Kasetsart J. (Nat. Sci.) 40 : 273 - 279 (2006)

Harvest Stages and Umbel Order Contribution on Eryngo (*Eryngium foetidum* L.) Seed Yield and Quality

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ABSTRACT

Harvest stages and umbel order contribution were studied from October 2003 to August 2004 to determine the optimum harvest time for eryngo seed production. Maximum seed yield of eryngo accession EF007 was obtained from the seventh (H7) and the eighth (H8) harvest stages with an average of 16.5 gm/m^2 when seed color was brownish black with 90% germination. The greatest contribution to seed yield was mainly from the seventh umbel order.

Key words: eryngo, umbel order contribution, harvest stages

INTRODUCTION

Eryngo (*Eryngium foetidum* L.) is a perennial herb in the family Apiaceae**.** It is known to be a native of Central and Latin America, from southern Mexico to Panama through Brazil and from Cuba to Trinidad. It was introduced into South East Asia by the Chinese as a substitute for coriander. This plant is an aromatic plant which is usually grown as a leafy vegetable, used as a seasoning and medicinal purpose in various countries such as Vietnam, India and in the Amazon region (De Guzmao *et al*., 2002).

In South East Asia, eryngo flowers throughout the year. The inflorescence is dichotomously branched and are densely crowded in simple oblong heads which are sessile on a whorl of radiating bracts. The structure of the flowers and fruits, however, is typical umbelliferous (De Guzman and Siemonsma, 1999), with indeterminate growth like many other umbelliferae (Rubatzky *et al.,* 1999). For example, carrot consists of many umbel orders. The start of flowering, seed development and seed ripening in the carrot crop do not occur synchronously on each umbel order (Hawthorn *et al.,* 1962).

The primary purpose in vegetable seed production is to obtain high yields while maintaining maximum seed quality. For crops having an indeterminate flowering pattern, the selection of harvest date is one of the most critical management decisions. Delaying harvest risks losses of high quality seed due to shattering, but harvesting too early will reduce yield and increase the percentage of immature seeds in the lot (Gray and Steckel, 1983).

The objective of this study was to evaluate the effects of harvest stages and umbel order contribution of eryngo in order to determine optimum harvest time for high seed yield and high seed quality.

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Received date : 07/09/05 Accepted date : 10/03/06

MATERIALS AND METHODS

Study site

The experiment was conducted at the Tropical Vegetable Research Center (TVRC), Kasetsart University, Khampang Saen Campus, Nakhon Pathom Province, Thailand, from October 2003 to August 2004.

Plant materials

Accession EF007 seeds were planted in peat media filled in plastic tray containing 104 inverted cone cells with a depth of 5.7cm and a volume of 20 cm^3 on October 10, 2003. After 49 days (November 28, 2003), the seedlings were transplanted into a well cultivated field at TVRC for subsequent seed production. The experiment design was a randomized complete block with 10 treatments. Each treatment was replicated four times. Plot size was considered 10 m^2. Plant to plant and row-to-row distance was maintained at 20 × 25 cm, resulting in optimum populations of 20 plants/ m^2 or 200 plants/ plot.

Transplanting fertilizer 15-15-15 and animal manure were applied at the rate of 18.75 g/m^2 and 18.75 kg/m^2, respectively. Fertilizer (15-15-15) was applied again on December 28, 2003 and January 28, 2004 at a rate of 18.75 g/m^2. The overhead irrigation system was applied during crop establishment and furrow irrigation was applied after flowering.

The 1^{st} harvest (H1) was started on April 12 when all seeds on the 1^{st} umbel turned brownish black color. The 2^{nd} harvest (H2) until final harvest (H10) were applied when the seeds on the 2^{nd} to the 10^{th} umbel turned to color as previous mentioned. At each harvest, all umbels of 10 plants were cut off and placed in separate nylon bags according to their umbel position (Figure 1). This resulted in the separation into the 1^{st}, 2^{nd}, 3^{rd}, 4^{th}, 5^{th}, 6^{th}, 7^{th}, 8^{th}, 9^{th} and 10^{th} umbel heads from each replicate and treatment.

Following 5 days of air-drying under ambient conditions, umbel heads in each bag were counted and then hand threshed. Seeds were cleaned by an air blower and then stored at 20°C and 30% relative humidity until the seed weight reached equilibrium moisture content (around 7 %). The weight of seeds in each bag was recorded and calculated to total seed yield. Results were expressed as seed yield per plant and per square meter. The weight and percentage contribution of seeds from each umbel order were also recorded. Seed number per umbel was also determined following mean 1000 seed weight calculation. Germination test (four 100 seed samples) was carried out on two layers of germination paper in rectangular transparent plastic boxes (14 × 9 × 5 mm) and incubated at 20-30°C (16 hours and 8 hours, respectively). Normal seedlings were evaluated daily as described by International Seed Testing Association (ISTA, 2003) and germination index (GI) was calculated by the following formula as proposed by AOSA (1983).

$$\text{Germination index} = \Sigma\,(N_i/D_i).$$

Where N_i = The number of normal seedlings counted at i^{th} date.

D_i = The number of days required to the i^{th} germination.

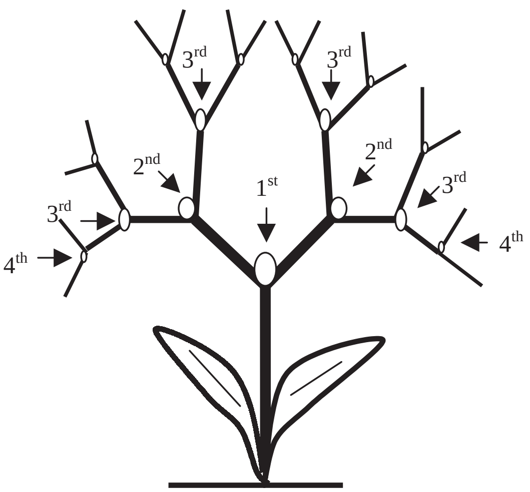

Figure 1 Diagram of eryngo plant structure showing the position of umbels. 1^{st} = First umbel order, 2^{nd} = Second umbel order, 3^{rd} = Third umbel order, 4^{th} = Fourth umbel order.

RESULTS AND DISCUSSION

1. Seed yield and its components

Seed yield in umbellifer plants can be determined by the number of umbel heads produced per unit area (Rubatzky *et al.*, 1999). The highest number of umbel heads of eryngo came from the 7th, 8th and 9th umbel orders (average 36.9 umbel heads) with no significant differences among these umbel orders (Figure 2). The highest seed yield was obtained from the 7th and the 8th harvest stages with an average of 16.5 g m^{-2} (Figure 3). This is a balance between seed maturity, potential yield and loss from shattering, resulting in a narrow window in which, seed yield can be maximized (George, 1999). Similar results have been found in onions (Steiner and Akintobi, 1986) and carrots (Hawthorn *et al.*, 1962; Gray and Steckel, 1983; Rubatzky *et al.*, 1999). Delaying umbel order harvest beyond this point, H9 to H10, did not compensate for the decreasing seed yield per plant due to seed shattering at the bottom orders. Major contributions to total seed yield were from the 7th and the 8th umbel order while the least contribution came from the 1st umbel order (Figure 4).

The number of seeds per umbel head showed a significant quadratic response, increasing at the early stages and reaching a maximum at the 5th and the 6th umbel orders before decreasing (Figure 5A). In contrast, 1000 seed weight showed a significant negative linear response, decreasing in weight as umbel order increased (Figure 5B). This result indicated that seeds harvested from the bottom umbel orders were heavier than seeds harvested from the top umbel orders. This is characteristic in many indeterminate flowering plants. For example, in soybean, Spaeth and Sinclair (1984) reported that the time of anthesis of individual flowers and nodal position of the fruit on the main stem (top vs bottom) influence seed size. Seeds from late-developing flowers or from nodes on the top of the main stem were smaller and had shorter filling periods. These seeds started growing later but matured at nearly the same time as seeds at the

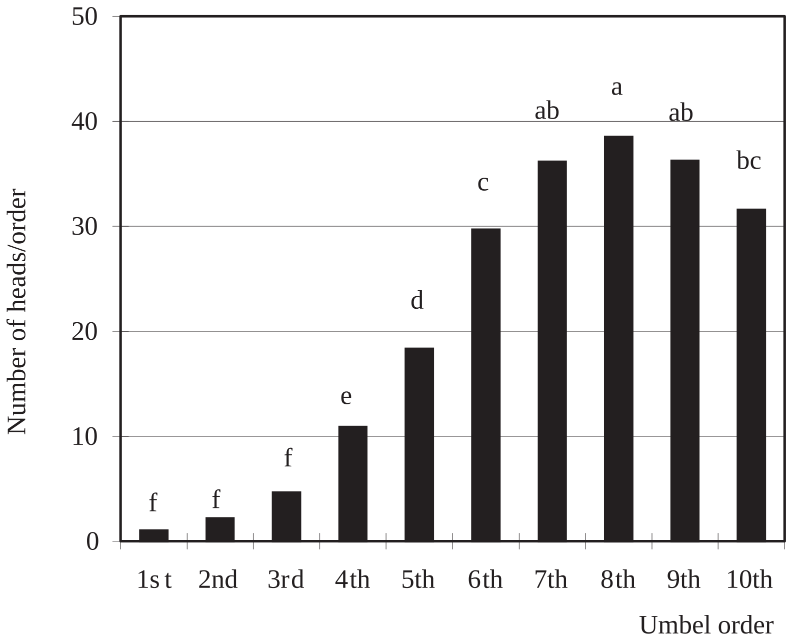

Figure 2 Number of umbel heads at each umbel order. Between bars, means followed by a common letter are not significantly different at the 5% level by DMRT.

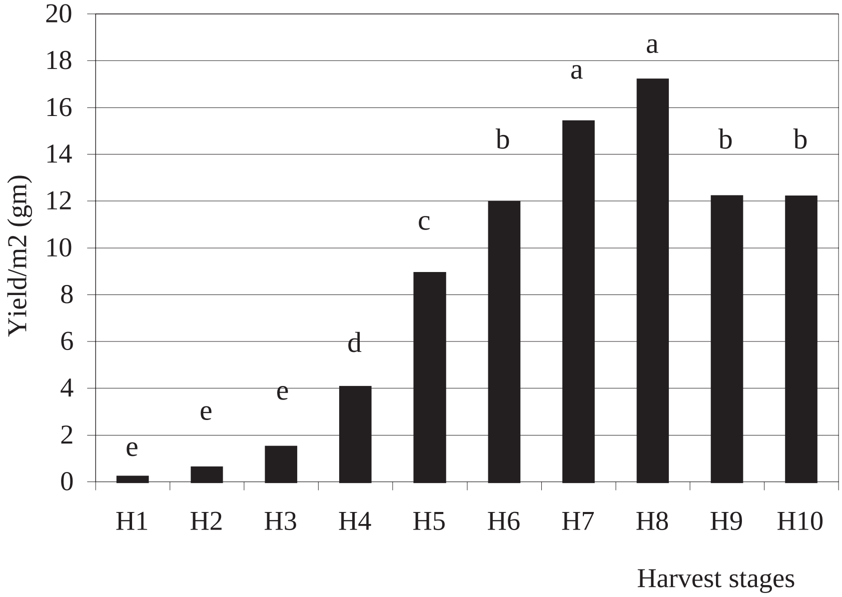

Figure 3 Seed yield/m^2 from different harvest stages. Between bars, means followed by a common letter are not significantly different at the 5% level by DMRT.

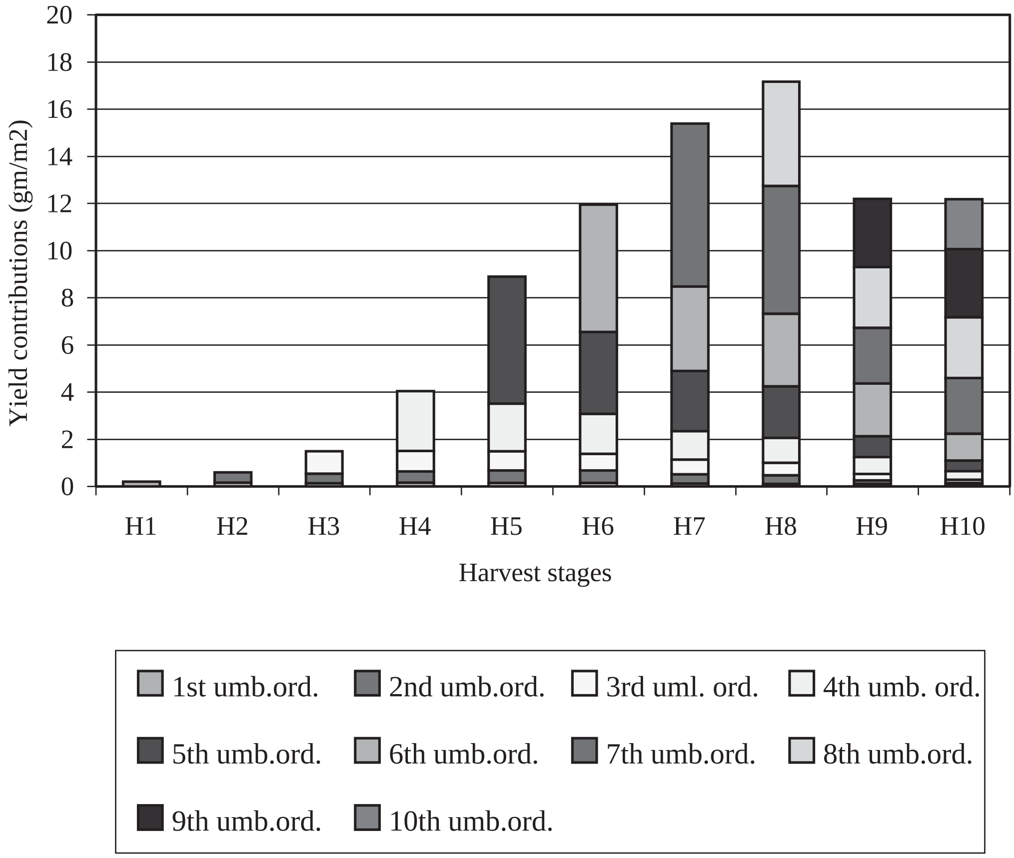

Figure 4 Yield contributions from each umbel order at different harvest stages.

bottom nodes or from early flowers. Variation in seed size on the plant is due at least partially to differences in seed filling duration. In carrot seed, Thakan and Ramnat (2002) reported that seeds from the first umbel order were heavier than those from the second and the third umbel orders. Similarly, Gray and Steckel (1980) showed that the amount of reserve material per embryo in carrot was greater in seed from the first umbel than from the second umbel. Thus, the heavier seed in eryngo was believed to follow the same trends as carrot.

3.2 Seed quality

Maximum seed quality was achieved towards the end of filling period, when seeds attained maximum dry weight (Harrington, 1972). Differences in harvesting times, therefore, can presumably result in differing seed quality. At each harvest stage, eryngo seed presumably from all orders were mixed to form one seed lot. There were significant differences in seed quality (P > 0.01) among treatments (Figure 6). The highest germination percentage (93.6-95.8%) was obtained from H1-H5 stages followed by H6 stage (91.2%). The H8 stage (maximum yield) gave the seed germination of 90% and seed from the last harvest stage (H10) had the lowest germination (85%). Germination index followed the same trend as germination percentage (Figure 6).

Eryngo seed quality was associated with the location of the seed on the mother plant. There was no doubt that the 1st to the 5th umbel orders produced heavier seeds, which also had higher germination and higher germination index. This suggesed that seeds from each umbel order could be regarded as being from separate populations having different physiological attributes. As Gray and Steckel (1980) pointed out in carrot, these differences were magnified at the time of harvest because the whole carrot plants were harvested when the 1st and some 2nd umbels were ripe, so stopping the development of seeds on the other umbels. Therefore, when seeds from different umbel positions were mixed together in the same seed lot, it was possible that this mixing is a source of variation in germination percentage. As a result, the high quality of eryngo seeds from the 1st to the 5th umbels stressed the value of increasing the number of the 1st to the 5th umbel orders in commercial crops. One potential method of reducing seed lot variability might be to grow eryngo seed crops at high populations. Reducing plant branching have more of the 1st to the 5th umbel orders with fewer umbel orders at the top as the same in carrot (Thakan and Ramnat,-2002).

Overall, the present experiment indicated

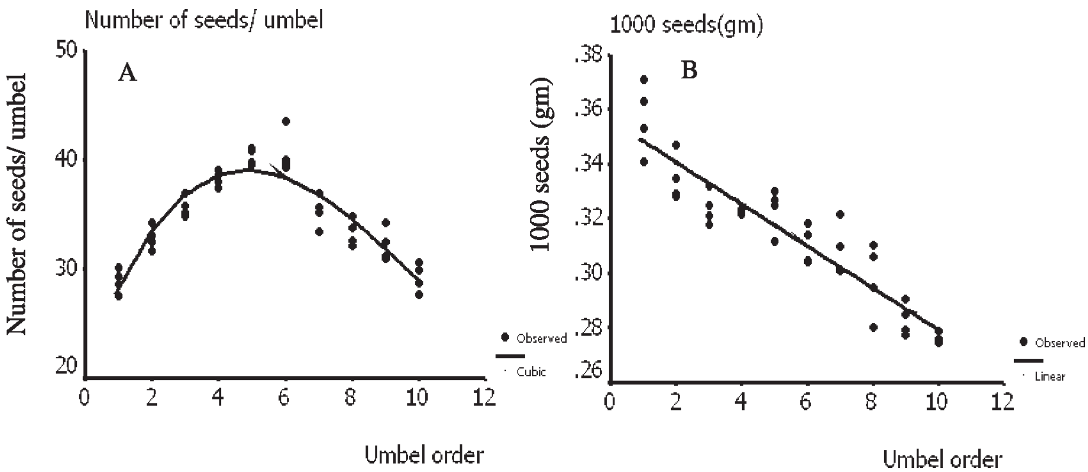

Figure 5 Relationship between (A) number of seeds per umbel head and umbel order and (B) 1000 seed weight and umbel order. Coefficients of determination (r^2) are significant at P≤0.01.

that eryngo had a potential in seed production at TVRC during the cool months (Mean Temp. 23° C, 70% RH). Thus, seed could be produced in some parts of Thailand having a cool and dry climate. The North East part of Thailand would be the most suitable area for eryngo seed production. To obtain high seed yield and seed quality, the seed production should follow the schedule shown in Figure 7 based on the results from the present work. The seed production should start in early September. Seedling should be grown in trays for at least 45 days so that roots could withstand handling. Transplanting should be done in mid to late October and seed can be harvested in 165-172 days after transplanting or at the beginning of April.

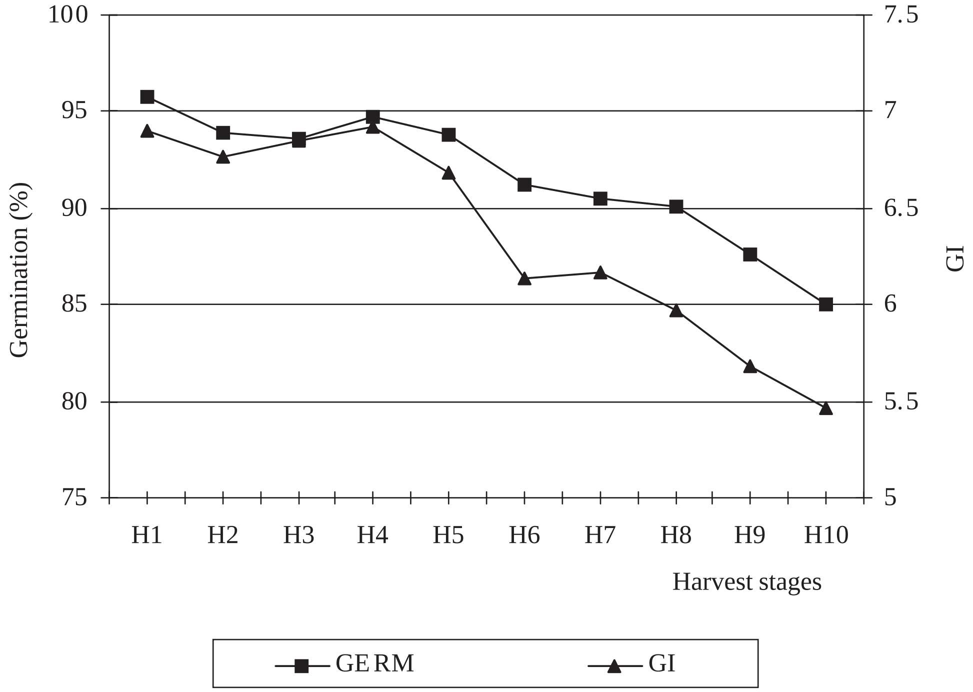

Figure 6 Germination percentage (GERM) and germination index (GI) at different harvest stages.

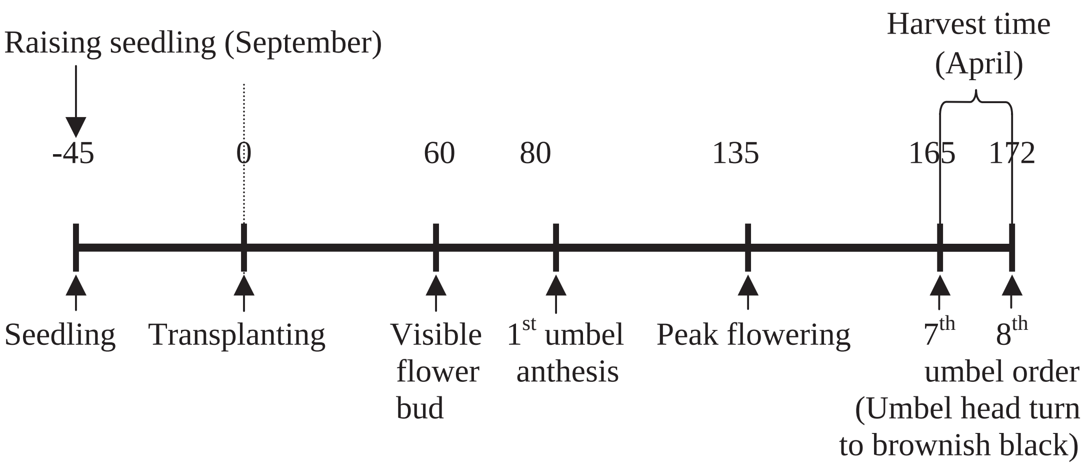

Figure 7 Seed production schedule of eryngo.

CONCLUSION

Maximum seed yield of eryngo accession EF007 was obtained from the 7th (H7) and the 8th (H8) harvest stages with an average of 16.5 gm/ m^2 when all seeds were brownish black. Seeds from the 1st umbel order to the 8th umbel order have germination over 90%.

ACKNOWLEDEMENTS

We would like to thank the Commissioner on Higher Education under the Academic Staff Development Program for providing financial support and the Tropical Vegetable Research Center (TVRC) for providing facilities used in this study.

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