PLANT DOMESTICATION AND THE DEVELOPMENT OF SEA STARWORT (ASTER TRIPOLIUM L.) AS A NEW VEGETABLE CROP

W.A. Wagenvoort[1], J.G. van de Vooren[2] and W.A. Brandenburg[3].

[1]Agricultural University, Dept. of Horticulture, P.O.Box 30, 6700 AA Wageningen, The Netherlands.
[2]Agricultural University, Dept. of Plant Taxonomy, P.O.Box 8010, 6700 ED Wageningen, The Netherlands.
[3]Government Institute for Research on Varieties of Cultivated Plants (RIVRO), P.O.Box 32, 6700 AA Wageningen, The Netherlands.
Publication 557

Abstract

The germination, growth and quality of *Aster tripolium* L. was analysed to study cultivation of the wild leafy plant into a commercial vegetable crop. Soil type and soil condition (non-saline, brackish and saline)were basically proved in relation to germination capacity, yield and plant behaviour with respect to external and internal quality aspects.

Germination at constant and variable temperature regime resulted in the best figures for temperatures between 21° and 17°C only within non saline conditions, For both, riversand and sandy loam plant growth was established with the best results for non-saline conditions in sandy loam. Ageing diminished plant quality demonstrated for external as well as for internal analysed parameters. The rather easy domestication and the available variation offers all possibilities for the development of Sea starwort as a new vegetable crop.

Introduction

Plant domestication refers to the process of adaptation to man made habitats (De Wet, 1981). Well established cultivated plants show us several traits, such as gigas growth especially allometric growth-, increase of number of plant parts and adaptation of habitus, which form principal differences between cultivated plants and their wild relatives c.q. ancestors (Schwanitz, 1967).

The promotion of a wild plant into a cultivated edible vegetable is used as a starting point for diversification of the vegetable crop assortment.

Aster tripolium is a fast growing perennial plant, which leaves are collected for vegetable consumption in springtime. To grow a Sea starwort for commercial production it is worthwhile to select populations with vegetative shoot formation. To prolong and stabilize the market supply an extended growth period is suitable. Ageing due to a longer growth period can influence the quality, leaves become fibrous and taste bitter. With emphasis to germination, plant growth and internal quality experiments were performed in non saline, brackish and saline soil substrates, to establish crop cultivation conditions.

Materials and methodes

Botanical Variation

Aster tripolium L. (Compositae) a halophyte species can be found along the European coasts (except around Iceland), in Nothern Africa, in the Middle- and east-European salt marshes, China and Japan (Gray, 1971; Xu-Beng-shing et al., 1982). Being widely distributed, the plant grows in diverse environments, but mainly on saline soils. When offspring of plants, from diverse origins is grown together in a experimental field it is not possible to distinguish populations from various collection sites (van Ark & van de Vooren, in prep.). This means that differences found in nature between populations, these differences are largely due to environment. The response to salt marsh environments includes both genetic changes and phenotypic plasticity (Gray, 1971; Huiskes et al., 1985).

Within Dutch populations, two varieties are recognized. The most common variety, *A. tripolium* L. var. *tripolium* is characterized by the presence of ray florets in the capitula, whereas the other variety, *A. tripolium* var. *discoideus Rchb.* is characterized by capitula without ray florets (Heukels & van der Meyden, 1983).

Crop analysis

Germination behaviour was studied within replicates of 250 seeds collected in autumn from marchland plants. The seeds were sown in plastic trays (50:30 cm) filled with riversand. Cumulative germination percentage was counted in a fytotron at constant 21°C and alternating temperatures 21°-17°, 21°-13°, 17°-13° and 13°-5°C respectively 8 h illumination by fluorescent tubes (35 W/m^2). For analysing dormancy dry seeds and seeds soaked for 24 h and 48 h in tap water and water soluted with sea salt (15 g/l) as well as seeds soaked for 24 h in a Ga^3 solution (1000 ppm) were germinated in riversand at 21°C.

To determine seasonal leaf production on June 8 seedlings ($400/m^2$) were planted in boxes filled with riversand and sandy loam from the marchland. Irrigation with saline (15 g/l sea salt) and non-saline tap water was realised within two soil watertables (10 and 25 cm below field level). Yield took place at July 14 and 28 as well as on August 14. An analysis of variance (ANOVA) proved statistical differences for the three harvest dates.

In a second experiment seeds were sown in paper pots in the middle of April and planted the end of May in similar containers filled with riversand only and a constant soil watertable of 10 cm below field level. The plants were grown in tap water, brackish and salt water, respectively 7.5 g and 15.0 g sea salt/l. In three repetitions respectively for non-saline and brackish and four within the saline irrigation, three yields (June - August) were collected. Dry weight percentage was analysed of 10 plants. From the pressed cell sap (10 1) nitrate content, osmotic value and organic acids were analysed (v. Tuyl, et al, 1964). For both experiments a constant EC was maintained of approximately 1 m S/cm for non saline, 20 m S/cm and 33 m S/cm for brackish and saline substrates.

From the second experiment a sensory test with panels of 7-8 persons took place in the Sprenger Institute. From the second and third harvest, the panel members judged the approximately 10-15 minutes boiled leaves into categories for salt adaptation, aroma, consistence boiled leaves into categories for salt adaptation, aroma, consistence and taste. The method of paired comparisons selected the differences between samples (Bock and Jones, 1978). Panel results were designed in a matrix and computerized with PACOMP (pared comparisons).

Results and discussion

In figure 1 the results of the cumulative germination is presented. The best germination percentage (80%) was obtained at a constant temperature of 21°C and alternating conditions of 21° and 17°C (Ungar, 1982). For 3 other temperature regimes germination rate decreased, however final germination percentage was approximately the same eccept for the very low (13°-5°C) temperature treatment.

From figure 2 it is demonstrated that dry seeds germinated the best. No significance could be obtained for a pre treatment soaked in water or saline water for one or two days. Final germination percentage could not be increased with a Ga^3 treatment, however germination rate improved in comparison to the other treatments.

It is obvious that the best germination will be obtained at temperatures between 21° and 17°C only in non saline conditions. After soaking some seed damage can occur, but suboptimal germination is also caused by purity of the seedlot, as no breeding selected the wild species.

Growth aspects

The plant growth in two different types of soil showed that cultivation of Sea Aster is reliable. Table 1 demonstrates some basic analysis necessary for testing crop growth.

The watertable did not influence the growth. In sandy loam yield decreased for the high watertable for the brackish treatment, which can be explained by lack of aeration the most effective under stress conditions. The total number of planted Sea starwort was pretty reduced by a soil pathogen. It is evident that soil texture and soil nutrition promote a better growth in sandy loam, the most expressed for non saline conditions. Plant density does not influence the yield per plant. The nitrate concentration in the fresh harvest leaves was variable, not alarming from the acceptable amount (approx. 3500 mg/kg fresh weight) for leafy vegetables.

Table 2 shows some analysis of the second experiment. The dry matter production demonstrated rather stable figures for the three harvest dates and was highest for the non saline soil type. This phenomenon was described by Albert 1975 as a special mechanism to dilute the salt concentration in the leaves of halophytes.

The nitrate concentration in the fresh leaves showed very variable figures as also analysed in the former experiment.

The nitrate concentration in the cell sap varied for each repetition during the growing period and within the treatments. Due to the salt concentration in the soil, a low value was observed for brackish soil and far less difference between the non-saline and saline treatment. Because of stress, water uptake can be hindered in saline substrates, however in non-saline soil, nitrate accumulation by the plant occurs to replace chloride (Stienstra, 1986). The highest nitrate amount was analysed for the second harvest within all treatments. Nitrate accumulation takes places as a consequence of environmental conditions, like extreme evaporations by high temperature and photosynthesis.

From the cell sap a linear relationship (r=0.99) was analysed for osmotic potential. When the salt concentration in the soil increased the osmotic potential accommodated. A tendency of increasing osmotic potential with plant ageing is found for brackish and saline soil conditions.

No linear relationship could be analysed for the chloride concentration in the cell sap. For the brackish and saline soil, chloride accumulation takes place, resulting in a more or less saturation curve (Adriani, 1958). Plant age related to harvest date was not particular demonstrated for this element.

The organic acid content was strongly higher for the non saline soil in comparison with the two other soil conditions. Probably plants produce organic acids to compensate Cl-ions as for a osmoticum under saline circumstances. Plant age could not influence this parameter.

Sensory test

In general the outern quality of the leaves showed after boiling differences in colour. The green colouring of the brackish and saline samples was pronounced in comparison to the brownish of the non-saline treatment. The taste of both brackish and saline was bitterish, moreover this sensation increased for the harvest of July, in fact the Sea starwort became uneatable.

From the sensory panel results (table 3) it is proved that the quality for saltish ness and consistence for both harvest dates judged equality between panel members. The factor aroma was less pronounced, so did preference. It is evident that taste (aroma + preference) is discutable, one prefers sweetness an other one salt ness. The June harvest showed significantly less saltish ness for the non-saline treatment. In the month of July the non-saline and brackish samples were less salty then the saline ones. From these results it is evident that salt condition of the soil influence saltish ness and consistence of the product.

As no agreement between panel members occured, no statistical significance could be proved for aroma. Obviously a deeper understanding will be given by analysing a range of sensory tests, by trained panel members.

From this preliminary result it can be concluded that only one harvest per growing season gives a fleshy-good tasting product. The older the crop the more bitter taste and tough consistence which diminish the quality of Sea starwort leaves drastically.

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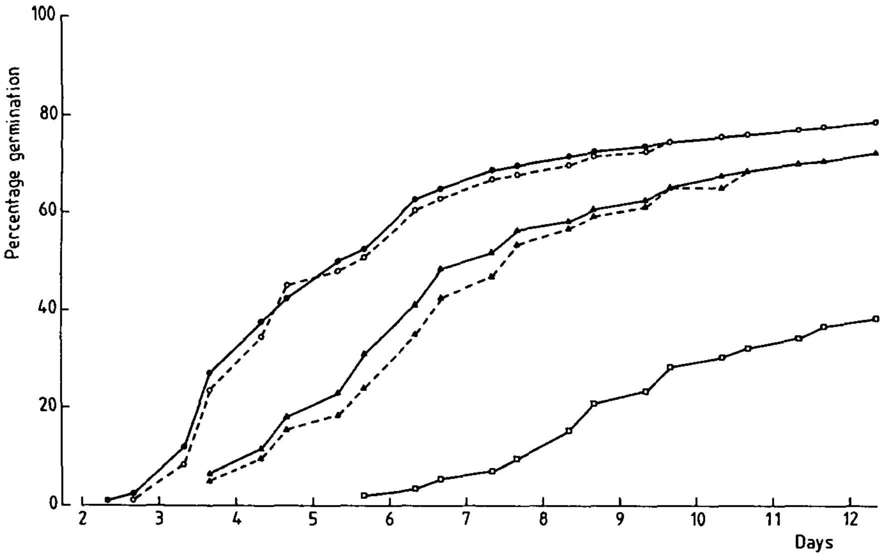

Fig. 1 Cumulative germination curve respectively for constant 21°C (•) and fluctuating 21°-17°C (○), 21°-13°C (△), 17°-13°C (▲) and 13°-5°C (□) for day and night temperature.

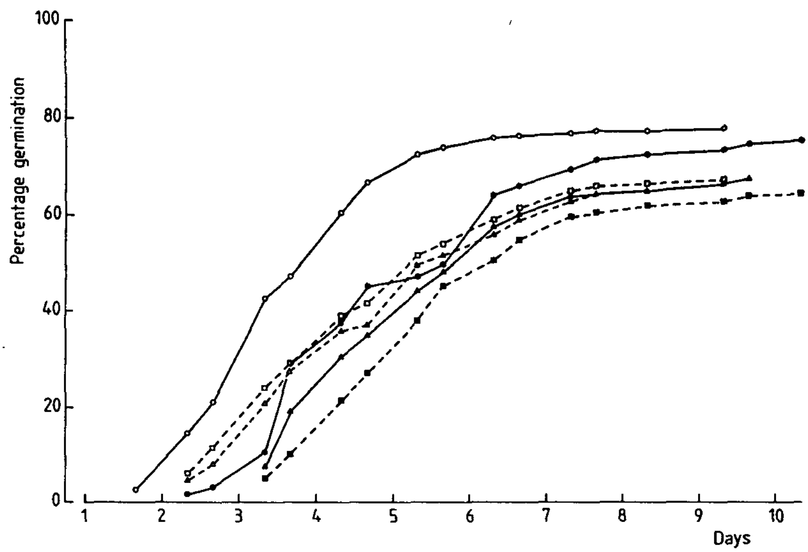

Fig. 2. Cumulative germination curve for dry seeds (•), seeds soaked in tapwater (△ and ▲) aswell for water mixed with seasalt (□ and ■) respectively for 24h and 48h and 24h in a GA_3 (○) solution.

Table 1. The mean figures of soil and plant analysis of three harvest dates.

soil type		Riversand				Sandy loam			
soil treatment		non-saline		brackish		non-saline		brackish	
watertable		10	25	10	25	10	25	10	25
NaCl	g/l	-	-	9	8	7	2	15	7
plants	/m^2	384	372	384	212	276	348	248	256
total yield	g/pl.	1.1	1.1	1.3	1.4	5.4	5.4	3.4	3.8
dry matter	%	10.4	10.9	10.1	12.0	13.6	12.9	11.8	13.1
NaCl	mg/kg	-	400	-	880	-	950	-	1050

Table 2. The mean results of plant analysis for 3 harvest dates.

soil type		Riversand								
soil treatment		non-saline			brackish			saline		
harvest		1	2	3	1	2	3	1	2	3
dry matter	%	12	10	13	9	8	9	9	8	9
NaCl	mg/kg	230	500	114	113	268	23	430	470	108
NO_3	mmol/l	4.2	8.9	2.1	2.0	4.7	0.5	7.6	8.2	1.9
Osmotic Ψ	mmol/l	380	350	340	470	530	540	590	640	650
Cl_3	mmol/l	20	15	25	180	225	185	210	250	275
organic acid	m. eq/l	150	150	190	50	45	50	55	45	50

Table 3. Analysis of pared comparisons from the sensory analysis. Significant difference (p<= 5%) different letters

Soil type	Riversand					
Soil treatment	Non-saline	Brackisch	Saline	Non-saline	Brackish	Saline
Harvest	June (11)			July (31)		
Saltish ness	-0.5038a	0.3288b	0.1756b	-0.5083a	-0.1013a	0.6095b
Consistence	0.7692a	-0.4615b	-0.3078b	0.7515a	-0.1420b	-0.6095b
Preference	-0.1538a	-0.0814b	0.2352a	-0.3650a	0.4653b	-0.1003ab
Aroma	-0.1538a	0.0000a	0.1538a	-0.2769a	-0.1908ab	0.0863a