

Performance of asparagus under the desert conditions of Arabian Peninsula: A pilot study

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Abstract

The performance of asparagus (*Asparagus officinalis* L.) under the desert conditions of the Arabian Peninsula was evaluated. Ten cultivars introduced from six countries were studied. Two months old seedlings were transplanted into field plots in February 2007 and spears produced in the second year were harvested over a period of four weeks. Significant differences were found among cultivars for the number and quality of spears. The average number of spears harvested per plant varied between 5.0 and 26.4 and the spear yield between 36.3 and 159.2 g plant⁻¹. The spear number and yield were highest in cultivar PI 277824. Seed yields from the first year of harvest varied from 29.7 to 136.2 g plant⁻¹ among cultivars. In many cultivars, spear yields obtained in the second year were comparable to the yields reported from the productive environments in the tropics. The results show that asparagus has considerable potential for cultivation under the desert conditions of the Arabian Peninsula.

Key words: Arabian Peninsula, *Asparagus officinalis*, crop diversification, desert environment, vegetables

Introduction

Deserts are arid regions, generally receiving less than 25 cm of precipitation a year, or regions where the potential evaporation rate is twice as great as the precipitation. Hot deserts, located 15°-25° north and south of the Equator have daytime sunshine all year round and include the Sahara, Arabian Peninsula and large parts of Iran and Iraq, northwest India and California. The Arabian Peninsula, in particular, is one of the hottest regions in the world, with daytime summer temperatures often exceeding 50°C. The soils reflect the aridity of the climate as they are poorly developed, shallow and rich in lime, gypsum, or salts. The extremely harsh conditions, together with the shortage of fresh water resources and natural salinization of vast areas severely limit the number of crops that can be successfully grown.

Despite the limitations to crop growth, agricultural sector has made considerable progress due to the incentives given to farmers by the governments, introduction of modern farming techniques and ingenuity of farmers. For instance, in the United Arab Emirates (UAE), the area under cultivation increased from 15,000 ha in 1970s to a current figure of about 260,000 ha. Vegetables contribute a significant share to the agricultural output, both in quantity and value. The most common vegetables grown are tomato, squash and cabbage. Beans, cucumber and peppers are also grown on a lesser scale, especially under controlled conditions in the greenhouses (MOEW, 2008).

The genetic resources program of the International Center for Biosaline Agriculture (ICBA) in Dubai (UAE) has been evaluating the germplasm of several exotic salt-tolerant crops including forage, vegetable and ornamental plants. The aim is to provide farmers in the Arabian Peninsula with a wide range of options for crop selection in order to diversify their production systems to minimize the risks from adverse climatic conditions and to meet the strategic national goal of reducing imports. Among the 'new' vegetable crops studied, asparagus (*Asparagus officinalis* L.) was

found to be promising for successful cultivation. Asparagus is considered to be the most salt-tolerant vegetable crop (Shannon and Grieve, 1999). Francois (1987) found that spear yield was reduced by only 2% per unit increase in soil salinity above a threshold of 4.1 dSm⁻¹. The wealth of nutrients, fiber and low calorie content make asparagus a nutritionally wise choice for today's health-conscious consumer with good prospects for introduction as a 'high value' crop for commercial cultivation. In this paper, we report the results of a pilot study to evaluate the performance of asparagus as a candidate crop for diversifying the agricultural production in the region.

Materials and methods

Seeds of ten asparagus cultivars originating from six countries were used in this study. They were provided by the Plant Genetic Resources Unit, Cornell University, USA. The seeds were germinated in jiffy packs in a greenhouse and 12 weeks old seedlings were transplanted into the open field at ICBA research station (25°05'49" N and 55°23'25"E) in February 2007. Each cultivar was planted in a single row of 3 m, spaced 1 m apart. The distance between plants within each row was about 25 cm. The soil at the research station was fine sand with very low organic matter (<0.5%). Prior to transplanting, the fertility of the soil was improved by incorporating organic fertilizer at the rate of 5 kg m⁻². The crop was irrigated with a drip system using low-quality water (salinity 2.8 dSm⁻¹). During the first year of growth, a single dose of urea one month after planting and two split doses of NPK fertilizer (20-20-20) were applied, each at the rate of 5 g plant⁻¹ by banding along the rows. There was no incidence of insects and diseases. The plots were kept free of weeds with proper field management. Towards the end of the growing season in December 2007 and in 2008, the old tops were removed, followed by the application of NPK fertilizer. The plants produced large number of spears in the following spring (February-March) each year. In the first year (spring 2008), the spears were allowed to grow into

flowering shoots for seed production. In the second year (spring 2009), the spears of 15-18 cm length were harvested daily from three randomly selected plants within each cultivar, by cutting close to the ground. The spear quality was assessed by measuring the diameter at the base and grading them into three classes: large (>1.0 cm), medium (0.5-1.0 cm) and small (<0.5 cm). In both the years, harvesting of spears continued for four weeks and was stopped as the number of spears with small diameter and open heads (considered to have no market value) noticeably increased. Data on plant height, crown diameter (aboveground estimate, based on the spread of shoots) and number of shoots were also recorded from three plants in which the spears were not harvested. The spear diameter and spear weight are expressed as the mean of 10 spears, randomly selected from each class. Berries produced by open pollination of the female plants were harvested during May-June 2008, dried for 1-2 weeks at low temperature (22-25°C) under forced ventilation, followed by the extraction of seeds by hand. All data were statistically analyzed using GenStat (Version 7.22 DE). Yield potential of individual cultivars was assessed from the average number and weight of the spears harvested per plant.

Results and discussion

The climate at the ICBA research station is hyper-arid with an annual rainfall of about 80 mm. The soil was fine sand in texture with very low organic matter (<0.5%), moderately alkaline (pH 8.2), strongly calcareous (up to 53% CaCO₃). The average temperatures during the period of study ranged from a low of 18°C to a high of about 36°C and the average relative humidity from about 50% to 65%. The daily mean temperature during spear production ranged between 20 and 22°C. The soil temperature at a depth of 15 cm was 1.5-2°C less than the air temperature.

The performance of the ten asparagus cultivars, assessed by the various morphological and agronomic parameters is shown in Table 1. Plant growth and spear production were found to be normal despite the harsh growing conditions at the research station (Figs. 1 and 2). Averaged over cultivars, plant height was 175.1±13.9 cm, crown width 22.1±1.8 cm and the number of shoots per plant 12.0±4.5. Analysis of variance revealed significant differences among cultivars for the mean spear number and yield ($P<0.001$). The average number of spears per plant among cultivars ranged between 5.0 (PI 398180) and 26.3 (IP

277824). The average spear diameter was 10.4 mm in the large spears, 7.6 mm in the medium-sized spears and 5.4 mm in the small-size spears. The average weight of large spears was 7.8 g, while that of medium and small spears was 6.8 and 4.5 g, respectively. Cultivar IP 420371 produced the highest proportion (100%) of large spears, followed by IP 398180 (46%). Cultivar IP 277824 produced a high percentage (67%) of medium-size spears (Table 1). The mean spear yield ranged between 36.3 g plant⁻¹ and 159.2 g plant⁻¹. It was highest in cultivar PI 277824, followed by PI 386246 (90.5 g plant⁻¹) and PI 277830 (79.8 g plant⁻¹). The quantity of seed harvested in the first year ranged between 25.5 and 136.2 g plant⁻¹, with an average of 57.4 g plant⁻¹ over cultivars. Cultivar IP 386246 produced the maximum quantity of seeds, followed by PI 277824 (64.1 g plant⁻¹).

Asparagus is generally grown as a temperate crop. There are also reports of it being successfully cultivated in several tropical and subtropical countries (Benson, 2008). However, cultivation under desert environments appears to be rather limited. Nichols (1992) stated that the main problem of production in deserts is the excessively high temperatures during harvest period which may cause seediness. Additionally, high temperatures limit photosynthesis affecting the storage reserves for the spear production in the following years. Despite these limitations, the production of asparagus was successfully carried out in the Sonoran desert in North America and under the desert conditions along the Peruvian coast (Nichols, 1992; Casas and Sanchez, 2008). It is obvious that the choice of varieties is critical to achieving high productivity in non-traditional environments.

Asparagus yields reported in literature vary widely from 400 to 15,000 kg ha⁻¹ (Benson, 2008). In tropical environments during the first year, a harvest period of one week and yield of about 500 kg ha⁻¹ has been envisaged (Bonnardeaux, 1996). Each year, the harvest period and the yield is expected to double up to year four, when the harvest period would be about two months and yields between 4000 and 5000 kg ha⁻¹. In the present studies, spear yields extrapolated to a population size of 22,000 plants ranged from about 800 to 3500 kg ha⁻¹ among cultivars. Several of the cultivars such as PI 277824, PI 386246 and PI 277830 produced yields in excess of 1000 kg ha⁻¹, indicating that asparagus could be successfully cultivated in desert environment of the United Arab Emirates and other countries in the Arabian Peninsula with similar environment. Heißner *et al.* (2006) reported that the

Table 1. Performance of asparagus cultivars grown under desert conditions in Dubai, UAE. Data shown are averages from three plants, except for seed yield

Cultivar	Origin	Plant height (cm)	Crown diameter* (cm)	Number of shoots per plant	Number of spears per plant				Spear yield (g plant ⁻¹)	Seed yield (g plant ⁻¹)
					Small	Medium	Large	Total		
PI 174056	Spain	185.5	20.1	13.3	4.0	6.0	0.0	10.0	58.8	47.3
PI 262900	Denmark	156.2	21.8	9.3	3.0	4.7	0.0	7.7	45.3	62.4
PI 277882	Denmark	164.2	19.1	12.0	0.3	9.3	0.0	9.6	64.9	55.1
PI 277824	England	162.4	18.6	9.0	8.7	17.7	0.0	26.4	159.2	64.1
PI 277828	England	154.6	21.4	15.0	1.3	5.0	0.0	6.3	40.0	25.5
PI 277830	Netherlands	178.3	24.1	15.7	0.0	6.0	5.0	11.0	79.8	49.3
PI 358728	Netherlands	188.8	21.1	16.0	5.3	6.7	0.0	12.0	69.3	50.0
PI 386246	France	190.2	23.3	12.0	7.0	8.7	0.0	15.7	90.5	136.2
PI 398180	Spain	175.7	23.3	4.7	0.0	2.7	2.3	5.0	36.3	29.7
PI 420371	Turkey	194.9	28.3	13.3	0.0	0.0	5.3	5.3	41.6	54.4
LSD ($P=0.05$)		41.4	5.5	9.4	-	-	-	2.9	18.7	-

*above ground estimate



Fig. 1. Asparagus growing under desert conditions at ICBA research station, Dubai, UAE.



Fig. 2. Spears of high quality produced in spring.



Fig. 3. Drying asparagus berries for seed extraction.

optimal soil temperature for the high spear yield and spear quality ranges from 18-22°C. In the present studies, the soil temperatures during spear production at the experimental station were very close to this, which might have contributed to the production of marketable spears. The results also show that the environment in Arabian Peninsula is also conducive for seed production to support the development of seed industry, which is crucial for large-scale adoption by the local farmers (Fig. 3).

In addition to the open field cultivation, asparagus would be suitable for production under protected conditions in polyhouses or greenhouses. It could be grown even in the backyards as a kitchen crop. In this study, the spears lacked the quality of export grade (should be between 1.1 and 1.6 cm), however, they would be quite suitable for domestic markets. It should be noted that the current yields were obtained under minimal management. With improved production practices and use of elite cultivars with specific adaptation to the soil and climatic conditions of the region, much higher yields and greater spear quality could be expected.

The results presented here show that asparagus has good adaptation to the desert conditions and excellent potential for diversification of agricultural systems in the Arabian Peninsula. Spear yields obtained in the second year are comparable to the yields reported from the productive environments in the tropics. The climatic conditions were also found to be suitable for seed production. Successful introduction of the crop to prospective growers, however, requires further evaluation of a wider range

of cultivars with agronomic adaptation and high yield potential together with the development of optimal production practices to maximize the yields.

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