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Overwintering behaviour of 56 safflower (*Carthamus* spp.) genotypes under the conditions of Northeastern Germany in 2006/2007

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Abstract
There are only few safflower genotypes described to be winter hard or frost tolerant in different countries. Because spring grown safflower often suffers from dryness or a short vegetation time when grown in Northeastern Germany, winter types could be an interesting alternative in growing this oilseed crop. In September 25th, 2006, 23 spring type breeding lines, 10 varieties or lines of them, 22 gene bank accessions of *Carthamus tinctorius*, and one accession of *C. lanatus* were planted in single rows using a randomized complete block design with three replicates in Ranzin (near Baltic sea, NE Germany). Seven accessions *of C. tinctorius* were reported to be winter types. Average plant emergence, counted at November 2nd, resulted in more than 16 plants per row and demonstrated good stand in most genotypes. Although long term average temperatures in December, January, and February are below 1°C for this region, in 2006/2007 the conditions were unusually mild with 4.8°C. Only three very short periods of frost (to -10°C) were recorded for the time between end of January to mid of February. However, only 2 plants out of all plots of *C.tinctorius* were counted to be alive at March 30th, 2007. In contrast, 89 plants of the three *C. lanatus* plots could be found. These plants grew normally and gave a kernel yield of 2.5 kgs together. In 2008, similar spring results were obtained for the same accession. These findings demonstrate that the climatic conditions of Northeastern Germany seem to be unfavourable for cropping *C. tinctorius* as winter type, but not for *C. lanatus*.

Key words: safflower - woolly distaff thistle - winter types

Introduction

In the 16th to 18th century, safflower (*Carthamus tinctorius* L.) widely was distributed in southwestern to central parts of Germany (Alsace, Wuerttemberg, Thueringen) as a dye crop (Koerber-Grohne, 1995). When saffron dyes were produced more economically in Northern Africa at the end of this period, safflower fields in Germany were disappearing continuously. Nowadays, safflower could be used as an oil crop in Germany, especially in organic farming (Reinbrecht, 2005). The growing conditions of safflower are not very favourable in Northeastern Germany, where winter temperatures are disappearing lately relative to other German regions and furthermore presummer dryness occurs each second to third year from April to June. After sowing, when young safflower plants do not have a good root development, they may suffer directly from the dry conditions, especially on light soils which are widely distributed over this region. Winter types could be an alternative for cropping spring type safflower under these less favourable conditions.

This study was performed to test a range of safflower genotypes considered to be suitable for a cropping over winter and to find out adapted winter types or frost tolerant genotypes of safflower to be used as cross parents in a future breeding programme.

Materials and Methods

The trial was performed during winter season 2006/2007 in Ranzin near Greifswald in Northeastern Germany. Ranzin (13° 31' East and 53° 57' North) is located around 20 km far from the Baltic sea. The mean temperature of the last three decades (1978-2007) is 8.8°C, the average temperature for the winter months december to february is 0.9°C at Greifswald weather station.

For the minimum temperature, 5.5°C and -1.2°C, respectively, are reported for this place

Tab. 1: Plant material of safflower (*Carthamus tinctorius* L.) or woolly distaff thistle (*Carthamus lanatus* L.) used in the overwintering trial sown at Ranzin, Northeastern Germany, at 25th, 2006, its sources, and the average plant emergence at Nov. 2nd, 2006

No.	Genotype	Material group (preliminary information for frost tolerance)	Source	Average emergence (number of plants)
1	0007/11	Breeding-line	Own	21.0
2	0007/15	Breeding-line	Own	21.0
3	0008/01	Breeding-line	Own	16.0
4	0010/32	Breeding-line	Own	21.0
5	0010/35	Breeding-line	Own	21.0
6	0015/06	Breeding-line	Own	13.7
7	0015/24	Breeding-line	Own	9.0
8	0019/04	Breeding-line	Own	17.0
9	0021/44	Breeding-line	Own	18.0
10	0022/12	Breeding-line	Own	21.0
11	0022/13	Breeding-line	Own	21.0
12	0031/18	Breeding-line	Own	15.7
13	0031/54	Breeding-line	Own	19.7
14	0031/61	Breeding-line	Own	19.3
15	0031/63	Breeding-line	Own	21.0
16	0032/03	Breeding-line	Own	16.0
17	0032/06	Breeding-line	Own	21.0
18	0032/09	Breeding-line	Own	21.0
19	0032/19	Breeding-line	Own	18.0
20	0032/24	Breeding-line	Own	21.0
21	0032/31	Breeding-line	Own	19.0
22	0032/32	Breeding-line	Own	18.0
23	0032/34	Breeding-line	Own	12.0
24	2000-00814	Accession	Bot. Garden Goettingen	21.0
25	2000-00814/1-1	Accession - selected line	Bot. Garden Goettingen	9.3
26	AC Sunset	Variety	Agric. & Agri food Canada	12.3
27	BG-HOH	Accession	Bot. Garden Hohenheim	21.0
28	BG-HOH-1	Accession - selected line	Bot. Garden Hohenheim	11.3
29	BS-52826 (*C. lanatus*)	Accession	Gene Bank Braunschweig	21.0
30	BS-62915	Accession	Gene Bank Braunschweig	19.7
31	BS-62922/1-1	Accession - selected line	Gene Bank Braunschweig	12.7
32	BS-62924/1-1	Accession - selected line	Gene Bank Braunschweig	14.3
33	BS-62926/1-1-1	Accession - selected line	Gene Bank Braunschweig	8.7
34	BS-62929	Accession	Gene Bank Braunschweig	21.0
35	CART-19/89	Accession	Gene Bank Gatersleben	16.3
36	CART-79/89/4-1-1	Accession - selected line	Gene Bank Gatersleben	5.0
37	CART-9-82/2-1	Accession - selected line	Gene Bank Gatersleben	7.3
38	Honghua-1	Variety	China Agric. University	18.0
39	Honghua-1-1	Variety-line	China Agric. University	12.7
40	Honghua-2	Variety	China Agric. University	15.7
41	PI-253529/1	Accession - selected line	ARS-GRIN	11.7
42	PI-406002 (KN 161)	Accession (frost tolerant)	ARS-GRIN	18.3
43	PI-406702 (Tosun 76C62)	Accession (frost tolerant)	ARS-GRIN	6.7
44	PI-506426 (FO-2)	Accession (frost tolerant)	ARS-GRIN	19.0
45	PI-537598 (1003)	Accession (frost tolerant)	ARS-GRIN	21.0
46	PI-537666/4-1	Accession - selected line	ARS-GRIN	7.3
47	PI-537682 (1104)	Accession (frost tolerant)	ARS-GRIN	21.0
48	PI-544017 (Honghua)	Accession (winter hard)	ARS-GRIN	21.0
49	PI-572475 (Saffire)	Variety	ARS-GRIN	19.7
50	PI-572475/1	Variety-line	ARS-GRIN	1.8
51	ProSpecieRara (KR 338)	Accession	FAL Zuerich-Reckenholz	1.0
52	Sabina-1-1	Variety-line	Norddt. Pflanzenzucht	9.7
53	Sabina-2-1	Variety-line	Norddt. Pflanzenzucht	15.3
54	Sabina-2-2	Variety-line	Norddt. Pflanzenzucht	17.3
55	Sabina-2-3	Variety-line	Norddt. Pflanzenzucht	20.7
56	W6-23110 (FO-4)	Accession (frost tolerant)	ARS-GRIN	21.0

(www.wetteronline.de, 2008). In winter time, night temperatures below -10°C are not seldom and snow covering can be completely abundant.

Plant material used in this experiment were 55 genotypes of *Carthamus tinctorius* L., consisting of 23 spring type breeding lines, ten varieties or lines of them, and 22 gene bank accessions, and one gene bank accession of the woolly distaff thistle (*Carthamus lanatus* L.; Tab. 1). Seven accessions of *C. tinctorius* were reported to be winter hard or frost tolerant (Johnson et al., 2005; informations of the GRIN system at www.ars-grin.gov). At September 25th, these 56 genotypes were sown in single row plots each of 1.45 m length with a space between plots of 0.48 m. The trial was laid out as a randomized complete block design with three replicates. After emergence, numbers of plants per row were counted at November 2nd, 2006. In case of more than 20 plants per row, the counting was set to 21. On March 30th, plant countings per row were repeated. Weeding was done by a treatment with Biathlon at rosette stage by covering the overwintered and alive safflower plants with cardboards, and afterwards manually. At the beginning of September 2007, mature plants or, if present, full rows were harvested and seeds were dried in an oven at 40°C and weighted. Countings were displayed as number of survived plants per genotype relative to the number of emerged plants by using the computer package PLABSTAT (Utz, 2002).

Results

The autumn and winter temperatures at Ranzin were relatively mild beginning from October, 2006. After a good plant development, the rosette stage was reached around end of November. Plant emergence, counted at November 2nd, revealed an intermediate to good stand of most of the genotypes tested (Tab. 1). The overall mean was 16.1 plants per row, the least squared difference (P=0.05) amounted to 4.7 plants. Depending on their lower seed quality, six genotypes displayed an emergence below eight plants per row.

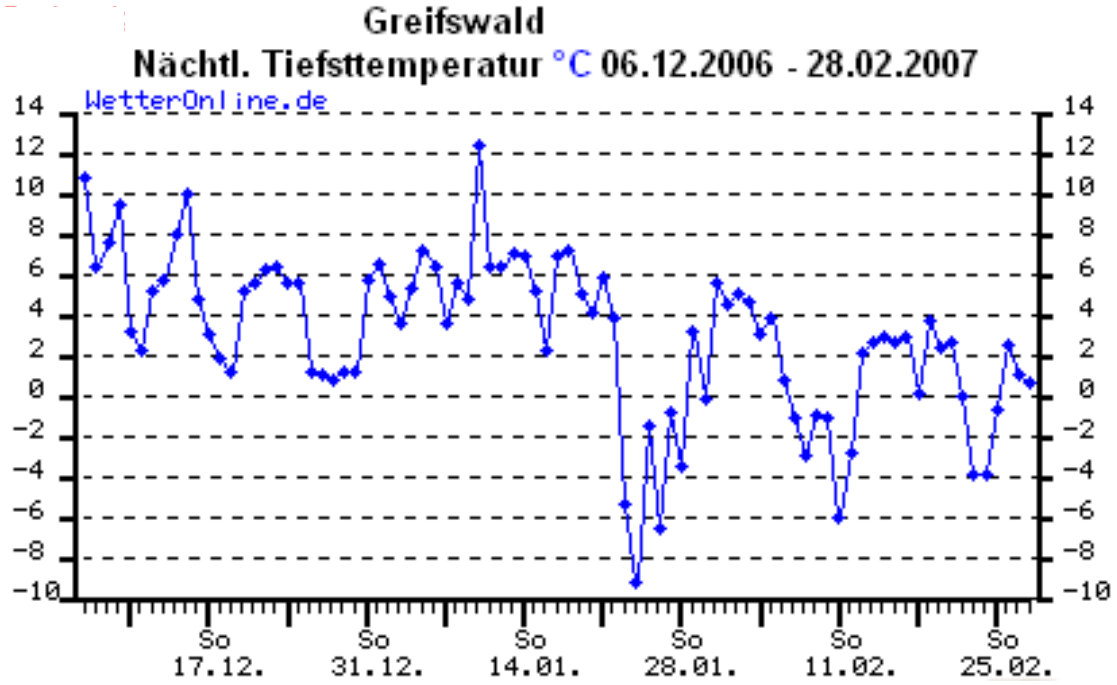

Fig. 1: Minimum temperatures (°C) at Greifswald weather station from December 2006 to February 2007

From beginning of December (2006) to end of February (2007), average temperature was at 4.8°C and the minimum temperature was at 3.1°C. This was a difference of about plus four degrees centigrade from the long term mean. However, the plants were remaining at rosette stage until 23rd of January, 2007. Four days on, minimum temperatures went down to -6°C and below. At 23rd, the minimum temperature at Ranzin was -10°C. A sharp wind from East was also

present at 23rd, and higher amounts of snow covering were recorded not until January, 25th. The minimum temperatures measured at the weather station at Greifswald are given in Fig. 1.

After this sharp temperature incision, most of the safflower plants showed heavy frost damages and disappeared in the following time. A second counting displayed survived plants only in five plots. Of *Carthamus tinctorius*, only one plant each were registered in genotype 33, 3rd replication, and in genotype 52, 2nd replication. In the *Carthamus lanatus* accession, countings gave 27, 35, and 27 plants per row in the 1st, 2nd, and 3rd replication, respectively. For *C. lanatus* nearly 100% survival can therefore be assumed, whereas for the two *C. tinctorius* genotypes, BS-62926/1-1-1 and Sabina-1-1, a survival of only 3.8% and 3.4%, respectively, could be calculated.

Fig. 2: Surviving safflower plants at flowering stage in Ranzin at beginning of July, 2007.

At the beginning of July, the remaining plants started flowering (Fig. 2) and went afterwards into normal ripening stages. Full ripening was reached at mid to end of August. The three rows of *C. lanatus* yielded in 2.545 kgs together. The Sabina-1-1 plant gave a normal yield of about 400 seeds, whereas the BS-62926/1-1-1 plant severly has been suppressed by rabbits before. Therefore only 22 kernels could be harvested at maturity.

At October 4th and 5th, 2007, harvested seeds of *C. lanatus* and Sabina-1-1 were sown again at Ranzin breeding station in two different plots. The *C. lanatus* plot was around 625 m², the Sabina-1-1 plot was only 5 m² large. The seed number was about 60 kernels per m². After emergence, the two plots revealed a normal plant stand. Again, *C. lanatus* overwintered without a greater plant loss and a good plant development was obtained at spring/summer 2008. In the small plot of Sabina-1-1, no single plant did survive after end of February, 2008, although minimum temperatures did not fall lower than -7°C in the whole winter season 2007/2008, and the two colder periods in December 2007 and January 2008 were lasting only a few days.

Discussion and Conclusions

Weather conditions over the winter seasons 2006/2007 and 2007/2008, especially minimum temperatures, were relatively mild compared to the long term mean. Although the conditions of the investigated time interval was not as rough as normal winters are in Northeastern Germany, the overwhelming majority of the *Carthamus tinctorius* plants in 2006/2007 did not survive. Because of a sufficient seed production, one of the two surviving plants could be retested in the next winter season 2007/2008. The result of this winter season demonstrates that the one plant of Sabina-1-1 did survive the previous winter “by random”. Our results are in contrast to the findings by Johnson et al. (2005), but with the hint that our testing location is situated more to the North than that two used by the mentioned authors (located at 46°37-43’ North), and winter time at our site could probably be longer. However, our findings demonstrate that the climatic conditions of Northeastern Germany seem to be unfavourable for cropping *C. tinctorius* as winter type, but not for *C. lanatus*. Therefore, *C. lanatus* can be used for the development of winter hard safflower types, if the realization of crosses between both species will be successful.

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References

Johnson, R.C., Dajue, L., Foiles, C., Bradley, V., 2005. Variation in winter hardiness among safflower accessions. In: Esendal, E. (Ed.), Proceedings of the 6th International Safflower Conference, Istanbul, Turkey, June 06-10, 2005, 113-118.

Koerber-Grohne, U. (1995) Nutzpflanzen in Deutschland – von der Vorgeschichte bis heute. Nikol-Verlagsgesellschaft mbH & Co. KG Hamburg, Germany.

Reinbrecht, C., 2005. Vergleich der Anbaueignung verschiedener Ölpflanzenarten und -sorten für den Ökologischen Landbau unter den Aspekten Speiseölgewinnung und Eiweißquelle [Oil crops: comparison of the suitability for cultivation in organic agriculture for the provision of edible oil and protein sources]. Final report of a project within the German Bundesprogramm Oekologischer Landbau (http://orgprints.org/5895).

Reinbrecht, C., Barth, S., von Witzke-Ehbrecht, S., Frick, C., Elfadl, E., Kahnt, G., Becker, H.C., Claupein, W., 2005. Screening of a worldwide safflower collection for adaptation to humid temperate climates and cultivation in organic farming. In: Esendal, E. (Ed.), Proceedings of the 6th International Safflower Conference, Istanbul, Turkey, June 06-10, 2005, 236-242.

Utz, H.F. (2002) PLABSTAT. A computer program for the statistical analysis of plant breeding experiments. Version 2N. Institute of plant breeding, seed science, and population genetics, University of Hohenheim.

WetterOnline.de, 2008. Weather data of the meteorological station Greifswald from 1978 to 2008 available by surfing under http://www.wetteronline.de.