Journal of Applied Botany and Food Quality 82, 170 - 178 (2009)

[1] Humboldt-Universität zu Berlin, Institute for Horticultural Sciences, Section Quality Dynamics/Postharvest Physiology
[2] Landesumweltamt Brandenburg, Eberswalde and VERN e.V. (Verein zur Erhaltung und Rekultivierung von Nutzpflanzen in Brandenburg, Greiffenberg)

Development of a network for the *on-farm* conservation of crop genetic resources: First results of a pilot project for the re-introduction of old *Lactuca* varieties to the market

C. Lehmann[1], G. Lissek-Wolf[1], R.Vögel[2], S. Huyskens-Keil[1]

(Received October 8, 2008)

Summary

In a pilot project, we examined the chance of maintaining plant genetic resources by commercial utilization of old varieties using *Lactuca sativa* as a model plant. Nine market gardens in the region of Berlin and Brandenburg cultivated 18 old varieties during four cultivation periods to test field performance. They supplied the products to the market in their customary manner to analyse marketing success. Seven of the market gardens practice organic horticulture. In a complementary field trial at Humboldt-Universität zu Berlin, we established data concerning the field performance of the varieties, analysed dry matter contents, nitrate and phenol concentrations, and observed shelf life for two days under simulated retail conditions (18°C, 80% rel. air humidity).

Generally, yield was acceptable for market purposes. However, cultivation in autumn failed because of the cold climate. Biotic and abiotic factors like slugs or hail caused non-specific damages. Specific problems of particular varieties were less important. Based on the results of 2007, the varieties can be put preliminarily into three categories: suitable for *on-farm* conservation, suitable for home gardens, and varieties with contrasting results depending on the respective market garden.

The nitrate concentrations of all varieties were clearly below the EU acceptable limit of 2500 mg/kg fresh weight of lettuce grown in the field. The phenol concentrations varied from 3.3 to 17.2 mg GAE/g dry weight. Generally, the cultivars had a reasonable shelf life of one to two days, however three varieties showed a better storability whereas four other cultivars deteriorated rapidly.

Marketing success was good in Berlin City but poor in the countryside of Brandenburg. The regular customers of the market gardens in Berlin who prefer organic food are a promising target group for further stimulation of interest to buy rare crop varieties.

The *on-farm* conservation of old varieties in market gardens requires relatively large quantities of seeds of good quality. However there might arise problems in seed supply as the VERN e.V. was confronted with bottleneck problems. Therefore, we organised a network of interested market gardens who take on maintenance and propagation of individual varieties. The network will be developed in co-operation with the VERN e.V. who will also process the seed as well as organise the exchange of the various varieties within the network. Further, the network will deal with problems concerning maintenance breeding and seed quality.

Introduction

Within the past decades, the diversity of cultivated plants decreased seriously (FAO, 1996 a). A major part of crop plant diversity is used neither in market nor in home gardening because the demand of intensive production relies on a relative small number of elite varieties. Further, plant breeders concentrate to meet the demand of intensive market gardening exclusively. The loss of agro-biodiversity puts plant genetic resources at risk and jeopardizes the cultural heritage of crop plant diversity as well as traditional knowledge and use (GLADIS, 2001).

Two main complementary methods have been developed to conserve crop genetic resources: *ex-situ* in gene banks and *in-situ* in farmer's fields or in the natural environment (GEPTS, 2006). In 1996 the FAO adopted the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources (FAO, 1996 b) which emphasized *in-situ* conservation and proposed a catalogue of measures promotion. *On-farm* management is particular important because it allows conservation of genetic resources by using them economically.

In industrialised countries *on-farm* management aims to re-introduce old varieties into the market (EFKEN, 2005). Therewith a broader range of varieties will be made available for farmers and consumers. A further advantage is a dynamic use of crop plant genetic resources (CGR) in contrast to gene bank conservation. However, only those old varieties with an acceptable field performance are suitable for an effective *on-farm* management. The successful commercialization of old varieties is crucial for a sustainable *on-farm* management. The marketing concepts have to be concerned with regard to the complete value chain and the customer focus (EFKEN, 2005). Public relations work is required to encourage public awareness about CGR and to stimulate customer's interest for rare crop varieties.

In 2002, the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) published the national programme for the conservation and sustainable use of plant genetic resources (BMELV, 2002) to implement the Global Plan of Action of Leipzig (FAO, 1996 b). In this context, pilot projects are promoted that add to the conservation and to the innovative sustainable use of biodiversity.

In a pilot project, *Lactuca sativa* was chosen as a model plant because in comparison to other crops it is easy to grow and has a short period of cultivation. Furthermore, *L. sativa* stands out due to a remarkable number of distinct forms (HELM, 1954; DE VRIES, 1997) and a broad range of old varieties (RODENBURG, 1960). Altogether, at Humboldt-Universität zu Berlin (HU) 57 old *Lactuca* varieties were tested for field performance and suitability for the market as a requirement of an *on-farm* management (LEHMANN et al., 2008). In 2007 a set of 18 candidate varieties was examined in practice. We aimed to develop a collection of old varieties and to make it available to local market gardens as a niche product for an extensive horticultural production. Furthermore, rarities which are more suitable for home gardening will be added to an expanded collection.

The complete value chain from seed supply to cultivation and marketing was tested in a pilot project to analyse stimulating as well as inhibiting factors of an *on-farm* management. The objective is to demonstrate criteria for a promising and sustainable *on-farm* management under market conditions.

Material and methods

Field evaluation and pilot tests

In 2007, a field evaluation at the experimental station of Humboldt-Universität zu Berlin (HU) and pilot tests in nine market gardens were simultaneously carried out in four cultivation periods (Tab. 1). At HU, the experimental design was a complete randomized block with 15 plots per block and three replications. 12 plants of a variety were planted per plot with a distance of 30 x 30 cm. The plots were fertilized with 50 g/m² organic manure comprising of 14% organic N with planting. During the first two cultivation periods the plots were covered with fleece, during the next two cultivation periods nets were stretched over the plots to protect for birds and rabbits. The soil was prepared by hoeing and weeds were removed two times between planting and harvest. The plots were watered to demand. During the growing period the following data were collected: germination in percent, number of not harvestable plants in percent, fresh weight at harvest after removing the outer leaves as „market weight". Furthermore, diseases and pests were recorded.

Nine selected market gardens joined in the pilot project, seven in the region of Berlin and Brandenburg and two in Mecklenburg-Western Pomerania (Tab. 1). As the basic requirement to participate in the pilot project, the market gardens were asked to cultivate five old *Lactuca* varieties in two cultivation periods (see Tab. 2) in two sets each of at least 40 plants and collect data relevant for practice (see above). The market gardens carried out the field tests in their common practice. Furthermore, the market gardens had to assess the varieties

Tab. 1: Location and marketing of nine market gardens that 2007 participated in the pilot project.

Market garden no.	Location	Coordinates	Marketing (special features)
1	Ahrenzhain / Brandenburg	51°40'N 13°30'O	weekly market in Berlin (organic horticulture)
2	Barenthin / Brandenburg	52°55'N 12°14'O	weekly market in Berlin, direct delivery, (organic horticulture)
3	Oderberg / Brandenburg	52°52'N 14°00'O	direct delivery, retail trade in Oderberg (conventional horticulture)
4	Dahlem / Berlin	52°28'N 13°17'O	farmer's shop in Berlin (organic horticulture)
5	Bornow / Brandenburg	52°10'N 14°11'O	weekly market in Berlin (organic horticulture)
6	Fürstenhof / Mecklenburg	53°56'N 12°45'O	direct delivery, food coop, school canteen, (organic horticulture)
7	Bastorf / Mecklenburg	54°07'N 11°41'O	weekly market and health food shop in Wismar (organic horticulture)
8	Friesack / Brandenburg	52°43'N 12°37'O	farmer's shop, canteen (adult education, conventional horticulture)
9	Pinnow / Brandenburg	53°02'N 14°00'O	farmer's shop, weekly market in Angermünde, canteen (institution for handicaped persons, organic horticulture)

Tab. 2: Evaluation and pilot tests of 18 old lettuce varieties in four cultivation periods in 2007.

Form	Variety (gene bank accession or origin)	Characteristic	Early[1]	Spring[2]	Summer[3]	Autum[4]
butter head	Amphore (Rijk Zwaan) – reference variety	red coloured leaves		x	x	x
9 butter head	Frühlingsgruß (IPK LAC 89)	green, small compact head	x			
	Lettuce Cabbage (IPK LAC 76)	green, small compact head	x			
	Bunte Forelle (IPK LAC 81)	green with red speckled pattern		x		
	Stuttgarter Sommer (IPK LAC 17)	green, great loose head		x		
	Gigant (IPK LAC 03)	green, cultivar from Quedlinburg (1955)			x	
	Brunetta (IPK LAC 68)	reddish brown, cultivar from Quedlinburg (1954)			x	
	Goldforelle (IPK LAC 38)	yellowy green, with red speckled pattern			x	x
	Brauner Sommer (IPK LAC 89)	green, with brown painted leaf margins				x
	Hitzkopf (IPK LAC 95)	Grenn, medium sized, loose head				x
4 leaf lettuce	Früher Gelber Krausblättriger (IPK LAC 101)	green, lobed leaves, plant funnel-shaped	x			
	Struwwelpeter (IPK LAC 233)	green, characteristic name		x		
	Hohlblättriger Butter (IPK LAC 104)	green, very delicate leaves		x		
	Ochsenzunge (unknown)	green, elongated, very delicate leaves			x	
3 romana-type	Wiener Maidivi (IPK LAC 312)	green, outwardly curved leaf margins	x			x
	Trianon (IPK LAC 122)	green, open romana-type			x	
	Romaine Red Cos (IPK LAC 315)	red romana-type, delicate leaves		x		x
1 latin-type	Rehzunge (unknown)	dark green, reminiscent of a spinach plant	x			
1 stem lettuce	Chinesische Keule (Dreschflegel)	consumption of the stem or shoot		x	x	x

[1] sowing end of February, planting end of March, harvest middle of May
[2] sowing end of March, planting beginning of May, harvest beginning of June
[3] sowing end of May, planting in the second half of June, harvest beginning of August
[4] sowing beginning of August, planting beginning of September, no harvest

according to the following criteria: suitability of the varieties to the respective site, yield, suitability for commercialization, personal estimation of the varieties.

Climate

In 2007 the temperature means per months at the experimental station in Berlin-Dahlem exceeded the long term records of the years 1971-2000: from March to June by 2.0 - 3.7°C, temperature in July was average, while in August and September the temperature was 0.2 - 0.7°C cooler than the average (CHMIELEWSKI, 2008). In April 2007 precipitation was very low with 4 mm compared to the long term record of 34 mm (1971 - 2000). In Mai rainfall was three times higher (169.1 mm) than the long term record (50.6 mm), and from June till September precipitation was twice as much as the average (CHMIELEWSKI, 2008). Thus, April was hot and dry, Mai was hot and rainy, and the summer months were rainy and cool.

Test sets

Based on preliminary field tests at HU (HARTKOPF, 2006; SCHULLER, 2008) sets of 5 - 7 varieties were put together for four cultivation periods (early, spring, summer and autumn; see Tab. 2). Originally, these varieties except three varieties were accessions from the gene bank in Gatersleben and some of them are listed in the „catalogue for rare crops“ (VERN, 2008). Altogether, 18 *Lactuca* varieties were evaluated. The current commercial cultivar ‘Amphore’ (Rijk Zwaan) suitable for all cultivation periods served as a reference. However, this cultivar was not available until the second cultivation period.

Each test set comprised varieties that were distinct from the usual commercial lettuce selection as well distinguishable from each other (Tab. 2) to present the customers a clear offer with regard to test for marketing success. The varieties were chosen to represent conspicuously various *Lactuca* forms.

Lactuca forms not customary in Germany (like the latin group type ‘Rehzunge’ or the stem lettuce ‘Chinesische Keule’) were included to contribute to more diversity. Stem lettuce is common in some regions of Asia. The stems (or shoots) of this *Lactuca* form are eaten raw or cooked.

Chemical analyses

Two samples per plot were taken from each variety of the field experiment at HU for chemical analyses. Dry matter was determined after 48 h at 104°C drying. Nitrate concentrations were analysed after extraction in potassium aluminium sulphate with an ionic sensitive elektrode (KÜNSCH et al., 1981). Assay of total phenols was performed by means of the Folin-Ciocaltrau-method with gallic acid as the reference (JENNINGS, 1981). The adsorption was determined at a wavelength of 765 nm using a spectrophotometer (LKB Novaspek III, Pharmacia, Freiburg) and the phenol concentrations calculated as mg gallic acid-equivalent (GAE) per g dry matter. Three samples per variety served to test shelf life for two days at 18°C and 80% rel. air humidity.

Customer’s motivation

With questionnaires we examined the knowledge of the customers about old varieties at two different locations of market stands and in a farmer shop in Berlin. Furthermore, we examined the willingness of customers to contribute to the conservation of old varieties with their purchasing behaviour.

Results

The cultivation for the field experiment evaluation and the pilot tests succeeded in the first three cultivation periods, however failed in autumn because the plants developed very poorly due to the cold and rainy weather. At HU, cultivation in spring was slightly impaired because the plantation took place at the beginning of May when a heat-wave started.

Germination

The germination rates varied between the varieties as well as between the market gardens (Tab. 3). Even the germination rate of the commercial cultivar ‘Amphore’ varied between 14 - 100%, their average germination rate in most of the market gardens was high. In the first cultivation period two varieties could not be grown in one market garden (market garden no. 4) because they germinated too poorly (Tab. 4).

Varietal uniformity

In the evaluation experiment as well as in the pilot tests, it was found that some individuals of old varieties not anymore being subject of breeding work deviated from their variety specific pattern. For example, the colour of the leaf edges of ‘Brunetta’ varied from red to brown and in varieties like ‘Gigant’ or ‘Stuttgarter Sommer’ divergent heads were formed. In contrast, the commercial cultivar ‘Amphore’ was uniform.

Field performance

The percentage of harvestable plants varied considerably between varieties as well as between market gardens (Tab. 4). Predominantly, abiotic and biotic factors caused non-specific losses or damages. For example hail, snails or wireworms induced some major damages in the market gardens. Fungal pathogens were rather location-dependent, e.g. the soil borne fungus *Sclerotinia sclerotiorum* caused some losses in the field evaluation at HU and in market garden no. 4. Slight infestations of Septoria leaf spot occurred in market garden no. 2 and medium to strong infestation of grey mould in market garden no. 3 where several varieties were infested at a time.

Specific problems with internal tipburn were noticed in ‘Stuttgarter Sommer’ in all market gardens. Internal tipburn was further detected in ‘Frühlingsgruß’, ‘Früher Gelber Krausblättriger’, ‘Struwwelpeter’, ‘Hohlblättriger Butter’ and ‘Lettuce Cabbage’. In addition, ‘Hohlblättriger Butter’ bolted very fast in the spring cultivation period.

Yield

Tab. 5 shows the mean „market weight“ of the varieties. The weight of particular varieties varied between the market gardens and also between the two sets of a cultivation period within a market garden. Thus, the varieties demonstrated remarkable ranges when grown in various market gardens. In the field evaluation at HU the fresh weight of the varieties was below average in spring cultivation because the plants developed poorly during the hot weather period in May.

Within a cultivation period some varieties tended to have a higher fresh weight, while other varieties revealed a lower weight. ‘Goldforelle’ had the lowest weight. Generally, Romana types weighed more than 300 g on average and were heavier than butterhead or loose leaf types.

Tab. 3: Germination rates (%) of old lettuce varieties examined in the field evaluation and in the pilot tests of three market gardens.

Variety	Field evaluation	Garden no. 2		Garden no. 3		Garden no. 4		Garden no. 5		Mean
	HU	1. set	2. set	1. set	2. set	1. set	2. set	1. set	2. set	
Early cultivation										
Frühlingsgruß	82	78	74	46	46	12	62	no early		57
Lettuce Cabbage	49	28	28	16	10	26	12	cultivation for		24
Früher Gelber Krausblättriger	43	48	69	28	12	44	10	internal reasons		36
Wiener Maidivi	53	55	18	44	38	62	54			46
Rehzunge	80	63	58	58	96	92	68			74
Spring cultivation										
Amphore (reference)	100	46	14	92	98	100	100	94	42	76
Bunte Forelle	92	26	45	76	57	40	15	63	47	51
Stuttgarter Sommer	96	69	72	79	67	50	50	73	41	66
Struwwelpeter	54	52	61	71	69	50	50	54	53	57
Hohlblättriger Butter	82	78	83	78	80	35	35	71	46	65
Romaine Red Cos	86	69	46	84	84	50	20	64	78	65
Chinesische Keule	94	not cultivated		not cultivated		not cultiv.	60	not cultivated		77
Summer cultivation										
Amphore (reference)	98	86	84	70	100	no summer		68	48	79
Gigant	89	74	75	24	67	cultivation for		16	32	54
Brunetta	96	52	22	40	72	internal reasons		28	36	49
Goldforellen	87	85	93	20	51			53	60	64
Ochsenzunge	83	59	69	16	63			30	40	51
Trianon	82	70	50	40	82			54	32	59
Chinesische Keule	77	76	54	not cultivated				not cultivated		69

Tab. 4: Percentage of not harvestable plants (losses in %)

Variety	Field evaluation	Garden no. 2		Garden no. 3		Garden no. 4		Garden no. 5		Mean
	HU	1. set	2. set	1. set	2. set	1. set	2. set	1. set	2. set	
Early cultivation										
Frühlingsgruß	2.8	23.1	21.6	0.0	4.3	0.0	0.0	no early		8.6
Lettuce Cabbage	0.0	40.0	61.5	12.5	20.0	0.0	poor ger-	cultivation for		24.0
Früher Gelber Krausblättriger	0.0	33.3	66.7	0.0	16.6	0.0	mination	internal reasons		34.5
Wiener Maidivi	0.0	16.7	17.2	0.0	0.0	0.0	10.8			7.5
Rehzunge	0.0	100.0	80.7	7.1	0.0	36.8	0.0			37.4
Spring cultivation										
Amphore (reference)	13.9	36.5	28.6	10	0.0	1.4	4.0	0.0	0.0	13.3
Bunte Forelle	5.6	35.1	23.1	25.0	27.5	15.0	20.0	0.0	4.3	19.5
Stuttgarter Sommer	8.3	50.0	36.0	22.5	32.5	6.0	12.0	1.4	0.0	20.9
Struwwelpeter	8.3	28.6	39.4	10.0	7.5	2.0	2.0	0.0	5.7	12.4
Hohlblättriger Butter	2.8	28.6	22.2	32.5	40.0	100	100	5.6	23.9	39.5
Romaine Red Cos	5.6	29.7	7.7	15.0	17.5	0.0	5.0	0.0	0.0	9.6
Chinesische Keule	2.8	not cultivated		not cultivated		not cult.	8.3	not cultivated		
Summer cultivation										
Amphore (reference)	8.3	20.9	11.9	5.7	0.0	no summer		no data		9.4
Gigant	16.7	10.0	9.8	12.5	25.0	cultivation for		62.5	68.8	29.3
Brunetta	13.9	10.7	25.0	20.0	10.0	internal		28.6	72.2	27.8
Goldforellen	2.8	17.4	4.0	5.0	30.0	reasons		0.0	66.7	18.0
Ochsenzunge	13.8	6.3	10.8	25.0	7.5			0.0	75.0	20.8
Trianon	19.4	10.5	11.1	7.5	0.0			0.0	65.6	16.3
Chinesische Keule	2.8	2.4	6.9	not cultivated				not cultivated		4.0

Tab. 5: Fresh weight of plants at harvest after removing the outer leaves („market weight“ in g*) in the field evaluation at Humboldt-Universität zu Berlin and in the pilot tests of three market gardens (means ± SD, min. – max. in parentheses)

Variety	Field evaluation	Garden no. 2		Garden no. 3		Garden no. 4		Garden no. 5		Mean
	HU	1. set	2. set	1. set	2. set	1. set	2. set	1. set	2. set	
Early cultivation										
Frühlingsgruß	301.12 ± 38.56	not established		289 ± 21	402 ± 23	244 ± 29	234 ± 40	no early cultivation		294
	(273.36 - 345.15)			(251 - 321)	(369 - 430)	(200 - 325)	(150 - 305)	for internal reasons		
Lettuce Cabbage	272.81 ± 19.78	not established		285 ± 50	340 ± 74	200 ± 34	poor ger-			274
	(258.27 - 295.33)			(230 - 380)	(275 - 425)	(140 - 245)	mination			
Früher Gelber	351.61 ± 36.35	not established		260 ± 17	310 ± 31	260 ± 46	poor ger-			295
Krausblättriger	(326.30 - 393.27)			(230 - 280)	(275 - 356)	(200 - 300)	mination			
Wiener Maidivi	437.31 ± 54.09	not established		303 ± 298	403 ± 42	311 ± 43	313 ± 56			353
	(380.62 - 488.36)			(276 - 345)	(340 - 430)	(240-430)	(205 - 425)			
Rehzunge	352.24 ± 16.04	not established		293 ± 18	424 ± 48	268 ± 27	225 ± 44			312
	(333.72 - 61.88)			(270 - 326)	(360 - 492)	(220 - 320)	(150 - 335)			
Spring cultivation										
Amphore	84.63 ± 14.04	158 ± 13	159 ± 15	258 ± 19	285 ± 22	298 ± 40	254 ± 46	214 ± 65	260 ± 51	219
(reference)	(72.49 - 100.00)	(140 - 180)	(130 - 175)	(231 - 284)	(250 - 320)	(240 - 350)	(200 - 330)	(95 - 280)	(185 - 320)	
Bunte Forelle	129.51 ± 21.20	241 ± 14	247 ± 19	224 ± 42	230 ± 28	207 ± 36	202 ± 54	216 ± 66	327 ± 35	225
	(107.96 - 150.35)	(215 - 265)	(210 - 275)	(139 - 311)	(202 - 300)	(135 - 295)	(145 - 295)	(110 - 330)	(270 - 370)	
Stuttgarter Sommer	130.73 ± 28.83	234 ± 33	218 ± 42	255 ± 33	377 ± 74	234 ± 28	273 ± 67	243 ± 64	350 ± 59	257
	(97.49 - 148.95)	(185 - 270)	(170- 275)	(213 - 307)	(244 - 500)	(190 - 290)	(135 - 405)	(110 - 350)	(285 - 435)	
Struwwelpeter	160.47 ± 1.73	327 ± 32	324 ± 30	371 ± 25	380 ± 51	267 ± 45	274 ± 46	272 ± 69	288 ± 83	296
	(158.54 - 161.88)	(290 - 385)	(285 - 385)	(340 - 412)	(275 - 425)	(180 - 365)	(200 - 395)	(140 - 370)	(185 - 385)	
Hohlblättriger	165.91 ± 21.97	248 ± 8	245 ± 16	423 ± 17	388 ± 41	no harvest		198 ± 35	296 ± 78	281
Butter	(151.63 - 191.21)	(235 - 260)	(215 - 265)	(390 - 444)	(314 - 415)	bolted		(135 - 270)	(180 - 395)	
Romaine Red Cos	159.71 ± 30.57	250 ± 18	243 ± 27	538 ± 30	545 ± 53	366 ± 43	325 ± 53	307 ± 43	306 ± 18	338
	(132.38 - 192.72)	(220 - 270)	(190 - 280)	(498 - 589)	(488 - 629)	(295 - 445)	(275 - 425)	(195 - 365)	(265 - 325)	
Chinesische Keule	188.37 ± 17.75	not cultivated		not cultivated		not	191 ± 55	not cultivated		190
	(170.38 - 205.93)					cultivated	(105 - 300)			
Summer cultivation										
Amphore	310.50 ± 43.14	156 ± 9	152 ± 12	250 ± 32	251 ± 30	no summer cultivation		not established		224
(reference)	(281.95 - 360.12)	(140 - 170)	(135 - 170)	(203 - 291)	(210 - 293)	for internal reasons				
Gigant	276.61 ± 11.20	290 ± 17	295 ± 16	340 ± 62	386 ± 116			200 ± 66	177 ± 50	281
	(264.23 - 286.04)	(260 - 315)	(265 - 320)	(240 - 427)	(247 - 591)			(80 - 290)	(90 - 260)	
Brunetta	234.51 ± 6.19	229 ± 14	233 ± 10	274 ± 28	232 ± 47			156 ± 38	153 ± 44	216
	(227.70 - 239.78)	(200 - 250)	(215 - 245)	(232 - 306)	(129 - 293)			(95 - 220)	(90 - 228)	
Goldforellen	173.05 ± 42.35	220 ± 15	218 ± 17	193 ± 22	200 ± 28			103 ± 23	108 ± 19	174
	(129.12 - 213.61)	(190 - 240)	(185 - 245)	(165 - 230)	(165 - 260)			(65 - 135)	85 - 140	
Ochsenzunge	334.13 ± 64.13	375 ± 24	353 ± 17	453 ± 61	408 ± 61			344 ± 89	194 ± 101	
	(274.13 - 401.69)	(320 - 410)	(295 - 395)	(343 - 549)	(324 - 511)			(230 - 450)	(60 - 390)	
Trianon	345.21 ± 88.27	335 ± 20	335 ± 25	359 ± 39	361 ± 90			388 ± 118	299 ±86	346
	(249.72 - 423.82)	(295 - 360)	(300 - 355)	(285 - 411)	(236 - 530)			(240 - 600)	(160 - 410)	
Chinesische Keule	271.95 ± 19.76	345 ± 26	339 ± 23	not cultivated				not cultivated		319
	(255.30 - 293.79)	(290 - 375)	(290 - 370)							

* Fresh weights were determined with a precision of 0.1 g at HU and with a precision of 5 g in the market gardens.

Chemical analyses and shelf life

The results of the quality analyses of material from the field evaluation at HU are shown in Tab. 6. With regard to undesirable compounds the nitrate content varied considerably in all tested lettuce varieties from 28 - 1192 mg/kg fresh weight. The varieties ‘Goldforelle’, ‘Struwwelpeter’, ‘Frühlingsgruß’ and ‘Amphore’ tended to have the lowest nitrate contents. Generally, the nitrate contents meet the values reported for endogen levels of butterhead lettuce (HERRMANN, 2001), in any case were clearly below the acceptable limit of 2500 mg/kg (EU-VO 466/2001) of lettuce grown in the field. The climate mediated variation of nitrate contents became apparent also in 2007: the undesirable highest contents were determined in the early and first cultivation period (March/April) and in summer (end of June -

beginning of August) when it was cool and rainy. The lowest contents were analysed in the warm months of the spring cultivation period (beginning of May/beginning of June).

The health promoting compounds, e.g. total phenols varied from 3.3 to 17.2 mg GAE/g dry matter (Tab. 6). The phenol contents were tendentiously higher in plants cultivated in spring where the average temperature and irradiation were higher in comparison to the other cultivation periods. The phenol contents were in general comparatively high for lettuce cultivars and suggest a high nutritional value of the old varieties; however this has to be examined in more detail.

The shelf life of the lettuce varieties under simulated retail conditions (18°C, 80% rel. humidity, 2 days) can generally be classified as medium (score 2) (Tab. 6). The varieties 'Lettuce Cabbage', 'Wiener Maidivi' and 'Trianon' were better suitable for a short term storage than other varieties, however dry matter changes were rather high compared with commercially available lettuce. The varieties 'Früher

Tab. 6: Content of dry mass, nitrate, total phenols and changes of dry mass after two days of storage (18°C, 80% rel. air humidity) of old lettuce varieties (means ± SD, min. – max. in parentheses), and shelf life evaluation (score; medians, min. – max. in parentheses)

Variety	Dry mass (%) [1]	Nitrate (mg/kg fw)$^{-1}$	Total Phenol (mg GAE/g dm) [1]	Shelf life	
				Change of dm (%)	Score*
Early cultivation					
Frühlingsgruß	4.16 ± 0.52	1191.67± 259.92	4.32 ± 0.31	21.29 ± 1.61 ^{ab}	2 ^{a}
	(3.69 - 4.72)	(892.00 - 1356.00)	(3.98 - 4.58)	(19.86 - 23.04)	(2 - 3)
Lettuce Cabbage	4.82 ± 0.77	704.33 ± 216.25	3.83 ± 0.17	20.47 ± 0.38 ^{ab}	1 ^{ab}
	(4.03 - 5.57)	(576.00 - 954.00)	(3.66 - 4.00)	(20.21 - 20.74)	(1 - 2)
Früher Gelber	4.99 ± 0.29	712.33 ± 170.02	6.17 ± 0.41	26.62 ± 1.85 ^{a}	3 ^{a}
Krausblättriger	(4.66 - 5.21)	(528.00 - 863.00)	(5.73 - 6.53)	(24.68 - 28.38)	(3 - 3)
Wiener Maidivi	5.66± 0.96	419.67 ± 93.09	6.17 ± 0.64	17.36 ± 2.63 ^{b}	1 ^{b}
	(4.80 - 6.71)	(361.00 - 527.00)	(5.63 - 6.87)	(14.40 - 19.43)	(1 - 1)
Rehzunge	4.43 ± 0.29	630.33 ± 178.03	5.30 ± 0.71	not analysed	
	(4.19 - 4.75)	(428.00 - 763.00)	(4.49 - 5.85)		
Spring cultivaltion					
Amphore	7.75 ± 0.43	53.62 ± 20.3	17.24 ± 1.46	14.45 ± 2.28 ^{a}	3 ^{a}
(reference)	(7.36 - 8.21)	(34.16 - 74.77)	(15.66 - 18.53)	(12.30 - 16.84)	(3 - 3)
Bunte Forelle	6.88 ± 0.55	146.90 ± 96.72	10.99 ± 2.76	12.70 ± 1.26 ^{a}	3 ^{a}
	(6.27 - 7.35)	(35.43 - 208.59)	(9.36 - 14.18)	(11.41 - 13.91)	(3 - 3)
Stuttgarter Sommer	7.06 ± 0.45	83.74 ± 49.30	12.13 ± 3.80	14.83 ± 2.39 ^{a}	2 ^{a}
	(6.80 - 7.58)	(27.28 - 118.28)	(9.37 - 16.46)	(12.91 - 17.39)	(2 - 3)
Struwwelpeter	7.85 ± 0.57	28.18 ± 1.84	10.76 ± 0.52	15.15 ± 2.54 ^{a}	3 ^{a}
	(7.40 - 8.49)	(26.30 - 29.97)	(10.24 - 11.27)	(13.35 - 18.05)	(3 - 3)
Hohlblättriger Butter	7.36 ± 0.12	73.50 ± 39.80	16.45 ± 2.38	9.39 ± 2.51 ^{a}	3 ^{a}
	(7.26 - 7.49)	(45.51 - 119.07)	(14.67 - 19.15)	(7.62 - 11.17)	(3 - 3)
Summer cultivation					
Amphore	4.77 ± 0.19	393.67 ± 226.19	5.69 ± 0.74	15.90 ± 0.84 ^{ab}	2 ^{a}
(reference)	(4.59 - 4.96)	(158.00 - 609.00)	(4.84 - 6.13)	(14.94 - 16.45)	(2 - 2)
Gigant	7.21 ± 0.50	623.67 ± 67.93	8.33 ± 0.47	19.76 ± 2.55 ^{ab}	2 ^{a}
	(6.68 - 7.68)	(546.00 - 672.00)	(8.05 - 8.87)	(17.33 - 22.41)	(2 - 2)
Brunetta	6.66 ± 0.48	531.33 ± 505.85	7.83 ± 1.15	14.73 ± 1.34 ^{ab}	2 ^{a}
	(6.10 - 7.00)	(220.25 - 1115.71)	(6.81 - 9.07)	(13.46 - 16.13)	(2 - 2)
Goldforellen	6.56 ± 0.27	325.74 ± 50.75	5.82 ± 1.35	29.34 ± 3.58 ^{a}	2 ^{a}
	(6.29 - 6.82)	(279.06 - 396.29)	(4.98 - 7.38)	(25.57 - 32.69)	(2 - 2)
Ochsenzunge	6.65 ± 0.82	484.33 ± 397.59	10.97 ± 0.35	13.17 ± 0.56 ^{ab}	2 ^{a}
	(5.82 - 7.45)	(208.00 - 940.00)	(10.67 - 11.35)	(12.52 - 13.57)	(2 - 2)
Trianon	8.50 ± 1.02	136.33 ± 63.58	13.22 ± 1.50	9.27 ± 0.51 ^{b}	1 ^{a}
	(7.38 - 9.36)	(71.00 - 198.00)	(11.50 - 14.23)	(8.89 - 9.85)	(1 - 1)

*Score: 1 = marketable, 2 = slightly wilted, 3 = strongly wilted, not marketable; medians

[1] The Friedman Test ($\alpha = 0.05$) did not reveal any significant differences for dry mass, nitrate and total phenol contents.

Within each cultivation period, means, respectively medians sharing the same superscript letter within one column are not significantly different (Nemenyi-Test, $\alpha = 0.05$).

Gelber Krausblättriger', 'Amphore', 'Struwwelpeter' and 'Hohlblättriger Butter' could be stored for a relatively short time, i.e. they can be recommended solely for direct marketing.

Estimation of varieties by market gardens

Based on the estimation of the market gardens after the first year of the pilot tests the varieties may be classified in three categories: generally suitable for *on-farm* conservation in market gardens, not suitable for market gardening, and differently estimated varieties. Only two butterhead types ('Gigant' and 'Bunte Forelle') were generally suitable, all other butter head lettuces were estimated differently by the respective market gardens. However, none of the butter head lettuces was evaluated as not suitable by all market gardeners. The three romana lettuce types ('Wiener Maidivi', 'Romaine Red Cos' and 'Trianon') proved generally to be suitable. Two of the leaf lettuces ('Struwwelpeter' and 'Ochsenzunge') were assessed positively; the other two ('Hohlblättriger Butter', 'Früher Gelber Krausblättriger') were evaluated rather suitable for home gardens. The latin group type was estimated useful for market gardening in most cases. Only two market gardens tested the stem lettuce and achieved good results in the field. Marketing was more of a problem because the customers need special information how to use it.

Customer's motivation

The customers in the country side of Brandenburg did not accept the old varieties with an unfamiliar appearance instead preferred 'normal' green butterhead type. However, in the city of Berlin the old varieties were easy to sell because these customers like unusual and new offers.

With questionnaires we examined the customer's motivation at market stands on two weekly markets and in a farmer's shop in Berlin (Fig. 1). The involved gardeners practice organic horticulture and are direct marketers with a lot of regular customers. Only 19% of the respondents knew the correct answer that it means a variety not any more registered. 51% had wrong or confuse ideas. Further enquiries revealed that the majority confused wild plants with the term historical variety. When the customers were asked for their reasons for buying an old variety most of them agreed with all possible options with the emphasis on supporting the diversity of vegetable varieties. The analysis of the questionnaires showed that it has priority for those customers to buy organic vegetables. They support the diversity of varieties as a further positive effect if such an offer is available. All customers questioned considered the conservation of old varieties an important issue and 85% would pay a higher price.

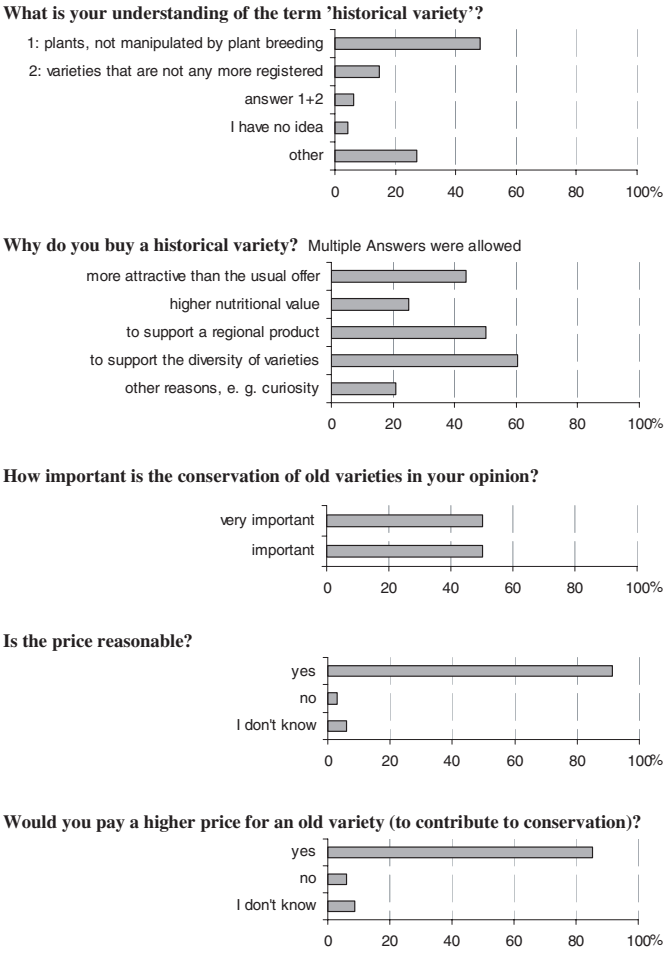

Fig. 1: Questioning of customers at two locations of weekly market stands and in a farmer's shop in Berlin (June/July 2007), n= 48 questionnaires, respectively short interviews.

Discussion

Suitability for *on-farm* Conservation

The pilot tests were successful except for cultivation in autumn and provided an insight into problems as well as chances of success for the re-introduction of old varieties into the market. Basically, the pilot tests confirmed the opinion that re-introducing old varieties into the market is in the interest of both, growers and consumers (HARDON and VAN HINTUM, 1994). On the one hand, market gardens expand their assortments of goods and on the other hand, customers gain more choice. However, the lack of acceptance by rural customers takes a constrictive effect. Obviously, a lot of public relations work is necessary to attract greater attention and raise awareness for the conservation of agro-biodiversity (KLEINHÜTTELKOTTEN et al., 2006).

The results of 2007 preliminarily allow to classify the varieties with regard to their suitability for *on- farm* conservation in which some varieties like 'Bunte Forelle', 'Wiener Maidivi' or 'Struwwelpeter' were well suited, however other varieties like 'Früher Gelber Krausblättriger' or 'Hohlblättriger Butter' are more adequate for home or hobby gardens. Generally, we can establish that predominantly non-specific factors raised problems like snails, wireworms or hail that affected not only individual varieties. Only some varieties had specific problems with tipburn like 'Stuttgarter Sommer' or 'Hohlblättriger Butter'.

Marketing success and potential target groups of consumers

In the city of Berlin marketing was very successful in contrast to the rural region of Brandenburg. Therefore it is more promising to focus the re-introduction of old varieties on the city where potential customers are available. The analysis of the interviews made clear that the regular customers of the direct marketers contribute essentially to the sales success because the strong customer loyalty helped to accept old varieties.

In conclusion, customers who prefer organic food are frequently disposed to make a contribution to the conservation and promotion of agro-biodiversity. Therefore, these customers are a promising target group for further information campaigns and public relations concerning genetic resources as well as stimulation of interest for rare crop varieties.

The need for a network for the *on-farm* management of old varieties

In the context of the pilot project it turned out that the marked gardens demand relatively large seed quantities of individual varieties exceeding the magnitude a seed initiative like the VERN e.V. can regularly provide. The VERN e.V. maintains a multitude of old crop varieties, demonstrates the diversity of crops in show gardens for the public, and provides hobby gardeners with seeds in small quantities via the „catalogue for rare crops“ (VERN, 2008). The available capacity of the VERN e. V. is not designed to additionally provide sufficient seed quantities of particular varieties for the *on-farm* management in market gardens.

In face of this bottleneck problem it became essential to find new ways to produce seed. The Arche Noah seed network in Austria sets an important example in the conservation and propagation of old varieties. Under the auspices of Arche Noah maintainers who take on responsibility for particular varieties form a network (ARCHE NOAH, 2008) thereby achieve a great capacity of work. A further example that sheds light on the aspect of maintenance breeding is the approach of VERN e.V. which pursues the conservation of old potato varieties in cooperation with a commercial breeder. In this way a limited number of special attractive varieties are better commercially available.

In the context of the pilot project, we took first steps to form an *on-farm* network. Market gardens participating in the project since 2007 were won over to take on maintenance and propagation of particular varieties from 2008. VERN e.V. will purify and process the seed. The network will exchange the various old varieties via VERN e.V.

Furthermore, the network will work on breeding aspects. Since sometimes off-types appeared in the pilot tests it will be necessary to eliminate off-types from seed bearing plants to maintain the respective variety identity. Based on the results of the field trials we establish or verify the respective variety descriptions because they are a prerequisite for such selections. In defining the respective varietals identities it must be taken into account what may be required for uniformity of an old variety in the context of an *on-farm* network. From our point of view uniformity may be less strictly determined than required by law (German Seed Act: SaatG and SortG) because we intend the conservation of old varieties as genetic resources. In this context, a certain variability may be tolerated as long as the varietals identity is recognizable.

On-farm conservation as a dynamic method leads to the question if it is desirable to improve special characteristics of individual old varieties by breeding. The participants of the network may deal with the details from case to case and find adequate solutions when they practice participative breeding.

Moreover, the pilot tests revealed that action must be taken to improve seed quality. The heterogeneous germination rates (Tab. 3) indicate that various causes influenced the germination success. On the one hand, conditions varied between the respective market gardens and on the other hand, the seed of the old varieties was not produced following the standards of current commercial cultivars. The VERN e.V. produces seed outdoors which may result in loss of seed quality because lettuce is quite sensitive to rainy weather during flowering and seed ripening. Further, seed vigour depends on the degree of ripeness (BREMER, 1962). With the help of the network we search for appropriate solutions that can be realized by the involved maintainers according to their equipments.

We develop a co-operation model for the emerging network with the aim to produce adequate quantities of seed in good quality, ensure technical support for the maintainers, facilitate exchange between maintainers concerning seed propagation and breeding work, and satisfy the legal requirements because seed exchange will be restricted to the network under the auspices of the VERN e.V. Moreover, interchange between network members may help to optimize cultivation of the old varieties and stimulate new marketing activities.

Acknowledgement

The pilot project is funded by Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (BMVEL/BLE) FKZ 05BM007/2. We thank the seed company Rijk Zwaan for gratuitously providing the seed of the reference variety ‘Amphore’, thus supporting the project.
We thank Inge Dressel for technical assistance and Tobias Schober for supporting the field trials. We are grateful to Ruth Kleinöder who conducted pre-tests in the field at the Domäne Dahlem and helped with many valuable suggestions and a lot of advice.

References

BREMER, A.H., 1962: Salat, *Lactuca sativa* L.. In: Kappert, H., Rudorf, W. (Hrsg.), Handbuch der Pflanzenzüchtung, Band 6, Züchtung von Gemüse, Obst, Reben und Forstpflanzen, 253-270. Paul Parey Berlin, Hamburg.

BUNDESMINISTERIUM FÜR ERNÄHRUNG, LANDWIRTSCHAFT UND VERBRAUCHERSCHUTZ (BMELV), 2002: Nationales Fachprogramm zur Erhaltung und nachhaltigen Nutzung pflanzengenetischer Ressourcen landwirtschaftlicher und gartenbaulicher Kulturpflanzen. [Online] http://www.genres.de/pgr/nationales_fachprogramm/ (cited 19 May 2008).

CHMIELEWSKI, 2008: Wetterbeobachtungen [Online] http://www.agrar.hu-berlin.de/struktur/institute/pfb/struktur/agrarmet/service/wb (cited 19 May 2008).

DE VRIES, I.M., 1997: Origin and domestication of *Lactuca sativa* L. Genetic Resources and Crop Evolution 44, 165-174.

EFKEN, J., 2005: On-farm-Management in Deutschland – Funktion, Gestaltung und Strategie. Schriften zu genetischen Ressourcen 25, 14-22 [Online] http://www.genres.de/infos/pdfs/bd25/25-09.pdf (cited 6 May 2008).

FAO, 1996a: The state of the world’s plant genetic resources for food and agriculture, FAO Rome, [Online] http://193.43.36.103/ag/agp/AGPS/Pgrfa/pdf/SWRFULL2.PDF (cited 6 May 2008). Food and Agriculture Organization, Rome.

FAO, 1996b: Global plan of action for the conservation and sustainable utilization of plant genetic resources for food and agriculture and the Leipzig declaration adopted by the international technical conference on plant genetic resources, Leipzig, Germany 17-23 June 1996 [Online] www.fao.org/ag/AGP/AGPS/pgrfa/pdf/gpaeng.pdf (cited 6 May 2008). Food and Agricultire Organization, Rome.

GEPTS, P., 2006: Plant genetic resources conservation and utilizaton: The accomplishments and future of a social insurance policy. Crop Science 46, 2278-2292.

GLADIS, T., 2001: Wertevielfalt, Biodiversität und genetische Ressourcen. Schriften zu genetischen Ressourcen 16, 14-22 [Online] http://www.genres.de/infos/rei-bd16.htm (cited 6 May 2008).

HARDON, J.J., VAN HINTUM, T.J.L., 1994: Integrated approaches to *ex-situ* and *in-situ* conservation. In: Begemann, F., Hammer, K. (eds.), Integration of conservation strategies of plant genetic resources in europe, 176-180. Proceedings of an international symposium on plant genetic resources held in Gatersleben, Germany, 6-8 December 1993. ZADI and IPK.

HARTKOPF, E., 2006: Evaluierung eines Sortiments alter Salatsorten, *Lactuca sativa* L. Bachelor-Arbeit, Institut für Gartenbauwissenschaften, Fachgebiet Pflanzenzüchtung, Landwirtschaftlich-Gärtnerische Fakultät der Humboldt-Universität zu Berlin.

HELM, J., 1954: *Lactuca sativa* L. in morphologisch-systematischer Sicht. Die Kulturpflanze 2, 72-129.

HERRMANN, K., 2001: Inhaltsstoffe von Obst und Gemüse. Verlag Eugen Ulmer GmbH &Co., Stuttgart.

JENNINGS, A.C., 1981: The determination of dihydroxy phenolic compounds in extracts of plant tissues. Analytical Biochemistry 188, 396-398.

KLEINHÜCKELKOTTEN, S., WIPPERMANN, C., BEHRENDT, D., FIEDRICH. G., SCHÜRZER DE MAGALHAES, I., KLÄR, K., WIPPERMANN, K., 2006: Kommunikation zur Agro-Biodiversität. Voraussetzungen für und Anforderungen an eine integrierte Kommunikationsstrategie zu biologischer Vielfalt und genetischen Ressourcen in der Land-, Forst-, Fischerei- und Ernährungswirtschaft (einschließlich Gartenbau). ECOLOG-Institut/Sinus Sociovision, Hannover/Heidelberg.

KÜNSCH, U., SCHÄRER, H., TEMPERLI, A., 1981: Eine Schnellmethode zur Bestimmung von Nitrat in Frischgemüsen mit Hilfe der ionensensitiven Elektrode. Mitteilungen der Eidgenössischen Forschungsanstalt für Obst-, Wein- und Gartenbau, Wädenswil, Flugschrift 106.

LEHMANN, C., LISSEK-WOLF, G., VÖGEL, R., HUYSKENS-KEIL, S., 2008: Striking a new path for conservation of crop genetic resources: First results of a pilot project to re-introduce old *Lactuca* varieties into the market. Acta Horticulturae, in press.

RODENBURG, C.M., 1960: Salatsorten: Eine internationale Monographie. Sortenbeschreibungen Nr. 3, Instituut voor de Veredeling van Tuinbouwgewassen, Wageningen, Holland, 260.

SCHULLER, Ch., 2008: Anbaueignung und Qualitätsmerkmale ausgewählter historischer Salatsorten (*Lactuca sativa* L.), Bachelor-Arbeit, Institut für Gartenbauwissenschaften, Arbeitsgruppe Produktqualität/Qualitätssicherung, Landwirtschaftlich-Gärtnerische Fakultät der Humboldt-Universität zu Berlin.

VERN, 2008: Katalog für seltene Kulturpflanzen (catalogue for rare crop varieties) [Online] http://www.genres.de/infos/vern/kataloguebersicht/sortenliste.htm (cited 19 May 2008).

Addresses of the authors:

Dr. Cornelia Lehmann, Gunilla Lissek-Wolf, Dr. Susanne Huyskens-Keil, Humboldt-Universität zu Berlin, Institute for Horticultural Sciences, Section Quality Dynamics/Postharvest Physiology, Lentzeallee 75, 14195 Berlin

E-mail: cornelia.lehmann@agrar.hu-berlin.de

Rudolf Vögel, Landesumweltamt Brandenburg, Tramper Chaussee 2, 16225 Eberswalde and VERN e.V., Verein zur Erhaltung und Rekultivierung von Nutzpflanzen in Brandenburg, Burgstraße 20, 6278 Angermünde/OT Greiffenberg