Genetic variation for aspects of frost-tolerance in the Göttingen Winter Bean Population

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Introduction

North of the Alpes, faba bean (*Vicia faba* L.) are mainly grown as spring crop. Yet, some winter beans are available and used, mainly in UK. They promise better use of water and better weed competition, avoidance of summer drought and pests and higher yield than spring beans. With climate change and breeding progress for winter hardiness, winter beans will extend to regions such as Germany. Since 1989, at Göttingen a **genetically diverse, highly winter-hardy bean population** (comprising most of the breeding material for current Central European winter bean breeding) is subjected to ongoing improvement.

Objectives

Field tests for winter hardiness suffer from the unpredictability of winter conditions. Since 2004 we operate a small conventional platform to phenotypically assess and analyze FROST TOLERANCE as major component of winter hardiness of JUVENILE, POTTED winter beans.
The current work was conducted to gather further experience with this platform and to en detail characterize our core set of >200 winter bean SSD lines.

Materials and Methods

N=232 highly inbred winter bean lines were employed. They are SSD lines bred from the **Göttingen Winter Bean Population** (Gasim 2003). Six experiments were conducted in a 4m² **Vötsch** plant growth chamber (VB4018 extra; down to minus 20°C) in winter 2009/2010 and repeated in 2010/2011. A single experiment held 42 inbred lines, with 3 insulated pots (17cm²) as one incomplete block (6x7 rectangular lattice) that contained 6 inbred lines with four individuals each, and r=2. Because of the three checks and further redundant entries, number of actually tested lines (N=232) was smaller than 6x42=252.

Plants were hardened for 10 days at 4-5°C and then subjected to 4h of frost in each of three consecutive 'nights' (-13°C, -18°C, -18°C). Approach to frost took 4h, recovery from frost took 6h. Between actual frost events plants were kept at 5°C. After this test, plants were cared for in mild conditions (10-20°C). Four days after test, shoots were cut to provoke regrowth (proving survival) or death (frost susceptibility). NUMBER Of DAYS OF SURVIVAL after test was recorded for a period of 30-45 days; thereafter, any regrown shoots were harvested as 'REGROWTH' in [g]. Number of days of survival were transformed into DISPOSITION TO SURVIVE in [°; from 0° to 90°] (Roth & Link 2010).
DISPOSITION TO SURVIVE=$\arctan(x_i/\mu_x)$.
x_i = number of days until death
μ_x=mean number of days until death of those plants that actually died. Surviving plants: 90°.

ANOVA: Lattice analysis was conducted for the single experiments (PLABSTAT). Each experiment was then analysed across its two years, based on the lattice-adjusted entry means. Genotypic variance was tested for significance against entry x year interaction variance.

Aggravating (left - right) symptoms of frost injury;
upper photos: loss of turgor
lower photos: colour loss

Steps of test (left-right): Symptoms after three frost ‚nights', plants after shoot chop-off, several weeks later with regrowth or death

Results and Discussions

Per cent survival (-18°C) of six sets of 42 faba bean lines each, tested as young potted plants in growth chamber in two consecutive rounds ('seasons': 2010 and 2011)

Experiment	2010		2011	
	Survival (%)	Date of End	Survival (%)	Date of End
1	55.4	01.02.2010	93.2	05.01.2011
2	56.5	12.02.2010	48.0	31.01.2011
3	68.8	22.02.2010	85.6	18.02.2011
4	53.9	21.03.2010	48.2	04.03.2011
5	66.1	30.03.2010	49.7	18.03.2011
6	38.4	15.04.2010	74.5	01.04.2011

Results of 6 six experiments, analyzed across two 'seasons' in growth chamber; 42 winter bean lines per experiment

Experiment	Disposition to Survive [°]			Regrowth [g]		
	Mean	Genot. Standard Deviation	h²	Mean	Genot. Standard Deviation	h²
1	77.28	10.59	0.71	1.98	0.67	0.49
2	68.52	7.90	0.50	1.13	0.60	0.63
3	78.29	4.04	0.23	1.66	0.68	0.70
4	67.35	7.60	0.44	1.29	0.39	0.32
5	70.62	12.16	0.74	1.64	0.70	0.52
6	69.63	9.44	0.72	1.90	0.95	0.64

Significant genetic variation promises marked gain from selection for frost tolerance
Field-born experience was corroborated by checks
Problems: Experiments differ markedly for their means; no data from survivors for 'Number of Days of Survival; 'Regrowth' variation is not meaningful for those that survive without injury; Data distribution features need consideration

References
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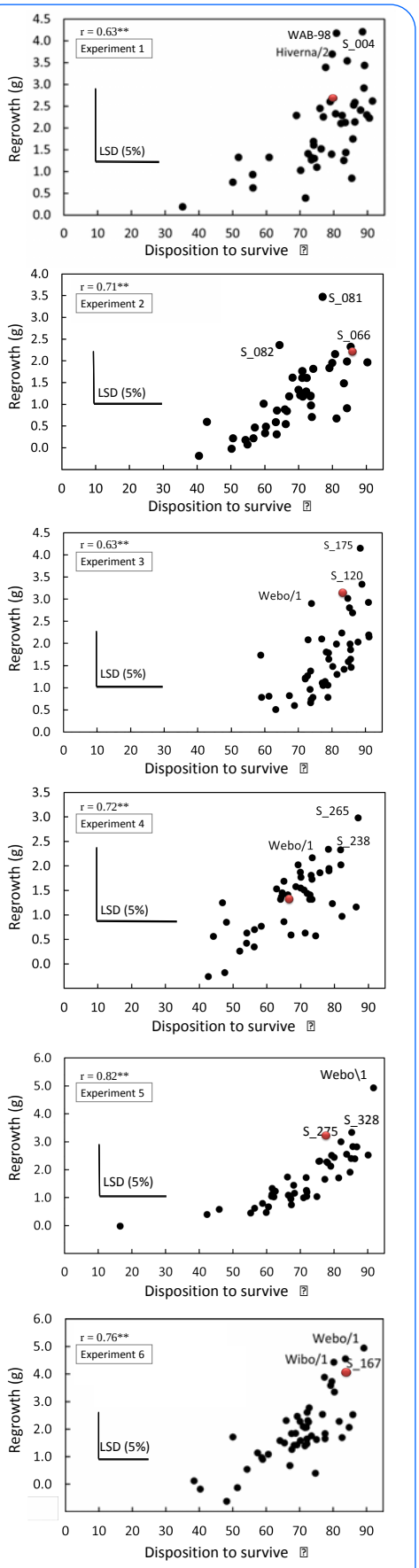

Regrowth *vs.* Disposition to Survive (means across two seasons).
● shows the averages of the three check inbred lines (Webo/1, Wibo/1, Hiverna/2)