
<td>Fernanda</td>
<td>38 ab</td>
<td>48 a</td>
<td>33 bc</td>
</tr>
<tr>
<td>Superex</td>
<td>34 ab</td>
<td>43 bc</td>
<td>33 bc</td>
</tr>
</tbody>
</table>

P≤0.05

* = Means followed by the same letter in a column are not significantly different but means followed by different letters in a column are significantly different at 95% (P≤0.05) by DMRT.
Table 2. The average bulb firmness and total soluble solids (TSS) of each onion variety after harvest at three locations in Chiang Mai (MaeWang, Praow and Fang) and one location in Khon Kaen.

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Bulb firmness (N)</th>
<th>TSS (°Brix)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MaeWang</td>
<td>Praow</td>
</tr>
<tr>
<td>Cavalier</td>
<td>2.25 ab</td>
<td>2.28 ab</td>
</tr>
<tr>
<td>Sirius</td>
<td>2.28 ab</td>
<td>2.26 b</td>
</tr>
<tr>
<td>Minerva</td>
<td>2.33 a</td>
<td>2.27 b</td>
</tr>
<tr>
<td>Buccaneer</td>
<td>2.25 ab</td>
<td>2.32 ab</td>
</tr>
<tr>
<td>Colossus</td>
<td>2.21 b</td>
<td>2.32 ab</td>
</tr>
<tr>
<td>Annika</td>
<td>2.24 ab</td>
<td>2.32 ab</td>
</tr>
<tr>
<td>Sweet Uno</td>
<td>2.22 b</td>
<td>2.28 ab</td>
</tr>
<tr>
<td>Lucinda</td>
<td>2.26 ab</td>
<td>2.23 b</td>
</tr>
<tr>
<td>Fernanda</td>
<td>2.29 ab</td>
<td>2.30 ab</td>
</tr>
<tr>
<td>Superex</td>
<td>2.28 ab</td>
<td>2.37 a</td>
</tr>
</tbody>
</table>

\( P \leq 0.05 \) = Means followed by the same letter in a column are not significantly different but means followed by a different letter in a column are significantly different at 95% (\( P \leq 0.05 \)) by DMRT.
Figure 1. The total yield of each onion variety after harvest at three locations in Chiang Mai (MaeWang, Praow and Fang) and one location in Khon Kaen. Symbols labeled with different letters are significantly different at 95% (P≤0.05) by DMRT.

Figure 2. The average bulb weight of each onion variety after harvest at three locations in Chiang Mai (MaeWang, Praow and Fang) and one location in Khon Kaen. Symbols labeled with different letters are significantly different at 95% (P≤0.05) by DMRT.
Figure 3. The bulb shape, size and peel-pulp color of each onion variety after harvest at three locations in Chiang Mai (MaeWang, Praow and Fang) and one location in Khon Kaen.