Project Title	Effects of variety and growth conditions on shelf life and appearance in pot- and field-grown coriander
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Project leader:	T J Flowers; School of Life Sciences, University of Sussex, Falmer, Brighton, BN1 9QG
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Key staff:	Tim Flowers Uliana Bashtanova
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Project coordinator:	Dr Claire Donkin, Swedeponic UK Ltd. Dr David Hand, Humber VHB
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The results and conclusions in this report are based on a series of experiments conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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[Name]
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[Organisation]

Signature ..... Date .....

Report authorised by:

[Name]
[Position]
[Organisation]

Signature ..... Date .....

[Name]
[Position]
[Organisation]

Signature ..... Date .....

CONTENTS

Grower Summary

Headline

- Five ‘leafy’ varieties of coriander with better appearance and harvesting window than the seed varieties used by industry at present have been preliminarily selected for future production in the UK.

Background and expected deliverables

Development and expansion of the market for fresh coriander is restricted by its extreme perishability. Coriander has been recognised as the most problematic herb in terms of shelf-life, habit and flavour persistence at a ‘Steering Group’ meeting of the BHTA growers, attended by members of the HDC and researchers in 2005. The short shelf life is a genetic characteristic of this species – the leaves in the basal rosette die quickly after the production of a flowering stem. This feature creates problems for coriander herb growers as the harvesting window and shelf-life of coriander leaves is short and production of green biomass is low. However, it is possible to postpone withering using the biodiversity of coriander as a species.

Coriandrum sativum (Apiaceae) is an annual herb, which has been cultivated since ancient times in many countries both for fruits (as a spice/healer) and for leaves as a vegetable. The dual use of coriander resulted in selection of varieties according to their genetic features. Varieties selected for fruit production have few leaves in the rosette (1-5) and flower early (the flowering stem appears on day 40-55). These ‘seed’ varieties originated mainly in the Indian subcontinent, Near East, Mediterranean countries and Africa, where fruits were used in cooking.

In contrast, in Central Asia and the Caucasian region leaves of coriander are an important ingredient in the cuisine. Here the local ‘leafy’ varieties are characterised by high production of leaves in a basal rosette (5-15) and later flowering (the flowering stem appears on day 45-75). Thus, the appearance of coriander as a vegetable depends on the habit of the basal leaf rosette, which in turn is determined by the genetic makeup. In this context, ‘leafy’ varieties of coriander have two potential benefits compared to ‘seed’ varieties: firstly, the leaves live longer, and secondly, the plants look luxuriant. Traditionally in Britain varieties of European origin are cultivated which belong to the ‘seed’ group. Therefore it is important to identify new ‘leafy’ varieties of coriander and introduce them to growers to improve coriander performance as a herb on the British market.

The project is designed to identify new ‘leafy’ varieties, using material stored in gene-banks. The biggest collection of coriander is stored in N. I. Vavilov Research Institute of Plant Industry (VIR), Russia which contains 334 samples from all over the world, and is enormously rich in European, Caucasian and Asian varieties.

Promising varieties in terms of appearance, harvesting window and shelf-life have been selected and their performance has been checked in greenhouses in different seasons. These serial trials will reveal the best leafy varieties, which will undergo further trials to evaluate the effect of growth conditions on their appearance, harvesting window and shelf-life.

As a result of this detailed research programme, growers will be offered an informed choice of ‘leafy’ coriander varieties with known consequences of changes in growth conditions on appearance, harvesting window and shelf-life. Growers will be able to exploit results of this study immediately.

Summary of the project and main conclusions

Seeds of 47 'leafy' varieties were obtained from the VIR, Russia, based on a literature search available only in VIR, examination of VIR Herbarium and personal communication with the curator of the collection of rare vegetables, Dr Olga Zvereva. Trips to VIR were sponsored by Humber VHB and Swedeponic UK Ltd. A first selection (28 varieties) was obtained in May 2006 and a second group (19 varieties) in January 2007, due to a lack of sufficient quantities of seeds of these varieties in May.

The appearance of the first 28 varieties was checked in plants grown in soil in a greenhouse during June-July 2006. Photographs and short descriptions of their appearance are provided in Appendix A of the main report. Of these 28 varieties, 15 varieties were selected as promising by scientists and representatives of Humber VHB and Swedeponic. Selection was based on visual appearance of the varieties in soil and a count of the number of leaves in the basal rosette. These chosen varieties were re-grown, again in soil in a greenhouse, during July-October 2006 to obtain seeds for trials in pots, as initially only about 200 per seeds per variety were supplied by the genebank.

Pot trials of 15 varieties were performed in winter (November-December) 2006 and in spring (February-March) 2007. Plants were grown in pots on substrates obtained from Humber VHB and Swedeponic. Varieties which are currently used by the industry: var. *americanum* (obtained from Swedeponic) and var. *Kashmir* (obtained from Humber VHB) were used as controls. The plants were irrigated with nutrient solution whose composition was the same as that presently used by industry. As plants reached a harvestable stage, several characteristics were monitored including plant height, leaf area, number of leaves in the basal rosette, appearance of petioles, elevation of rosette and dry weight.

Plants were then left in the same growing conditions and their aging was monitored to obtain additional information on three important characteristics including: length of harvesting window, final number of leaves in rosette and time of bolting. Photographs of plants at the beginning and at the end of the harvest window were taken. Results of these trials are presented in the tables and photographs provided in the main report.

Informal tasting of varieties was performed twice. Only one variety was consistently found to have an unpalatable taste (by scientists and by industry representatives) this was variety 5. which was perceived to be not suitable for the coriander herb industry.

Varieties 79 and 153 are not suitable for coriander herb industry as they performed very similarly to the control in pot conditions. They also did not show any remarkable features when grown in soil.

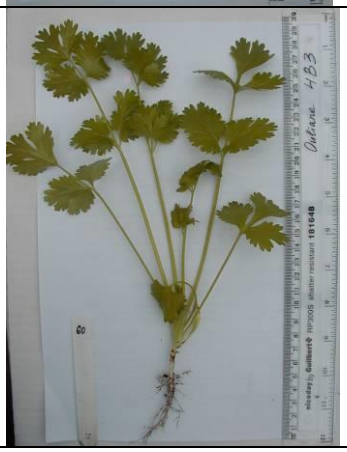
Varieties 62 and 64 may be suitable for field growers, as they produce big leaves in high numbers giving a floppy appearance to the petioles. These varieties will not be trialled further.

Varieties 52, 59, 61, 103 and 123 will be trialled for a second time before any decision on their suitability for pot industry should be made.

Based on appearance and on harvesting window shown in two trials, the five most promising leafy varieties are: 4, 43, 57, 58 and 60. Details of each variety are listed in Table 1 below.

Table 1 Characteristics of the five most promising leafy coriander varieties for commercial pot herb production in the UK

Variety 4	Produces about the same number of leaves in basal rosette as control during growth, so their growth rates are similar. What is more important, variety 4 continues to produce leaves, when production in control is stopped. It also has straight non-flopping petioles, lower elevation of rosette, higher dry biomass and longer harvesting window than control (long period of stable green colour of leaves and late bolting)..	
Variety 43	Produces more leaves in basal rosette than control during growth period; it also continues to produce leaves, when production in control is stopped. It also has straight non-flopping petioles, lower elevation of rosette, and higher dry biomass than control and longer harvesting window (long period of stable green colour of leaves and late bolting). Variety 43 is an exceptionally slow bolting variety, thus should be used by field growers when bolting is an issue.	
Variety 57	Produces more leaves in basal rosette than control during growth period; it also continues to produce leaves, when production in control is stopped. It also has straight non-flopping petioles, lower elevation of rosette, and higher dry biomass than control and longer harvesting window (long period of stable green colour of leaves and late bolting).	

Variety 58	Produces more leaves in basal rosette than control during growth period; it also continues to produce leaves, when production in control is stopped. It also has straight non-flopping petioles, lower elevation of rosette, and higher dry biomass than control and longer harvesting window (long period of stable green colour of leaves and late bolting). Variety 58 also has bigger leaves than control.	
Variety 60	Produces more leaves in basal rosette than control during growth period; it also continues to produce leaves, when production in control is stopped. Its petioles flopped in first trial, but in the second trial were straight, comparing to control. Variety 60 has lower elevation of rosette, and the same biomass as control, but longer harvesting window. Variety 60 also has much bigger leaves than control.	

It should be noted that this selection (varieties 4, 43, 57, 58, 60) is very preliminary, as the performance of these varieties has not yet been checked in the summer. Only after a third trial and vigorous statistical analysis, can any firm decision be made. At present only descriptive statistics have been applied, which shows the degree of variation of characteristics, but not comparability of treatments/varieties.

Nineteen varieties (second part obtained in January 2007) will undergo the same selection process as the first group where they will be checked for appearance in soil then propagated and then trialled in pots in different seasons.

Financial benefits

It is not yet possible to calculate any financial benefit, as only initial trials on leafy varieties have been performed and only preliminary decisions on which is most promising made.

Action points for growers

It is not yet possible to identify action points, as only initial trials on leafy varieties have been performed and only preliminary decisions on which is most promising made.

Science Section

Introduction

Coriandrum sativum (Apiaceae) is an annual herb, which has been cultivated since ancient times in many countries both for fruits (as a spice/healer) and for leaves as a vegetable (Ivanova and Stoletova, 1990). The dual use of coriander resulted in selection of varieties according to their ontogenetic features. During the vegetative stage plants produce from 1 to 15 leaves in a basal rosette. At the onset of flowering, the leaves in the basal rosette are completely developed and shortly after they wither. Thus, varieties selected for fruit production have few leaves in the rosette (1-4) and flower early (the flowering stem appears on 43-55 day) (Diederichsen, 1996). These 'seed' varieties originated mainly in the Indian subcontinent, Near East, Mediterranean countries and Africa (Diederichsen, 1996), where fruits were used in cooking (Stoletova, 1931). In contrast, coriander leaves are an important ingredient in the cuisine of Central Asia and the Caucasian region (Ivanova, 1966). Here the local 'leafy' varieties are characterised by the high production of leaves in a basal rosette (5-15) and late flowering (stem onset on 66-76 days) (Alborishvili, 1984; Diederichsen, 1996). The appearance of coriander as a vegetable depends on the habit of the basal leaf rosette, which in turn is determined by the ontogenetic programme of the genotype. In this context, 'leafy' varieties of coriander have two potential benefits compared to 'seed' varieties for UK herb growers these are firstly, leaves live longer and secondly, plants look luxuriant.

Coriander producers have not as yet benefited from the advantages of 'leafy' varieties, primarily because 'leafy varieties' have not been evaluated for growth habit and flavour, so the UK industry has not taken the risk of growing them in preference to the better known 'seed' varieties. It is time now to investigate growth habits, shelf life and flavour compounds of new 'leafy' varieties of coriander and to introduce a range of new varieties to the industry in order to enhance the market share of UK herb growers.

Materials and Methods

Seeds of 47 'leafy' varieties were obtained from N. I. Vavilov Research Institute of Plant Industry (VIR), Russia. VIR was organised in 1894 by the brilliant Russian plant scientist Nikolai Vavilov. Vavilov is a creator of the theory of "Centres of Origin of Cultivated Plants", whose central tenet is that the geographical origin of crop species is where the highest number of its wild relatives are found. To confirm his theory Vavilov made several world expeditions and collected masses of seeds of crops and their wild relatives. That was the start of the collection, which is now the oldest and biggest in the world. The coriander collection in VIR contains 347 samples from all over the world, and is enormously rich in European, Caucasian and Asian varieties, which are most useful for this study. Vavilov's and later findings are documented in the VIR Herbarium, which is, along with the unique VIR library, a valuable source of information. Trips to VIR were sponsored by Humber VHB and Swedeponic UK Ltd.

The first group (28 varieties) was obtained in May 2006 and the second group (19 varieties) in January 2007 - due to a lack of seeds of these varieties in May.

Soil trials: Plants were grown in a greenhouse in raised bed, 50 cm depth, or in 3 l pots. The soil was a mixture of compost:sand = 2:1. Top soil (5 cm) was a mixture of peat:compost = 1:1. The range of temperature in the greenhouse was 12-18 °C at night and 20-30 °C at day.

Pot trials: Plants were grown in a greenhouse in pots on substrate obtained from Humber VHB and Swedeponic. The nutrient solutions were the same as used presently by industry. The range of temperature in the greenhouse was 5-10°C at night and 18-24 °C at day. Additional artificial light was given for 12 h/ day.

Analysis: At present only descriptive statistics have been calculated (see tables), which shows degrees of variation of characteristics, but not comparability of the treatments/varieties.

Results and Discussion

Examination of VIR Herbarium showed:

- Number of leaves in rosette in varieties of European origin never exceeds 6 (with rare exceptions), and they wither at the onset of flowering, so are true 'seed' varieties.
- Varieties from Caucasus (Daghestan, Armenian, Georgia) have from 5 to 13 leaves in the rosette, thus are a mixture of seed and vegetable varieties.
- Asian varieties are also a mixture of seed and vegetable varieties; the majority (70%) are seed varieties, but some vegetable varieties could be found in Kyrgyzstan, Kazakhstan, Iran, Afghanistan, China, Mongolia. In Uzbekistan, exceptionally, there are plenty of vegetable varieties.
- Leaves of vegetable varieties do not wither at bolting, thus the taste of the leaves of these varieties is more likely to be sustained, than that of seed varieties where taste changes at bolting when the leaves start to wither (Potter, 1996).

Examination of the literature available in the VIR Library showed that coriander:

- Is very sensitive to shortage of phosphate and potassium at the vegetative stage (Palamar' and Chotina, 1953).
- Prefers ammonium to nitrate as a form of nitrogen supply (Palamar' and Chotina, 1953).
- Is intolerant to chalky soils (Palamar' and Chotina, 1953).
- Is a typical long day plant (Palamar' and Chotina, 1953; Konstantinov and Zhebrak, 1963), although in English publications, it is usually stated that coriander is insensitive to day-length (Palamar' and Chotina, 1953).
- Is sensitive to a shortage of water and high temperatures, which induce bolting

Although it is stated in English publications that bolting correlates with the number of leaves in the rosette (the more leaves the later is bolting), this is not so according to VIR (see Table 1) (Girenko and Cytovich, 1980; Girenko, 1992). This means that leaves grow at different speeds in different varieties, and it is possible to select a variety, which produces more leaves than a seed variety during the same period of growth.

Table 1: Number of leaves in rosette of *Coriandrum sativum* versus time of bolting (from Girenko and Cytovich, 1980; Girenko, 1992)

Origin of variety	Rosette, Number of Leaves	Bolting, Days from seedling
Ethiopia	5-10	50
Kazakhstan	6-7	32
Azerbaijan	6-7	42
Daghestan	6-7	33
Daghestan	6-7	42
Daghestan	6-8	40
Uzbekistan	6-8	48
Georgia	6-8	37
Georgia	6-11	42
Azerbaijan	7	33
Georgia	7-11	43
Georgia	7-12	28
Azerbaijan	8-11	34
Georgia	8-12	29
Kazakhstan	9-11	30
Georgia	9-13	44
Armenia	10	27

Several scientific publications identified promising vegetable varieties (Girenko and Cytovich, 1980; Girenko, 1974, 1992; Alborishvili, 1971, 1984), which were then obtained from VIR.

Personal communication with curator of rare vegetable plants, Dr Olga Zvereva, also identified vegetable varieties of coriander which are worth further study.

The total number of varieties obtained from VIR was 47.
First group (28 varieties) was obtained from VIR in May 2006.

The origin of these varieties is as follows:

Caucuses	Asia	Others
Georgia – 8	Kazakhstan – 2	Africa - 2
Armenia – 4	Uzbekistan – 1	European part of Russia – 1 (originally 2 but one did not germinate)
Azerbaijan – 5	Syria – 1	VIR selection - 2
Daghestan – 2		
Total – 19	Total – 4	Total - 5

The appearance of 28 varieties (first group) was checked in soil in the greenhouse in June-July 2006. Photographs and a short description of their appearance are provided in Appendix A. Informal tasting of varieties was performed twice firstly when all varieties were grown in soil and secondly during the spring 2007 pot trial of promising leafy varieties (15 were selected, see below). The taste description is given in Appendix A. Only one variety was consistently found unpalatable (by scientists and by industry representatives). This was variety 5 and will not be trialled further.

Out of these 28 varieties, 15 varieties (4, 5, 43, 52, 57, 58, 59, 60, 61, 62, 64, 79, 103, 123 and 153) were selected as promising by scientists and representatives of Humber VHB and

Swedeponic. Selection was based on visual appearance of varieties in soil and a count of the number of leaves in the basal rosette.

These 15 varieties were propagated in soil in the greenhouse during July-October 2006 to obtain seeds for further research because only approximately 200 seeds per variety were provided by the gene bank.

Pot trials of 15 selected and propagated varieties were performed in winter (November-December) 2006 and spring (February-March) 2007. Plants were grown in pots on substrates obtained from Humber VHB and Swedeponic. Nutrient solutions were the same as used by the industry. As controls, varieties currently used by the industry, var. *americanum* (obtained from Swedeponic) and var. *Kashmir* (obtained from Humber VHB), were used. As plants reached their harvestable stage several characteristics of appearance were monitored:

- **plant height**, measured as length of longest petiole (cm),
- **leaf area**, measured as area of second leaf in rosette (mm^2),
- **number of leaves in the basal rosette**,
- **appearance of petioles:** can be either flopping or straight (a subjective characteristic),
- **elevation of rosette:** can be either elevated or prostrate, measured as hypocotyl length (cm),
- **dry weight,** measured as dry weight of green biomass (petioles + leaves) per plant (mg).

- Plants were then left in the same growing conditions, they were watered, but not fed, and their aging was monitored so that three important characteristics of the harvesting window were obtained:
- **length of harvesting window**, measured as period between dates when a pot reached a saleable state (harvest time) and beginning of yellowing/reddening or bolting, in days. If a plant in a pot changed colour or bolted then the whole pot is not saleable, so it is seen as a 'per pot' characteristic,
- **final number of leaves in rosette** at the end of harvesting window,
- **time of bolting**, measured as a period between dates of seedlings emerging and of appearance of flowering stem, per pot.

Results of these trials are recorded in the tables (2-12). Photographs of plants at the beginning and at the end of the harvesting window were taken (fig 1-9). Fresh seeds of varieties 52, 59, 61, 103 and 123 did not germinate for the first trial in the winter (probably a period of dormancy was essential) and were trialled only in spring 2007. Varieties 52, 59, 61, 103 and 123 will be trialled for the second time before any decision on their suitability for the pot industry can be made. If any of these varieties are found to be very promising then they will be trialled in pots for a third time. Therefore only tables and photographs are provided for varieties trialled twice: 4, 43, 57, 58, 60, 62, 64, 79 and 153. Swedeponic decided to change their growth substrate from spring 2007 onwards and so only results of the spring trial are provided (the results of the winter trial were discarded).

Table 2: Variety *Kashmir* (control for Humber VHB)

Date of harvest	Plant height	Leaf area[1]	Number of leaves	Dry weight	Petiole appearance	Elevation of rosette	Harvesting window	Final number of leaves[2]	Bolting
	[cm]	[mm^2]		[mg]		[cm]	[day]		[day]
15.Dec.06	9.4 ± 0.4	±	3.1 ± 0.2	45 ± 5	flops	3.6 ± 0.2	11	4.1 ± 0.1	36
15.Dec.06	10.5 ± 0.4	±	2.7 ± 0.1	39 ± 5	flops	3.6 ± 0.2	11		36
28.Feb.07	10 ± 0.5	±	3.5 ± 0.2	81 ± 10	flops	4.3 ± 0.2	10		32

Table 3: Variety *Americanum* (control for Swedeponic)

Date of harvest	Plant height	Leaf Area	Number of leaves	Dry weight	Petiole appearance	Elevation of rosette	Harvesting window	Final number of leaves	Bolting
	[cm]	[mm^2]		[mg]		[cm]	[day]		[day]
01.Mar.07	10.4 ± 0.6	±	4.1 ± 0.3	95 ± 15	flops	3 ± 0.3	21	4.2 ± 0.2	50

Table 4: Variety 4.

Date of harvest; grower	Plant height	Leaf Area	Number of leaves	Dry weight	Petiole appearance	Elevation of rosette	Harvesting window	Final number of leaves	Bolting
	[cm]	[mm^2]		[mg]		[cm]	[day]		[day]
15.Dec.06 **VHB**	11 ± 0.4	±	3.6 ± 0.2	60 ± 7	Straight	2.7 ± 0.2	21	8.1 ± 0.5	none[3]
15.Dec.06 **VHB**	12.3 ± 0.4	±	4.2 ± 0.4	83 ± 14	Straight	2.5 ± 0.3	21		none
01.Mar.07 **SWP**	12 ± 0.5	±	4.2 ± 0.3	98 ± 15	Straight	1.9 ± 0.2	20		50
28.Feb.07 **VHB**	14.1 ± 0.6	±	4.5 ± 0.3	80 ± 11	Straight	2.8 ± 0.5	19		50

Variety 4 produces about the same number of leaves in the basal rosette as the control during growth, so their growth rates are similar. What is more important is that variety 4 continued to produce leaves, when production in the control had ceased (see 'final number of leaves'). It also has straight non-flopping petioles, lower elevation of the rosette, a higher dry biomass than the control and a longer harvesting window (long period of stable green colour of leaves and late bolting) (see also fig. 1 and catalogue). It was therefore selected as one of the five most promising vegetable varieties of coriander.

[1] Images of leaves were taken, but not yet calculated (only for var. 43 and 153 this was performed)
[2] When cell is empty the record was not taken
[3] 'none' stated for bolting if it was not observed in duration of the experiment (50 days after sowing)

Table 5: Variety 43

Date of harvest; grower	Plant height	Leaf Area	Number of leaves	Dry weight	Petioles appearance	Elevation of rosette	Harvesting window	Final number of leaves	Bolting
	[cm]	[mm^2]		[mg]		[cm]	[day]		[day]
19.Dec.06 **VHB**	9.6 ± 0.5	771 ± 225	4 ± 0.2	55 ± 5	straight	2.8 ± 0.1	20	7.1 ± 0.4	none
19.Dec.06 **VHB**	10.6 ± 0.9	±	4.2 ± 0.2	63 ± 7.5	straight	2.2 ± 0.2	20		none
05.Mar.07 **SWP**	11.8 ± 0.5	±	4.7 ± 0.3	101 ± 14	straight	2.5 ± 0.3	20		none
05.Mar.07 **VHB**	12.9 ± 0.5	±	4.8 ± 0.3	90 ± 10	straight	2.3 ± 0.3	15		none

Variety 43 produces more leaves in the basal rosette than the control during the growing period. It also continues to produce leaves when production in the control has ceased (see 'final number of leaves'). It also has straight non-flopping petioles, lower elevation of rosette, higher dry biomass than the control and a longer harvesting window (long period of stable green colour of leaves and late bolting) (see also fig. 2 and catalogue). It was therefore selected as one of the five most promising vegetable varieties of coriander. Variety 43 is an exceptionally slow bolting variety and so should be used by field growers when bolting is an issue.

Table 6: Variety 57

Date of harvest;grower ID	Plant height	Leaf Area	Number of leaves	Dry weight	Petioles appearance	Elevation of rosette	Harvesting window	Final number of leaves	Bolting
	[cm]	[mm^2]		[mg]		[cm]	[day]		[day]
19.Dec.06 **VHB**	10.8 ± 0.7	±	4.3 ± 0.4	60 ± 13	straight	2.3 ± 0.2	16	9 ± 0.6	40
19.Dec.06 **VHB**	9.2 ± 0.5	±	4.1 ± 0.3	53 ± 9	straight	1.9 ± 0.1	16		40
05.Mar.07 **SWP**	11.6 ± 0.4	±	5.3 ± 0.2	111 ± 12	straight	3 ± 0.2	11		
05.Mar.07 **VHB**	12.5 ± 0.5	±	4.8 ± 0.2	74 ± 7	straight	3.4 ± 0.2	10		

Variety 57 produces more leaves in the basal rosette than the control during the growing period. It also continues to produce leaves when production in the control has ceased (see 'final number of leaves'). It also has a straight non-flopping petioles, lower elevation of rosette, higher dry biomass than the control and a longer harvesting window (long period of stable green colour of leaves and late bolting) (see also fig. 3 and catalogue). Thus it was selected as one of five most promising vegetable varieties of coriander.

Table 7: Variety 58

Date of harvest;grower ID	Plant height	Leaf Area	Number of leaves	Dry weight	Petioles Appearance	Elevation of rosette	Harvesting window	Final number of leaves	Bolting
	[cm]	[mm^2]		[mg]		[cm]	[day]		[day]
19.Dec.06 **VHB**	11.3 ± 1.7	±	3.7 ± 0.3	51 ± 10	straight	2.4 ± 0.2	20	8.5 ± 0.4	none
19.Dec.06 **VHB**	10.6 ± 1.4	±	4.5 ± 0.4	63 ± 14	straight	1.8 ± 0.2	20		none
01.Mar.07 **SWP**	14 ± 0.6	±	5 ± 0.2	123 ± 14	straight	1.6 ± 0.1	19		48
28.Feb.07 **VHB**	12.6 ± 0.6	±	4.1 ± 0.2	83 ± 9	straight	3.1 ± 0.2	13		

Variety 58 produces more leaves in the basal rosette than the control during the growing period. It also continues to produce leaves when production in the control has ceased (see 'final number of leaves'). It also has straight non-flopping petioles, lower elevation of rosette, higher dry biomass than control and longer harvesting window (long period of stable green colour of leaves and late bolting). Variety 58 also has bigger leaves (as far as could be judged from visual examination) than the control (see also fig. 4 and catalogue). It was therefore selected as one of five most promising vegetable varieties of coriander.

Table 8: Variety 60

Date of harvest;grower	Plant height	Leaf Area	Number of leaves	Dry weight	Petioles appearance	Elevation of rosette	Harvesting window	Final number of leaves	Bolting
	[cm]	[mm^2]		[mg]		[cm]	[day]		[day]
15.Dec.06**VHB**	12.8 ± 0.6	±	3.4 ± 0.1	51 ± 5	flops	2.7 ± 0.1	21	6.6 ± 0.4	46
15.Dec.06**VHB**	10.5 ± 1.1	±	3.3 ± 0.3	52 ± 11	flops	1.6 ± 0.1	21		46
01.Mar.07 **SWP**	11.7 ± 0.6	±	4.7 ± 0.3	102 ± 10	straight	2.6 ± 0.3	12		37
28.Feb.07 **VHB**	13.4 ± 0.6	±	4 ± 0.2	85 ± 11	straight	3.6 ± 0.2	13		

Variety 60 produces more leaves in the basal rosette than the control during the growing period. It also continues to produce leaves when production in the control has ceased (see 'final number of leaves'). Its petioles flopped in the first trial, but in the second trial were straight comparing to the control. Variety 60 has a lower elevation of the rosette and the same biomass as the control, but longer harvesting window. Variety 60 also has much bigger leaves (as far as could be judged from visual examination) than the control (see also fig. 5 and catalogue). Thus it was selected as one of five most promising vegetable varieties of coriander.

Table 9: Variety 62

Date of	Plant	Leaf	Number	Dry	Petiole	Elevation	Harvest	Final	Bolting

harvest; grower	height	Area	of leaves	weight	appearance	of rosette	ing window	number of leaves	
	[cm]	[mm^2]		[mg]		[cm]	[day]		[day]
19.Dec.06 **VHB**	10.5 ± 0.7	±	3.6 ± 0.2	63 ± 7	flops	2.8 ± 0.2	20	7 ± 0.3	none
19.Dec.06 **VHB**	12.3 ± 0.6	±	3.8 ± 0.3	75 ± 10	flops	2.2 ± 0.2	20		none
05.Mar.07 **SWP**	15.6 ± 0.6	±	4.7 ± 0.3	158 ± 22	flops	1.9 ± 0.3	7		
05.Mar.07 **VHB**	13.6 ± 0.7	±	4.1 ± 0.3	102 ± 14	flops	2.3 ± 0.2	13		49

Variety 62 has a higher number of leaves in the rosette, much bigger leaves (as far as could be judged from visual examination), higher dry weight, longer harvesting window than the control but has floppy petioles. It was rejected as not suitable for pot production and will not be trialled further. It may be a good variety for field growers of coriander, where the flopping appearance of leaves is not important (see also fig. 6 and catalogue).

Table 10: Variety 64

Date of harvest; grower	Plant height	Leaf Area	Number of leaves	Dry weight	Petiole appearance	Elevation of rosette	Harvesting window	Final number of leaves	Bolting
	[cm]	[mm^2]		[mg]		[cm]	[day]		[day]
16.Dec.06 **VHB**	9.2 ± 0.5	±	3.6 ± 0.2	45 ± 4	straight	3.1 ± 0.1	15	5.5 ± 0.4	none
16.Dec.06 **VHB**	9.6 ± 0.4	±	3.9 ± 0.2	50 ± 5	straight	2.7 ± 0.1	15		none
01.Mar.07 **SWP**	12 ± 0.6	±	4.7 ± 0.3	107 ± 13	flops	2.4 ± 0.2	12		33
28.Feb.07 **VHB**	13.3 ± 0.5	±	4.5 ± 0.2	79 ± 7	flops	3.9 ± 0.2	10		35

Variety 64 has a higher number of leaves in the rosette, much bigger leaves (as far as could be judged from visual examination) and higher dry weight than control but bolts early, as did the control. Thus it was rejected as not suitable for pot production and will not be trialled further. It may be a good variety for field growers of coriander, where the flopping appearance of leaves is not important and bolting is not an issue, for example in the north of England and in Scotland (see also fig. 7 and catalogue).

Table 11: Variety 79

Date of harvest; grower	Plant height	Leaf Area	Number of leaves	Dry weight	Petiole appearance	Elevation of rosette	Harvesting window	Final number of leaves	Bolting
	[cm]	[mm^2]		[mg]		[cm]	[day]		[day]
19.Dec.06 **VHB**	5.2 ± 0.1	±	2.4 ± 0.1	45 ± 5	straight	4.3 ± 0.2	21	6.4 ± 0.3	none
19.Dec.06 **VHB**	4.5 ± 0.2	±	3.0 ± 0.3		straight	3.3± 0.3	21		none
01.Mar.07 **SWP**					straight		16		49
28.Feb.07 **VHB**	11.3±0.3	±	4 ± 0.2		flops	3.6± 0.3	15		49

Variety 79 has a high final number of leaves in its rosette, so is a leafy variety, but has a slower growth rate (see 'plant height' and 'number of leaves') than the control. It has longer hypocotyls than the control. Variety 79 has smaller leaves (as far as could be judged from visual examination) than the control (see also fig. 8 and catalogue). It was therefore rejected as not suitable for pot production and will not be trialled further.

Table 12: Variety 153

Date of harvest grower	Plant height	Leaf Area	Number of leaves	Dry weight	Petiole appearance	Elevation of rosette	Harvesting window	Final number of leaves	Bolting
	[cm]	[mm^2]		[mg]		[cm]	[day]		[day]
15.Dec.06 **VHB**	11. 1 ± 0.6	848 ± 103	2.9 ± 0.2	41 ± 5	flops	3.2 ± 0.2	21	6.2 ± 0.3	46
15.Dec.06 **VHB**	11.1 ± 0.7	±	2.8 ± 0.2	37 ± 5	flops	2.8 ± 0.2	21		46
01.Mar.07 **SWP**	13 ± 0.5	±	4.1 ± 0.2	126 ± 16	flops	2.9 ± 0.3	12		39
28.Feb.07**VHB**					flops		12		39

Variety 153 has a low number of leaves in its rosette. It also has floppy stretched petioles (see also fig. 8 and catalogue). Thus it was rejected as not suitable for pot production and will not be trialled further.

Based on appearance (higher number of leaves, bigger leaf area, straight non-flopping petioles, lower elevation of rosette, and higher dry biomass than the control) and on harvesting window (long period of stable green colour of leaves and late bolting), the five most promising leafy varieties are currently identified as: 4, 43, 57, 58 and 60. They will be trialled for a third time (in summer 2007) to check that their good characteristics, shown in winter and spring, remain stable.

Data provided in the tables 2-12 showed, that performance of all varieties (including controls) changed in spring 2007, where biomass and number of leaves in the rosette increased, harvesting window decreased and earlier bolting was observed, when compared to the winter trial. Temperature, growth substrate, nutrition were kept the same through both trials and only one factor – light conditions – varied. In spring the days became brighter (light intensity and dose increased), and subsequently the quality of incident light changed. In cloudy weather it shifts further into to the blue region of the visible spectrum than when the sky is bright. We therefore suppose that light conditions affect the appearance and harvesting window of coriander and we will be checking this further to give growers clearer guidance on this matter.

The shelf-life of the most promising varieties will be evaluated at the same time as the effect of growing conditions is investigated in the next year (summer 2007 – spring 2008). During measurements of shelf life, plants will be kept in plastic sleeves (provided by Humber VHB and Swedeponic) at a constant temperature and artificial light, to mimic conditions in a supermarket. Shelf-life will be measured as a period between dates when a pot reached a saleable state (harvest time) and beginning of yellowing/reddening or bolting, in days.

Nineteen varieties (the second group obtained in January 2007) will undergo the same selection process as the first group and performance will be evaluated in soil. Plants will be propagated to multiply seed and then trialled in pots in different seasons. These varieties will be sown into raised beds during summer 2007 and in autumn their performance will be assessed, described and photographed for presentation in the Final report. Some of these varieties (Armenian origin) were already trialled once in pots.

Conclusions

Only preliminary conclusions can be drawn at this stage of the project.

- Several varieties can be identified which perform better than varieties currently used by pot industry: 4, 43, 57, 58 and 60. Identified varieties are similar for Humber VHB and Swedeponic. They also may be used by field growers, especially variety 60, which has a high number of leaves in the rosette and leaves are very big. Variety 43 should be used when bolting is an issue.
- Varieties 62 and 64 are not suitable for the pot industry due to the floppy appearance of petioles, but may be suitable for field growers, as they produce big leaves in high numbers
- Varieties 5, 79, and 153 are not suitable for the coriander herb industry.
- Growth conditions seem to change appearance and harvesting window of coriander with the effect of light being seen clearly.

Technology transfer

Regular meetings (4 in a year) have been held with representatives of Humber VHB and Swedeponic to discuss results.

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Appendix A

Catalogue of leafy vegetable varieties of *Coriandrum sativum* L.
Selection from collection of N.I. Vavilov Research Institute of Plant Industry (VIR), Russia
Part I

'Sadovyi', origin - Georgia
Rosette elevated, number leaves ~ 6
Bolting[4] = 27 days
Tasting[5] (1) = soft, coriander, slightly peppery, OK

Plants look very stretched, have small leaves and very long petioles, so variety 1 was not taken for further trials

[4] From seedling emerge; season - midsummer
[5] Tasted only once when grown in soil

‘Kinza’, origin – Azerbaijan
Rosette elevated, number leaves ~ 6
Bolting = 48 days

Tasting (1) = coriander, grassy, slightly bitter, OK

Plants look stretched, have small leaves and very long petioles (but better, than variety 1), so variety 3 was not taken for further trials

'Duganskii leafy vegetable Yaup-Shchoes', origin – Kazakhstan
Rosette prostrate, number leaves ~ 6
Bolting = 37 days; 35[6] days
Tasting (1) = bug, sweet, coriander, soft, OK.
Tasting[7] (2) = cashew nuts, sweet, soft, OK

Plants look very impressive, so variety 4 was taken for pot trials. After two pot trails was found one of the most promising.

[6] season - end of summer
[7] Tasted second time in pots by Humber VHB specialist

'Kish-Kish', origin – Daghestan (Russian Caucasus)
Rosette prostrate, number leaves ~ 7
Bolting = 47 days
Tasting (1) = sweet, coriander, grassy, UNPALATABLE.
Tasting (2) = dandelion bitterness, soft, nutty, UNPALATABLE.

Number of leaves is high, plants look strong, and the only possible disadvantageous, that rosette is flat. Variety 5 was taken for pot trails. Was then declined because of unpalatable taste.

origin - Azerbaijan
Rosette prostrate, number leaves ~ 5
Bolting = 29 days
Tasting (1) = coriander, OK

Plants do not look lush, number of leaves is low, and so variety 6 was not taken for further trials.

origin – Nagornyi Karabakh (part of Armenia)
Rosette prostrate, number leaves ~ 5
Bolting = 35 days
Tasting (1) = coriander, grassy, OK

Plants are miniature, number of leaves is low and so variety 9 was not taken for further trials.

origin - Ethiopia
Rosette prostrate, number leaves ~ 5
Bolting = 48 days
Tasting (1) = bug, sweet, coriander, grassy, UNPALATABLE

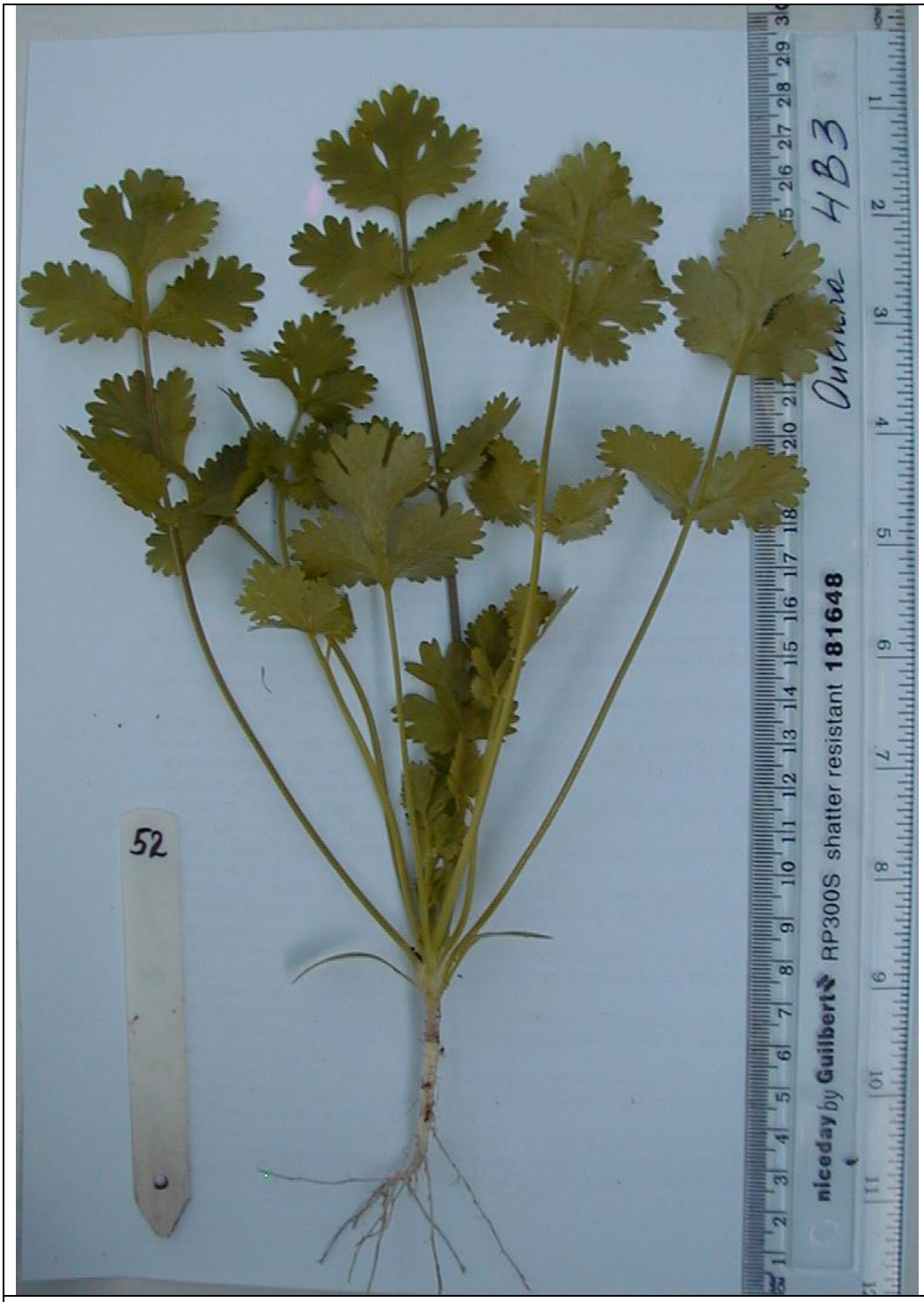
Taste is not acceptable, number of leaves is low and so variety 34 was not taken for further trials.

origin - Georgia
Rosette prostrate, number leaves ~ 6
Bolting = 42 days
Tasting (1) = grassy, sweet, slightly coriander, UNPALATABLE

Taste is not acceptable and plants are miniature. Thus variety 42 was not taken for further trials.

origin – Georgia
Rosette prostrate, number leaves ~ 6
Bolting = 37 days; 41 day
Tasting (1) = slightly bitter, soapy, coriander, grassy, OK
Tasting (2) = complex, coriander, PLEASANT

Plants look strong, so variety 43 was taken for pot trials. After two pot trails was found one of the most promising varieties.



origin - Azerbaijan
Rosette prostrate, number leaves ~ 7
Bolting = 35 days
Tasting (1) = grassy, seed, coriander, OK
Tasting (2) = OK

Petioles look floppy, but number of leaves is high, so plants were taken for further trials. No decision yet.

origin – Eastern Kazakhstan
Rosette prostrate, number leaves ~ 6
Bolting = 26 days; 26 days
Tasting (1) = slightly bitter, coriander, OK
Tasting (2) = pleasant balanced coriander flavour, PLEASANT

Plants look strong. They are miniature possibly of poor seed. Varity 57 was taken for further trials. After two pot trails was found one of the most promising.

origin – Abkhazia (part of Georgia)
Rosette elevated, number leaves ~ 8
Bolting = 29 days; 41 day
Tasting (1) = slightly bitter, grassy, coriander, OK
Tasting (2) = grassy, smooth finish, orange peel, lasts long, OK

Plants look strong, number of leaves is high and so variety 58 was taken for further trials. After two pot trails was found to be one of the most promising.

origin – Armenia
Rosette prostrate, number leaves ~ 7
Bolting = 29 days;
Tasting (1) = bug, sweet, coriander, soft, UNPALATABLE
Tasting (2) = smooth, sweet, bug
Initial decision = No, taste is not acceptable

Plants look very strong and number of leaves is high. Thus variety 59 was taken for further trials. No decision yet.

origin – Armenia
Rosette elevated, number leaves ~ 8
Bolting = 27 days; 35 days
Tasting (1) = seed, coriander, grassy, OK
Tasting (2) = bug, some bitterness, coriander, OK

Plants look excellent: strong, lush and very big leaves. Thus variety 60 was taken for pot trials. After two pot trials was found one of the most promising.

origin – Georgia
Rosette elevated, number leaves ~ 6
Bolting = 33 days
Tasting (1) = grassy, coriander, slightly bitter, soapy, blunt, UNPALATABLE
Tasting (2) = lemon-citrus note, grassy, coriander, soapy, OK

Plants look strong, so variety 61 was taken for further trials. No decision yet.

origin – Georgia
Rosette elevated, number leaves ~ 7
Bolting = 25 days; 41 day
Tasting (1) = coriander, grassy, slightly bitter, soft, OK
Tasting (2) = coriander, grassy, OK

Plants look very good: strong, lush, and so variety 62 was taken for further trials. After two trials was declined for pot industry, because has a floppy petioles. For field growers may be a very promising variety.

origin – Georgia
Rosette prostrate, number leaves ~ 8
Bolting = 23 days
Tasting (1) = bud (disappear quickly), coriander, OK
Tasting (2) = bud, coriander, OK

Plants are very strong and lush. Variety 64 was taken for further trials.

After two trials was declined for pot industry, because has a floppy petioles. For field growers may be a very promising variety, where bolting is not an issue.

‘Zernovoi’, origin – Azerbaijan
Rosette prostrate, number leaves ~ 5
Bolting = 28 days; 40 days
Tasting (1) = coriander, slightly sweet, slightly bitter, OK
Tasting (2) = coriander, OK

Variety was taken for further trials because industry liked plant appearance. After two pot trials was found not suitable for pot industry: plants are weak, miniature, petioles are floppy, elevation of rosette is very high.

origin – Daghestan (north Caucasus)
Rosette prostrate, number leaves ~ 5
Bolting = 33 days
Tasting (1) = bug! UNPALATABLE

Taste is not acceptable, number of leaves, so variety 86 was not taken for further trials.

'Dimbela', origin – Ethiopia
Rosette prostrate, number leaves ~ 6
Bolting = 35 days
Tasting (1) = coriander, slightly bitter, OK

Strange non-coriander appearance, number of leaves is low, so variety 96 was not taken for further trials.

origin – Belorussia
Rosette prostrate, number leaves ~ 6
Bolting = 28 days
Taste (1) = coriander, slightly bitter, OK

Appearance is odd, so plants were not taken for further trials.

Kinza, origin – Armenia
Rosette prostrate, number leaves ~ 7
Bolting = 38 days; 32 days
Tasting (1) = coriander, sweet, no bitterness, OK
Tasting (2) = very flat, almost none.

Plants look good and strong, so were taken for further trails. No decision yet.

Gagraskii, origin – Abkhazia (a part of Georgia)
Rosette prostrate, number leaves ~ 6
Bolting = 43 days
Tasting (1) = coriander, OK

Miniature plants, so variety 111 was not taken for further trials.

origin – former Czechoslovakia
Rosette elevated, number leaves ~ 6
Bolting = 33 days; 42 days
Tasting (1) = coriander, seed, no bitterness, OK
Tasting (2) = coriander, PLEASANT

Petioles look weak, but industry liked the appearance, so plants were taken for further trials. No decision yet.

Kinza, origin – Azerbaijan
Rosette elevated, number leaves = 5
Bolting = 33 days
Tasting (1) = coriander, OK

Petioles look very weak, number of leaves is low, and so variety 130 was not taken for further trials.

Kuzba, origin – Syria
Rosette elevated, number leaves ~ 5
Bolting = 18 days
Tasting (1) = mild, coriander, soft, OK

Number of leaves stays low, very early bolting, so variety 142 was not taken for further trails.

Kinza, origin – Uzbekistan
Rosette elevated, number leaves ~ 6
Bolting = 30 days; 41 days
Tasting (1) = coriander, seed, OK
Tasting (2) = peasant flavour

Number of leaves is high, plants look good, and so variety 153 was taken for further trials. After two pot trails was found not suitable for pot industry, because petioles are floppy and stretched.

Appendix B

Figures 1 – 9

Fig. 1. Top: variety 4 on 13th day after harvestable stage was reached (spring 2007)
Bottom: control var. *americanum* (left) versus variety 4 (right) on 1st day of harvest (spring 2007).

Fig. 2. Top: variety 43 on 13th day after harvestable stage was reached (winter 2006)
Bottom: control var. *americanum* (left) versus variety 43 (right) on 1st day of harvest (spring 2007).

Fig. 3. Top: variety 57 on 1st day after harvestable stage was reached (spring 2007)
Bottom: variety 57 (left) versus control var. *Kashmir* (right) on 1st day of harvest (winter 2006).

Fig. 4. Top: variety 58 on 13th day after harvestable stage was reached (winter 2006)
Bottom: variety 58 (left) versus control var. *Kashmir* (right) on 1st day of harvest (winter 2006).

Fig. 5. Top: variety 60 on 13th day after harvestable stage was reached (winter 2006)
Bottom: control var. *americanum* (left) versus variety 60 (right) on 1st day of harvest (spring 2007).

Fig. 6. Top: variety 62 on 13th day after harvestable stage was reached (winter 2006)
Bottom: control var. *americanum* (left) versus variety 62 (right) on 1st day of harvest (spring 2007).

Fig. 7. Top: variety 64 (left) versus control var. *Kashmir* (right) on 1st day of harvest (winter 2006)
Bottom: control var. *Kashmir* (left) versus variety 64 (right) on 1st day of harvest (spring 2007).

Fig. 8. Top: variety 79 on 13th day after harvestable stage was reached (winter 2006)
Bottom: control var. *Kashmir* (left) versus variety 79 (right) on 1st day of harvest (spring 2007).

Fig. 9. Top: control var. *americanum* (left) versus variety 153 (right) on 1st day of harvest (spring 2007)
Bottom: control var. *Kashmir* (left) versus variety 153 (right) on 1st day of harvest (spring 2007).