Resistance to common bunt (*Tilletia tritici*) and rust (*Puccinia sp.*) in hulled wheat

By Anders Borgen, Agrologica, Houvej 55, DK-9550 Mariager, Denmark

Abstract
Common bunt (*Tilletia tritici*) and rust diseases (*Puccinia sp.*) was scored in 123 varieties of wheat species other than bread wheat. The species included *Triticum spelta* (90 lines), *T.macha* (18 lines), *T.dicoccon* (6 lines), *T.timopheevii* (3 lines) and one representative of each of the species *T.vavilovii, T.karamyshevii, T. polonicum, T.carthlicum* and *T.compactum*. Huge differences in bunt susceptibility were found in all species. Lines with low susceptibility were identified in *Triticum spelta, T.macha, T.dicoccon, T.timopheevii* and *T.vavilovii* but none in the few investigated lines of species *T.karamyshevii, T. polonicum* and *T.carthlicum*. All lines of *T.macha, T.vavilovii* and *T.karamyshevii* were susceptible of rust, were as resistance to this disease was frequent in *T. spelta*. The study hereby has identified candidates for future plant breeding within these species.

Introduction
Since ancient times, common bunt (*Tilletia foetida* and *T. tritici*, syn *T.caries*) has potentially been the most devastating plant disease in bread wheat (*Triticum aestivum*) (Woolman & Humphrey 1924, Butress & Dennis 1947, Johnsson 1991). The disease is rarely seen in modern farming as it is controlled by fungicide seed treatment. Organic farming does not use fungicides, and about 25% of all organic wheat seed lots are every year discarded. The susceptibility of wheat varieties varies a lot (Kühn, 1880; Tubeuf, 1901; Cobb, 1902; Hecke, 1906-7; Pye, 1909; Darnell-Smith, 1910; Kirschner, 1916; Piorr, 1991; Banada *et al*., 1995; Blažkova and Bartoš, 1997; Polišenská *et al*., 1998; Huber og Buerstmayr, 2006; Liatukas and Ruzgas, 2005; Wächter *et al*., 2007; Nielsen, 2005, 2006) and 16 specific resistance genes have been identified so far. Also spelt (*Triticum spelta*) and emmer (*T.dicoccon*) are frequently infected by bunt spores indicating that at least some varieties of these wheat species are susceptible whereas little is published about the susceptibility of other covered wheat species. This confirms the findings of Tschaner (1764), who found differences in susceptibility between spelt lines. Since then, the susceptibility of spelt and other covered wheat species has only been investigated in minor screening experiments, and effective resistance has not been found.
Rust diseases (*Puccinia sp., including P. striiformis, P.recondita and P.graminis*) has always been additional important wheat diseases, and in recent years, new patho-types has developed, making resistance breeding in wheat even more important. Yellow rust (*P. striiformis*) has resulted in total crop loss in unsprayed wheat and triticale fields in 2009, making knowledge about the varieties susceptibility crucial, especially in organic production.

Materials and methods
Seed samples were collected from genebanks and research projects. Spikelets was infested with an abundance of spores, and the surplus was removed by sieving. Experiment was sown in October 2008, and each variety was sown in 1m rows with a spikelet distance of about 2 cm. After heading, bunt infection was assessed based on visible symptoms (Borgen and Kristensen 2003). Each row was assessed giving a general infection level, and afterwards each tiller was assessed for infection. If the general assessment and the spike inspection both showed infection rates above 25% infected heads, about 25 heads was inspected. In case of lower infections rates, all spikes in the entire row was inspected. Each variety was given a general score for infection of rust diseases (*Puccinia* sp.).

Results and discussion
In Tabel 1, the result of the experiment is presented sorted by species and bunt susceptibility. Huge differences in bunt susceptibility were found, ranging from 0-100% infection. However, in some varieties only few plants were available for assessment due to loss of plants during the experiment.

It can be concluded that some varieties have low susceptibility, most like due to genetic resistance. Resistance seem to be frequent in *T.Vavilovii*, *T.timophevii*, emmer and *T.macha*, and less frequent in spelt. All accession of macha was very susceptible to rust, and the few accessions of *T.vavilovii* and *T.karamyshevii* were extremely susceptible, whereas huge diversity among the spelt accessions were observed.
Spelt from the Agroscope Changins-Wädenswil Research Station seem to have little resistance to bunt, even some lines with low susceptibility were identified, but were in general less susceptible or rust.
Several lines from NordGen and private collections had a low susceptibility to common bunt, but showing some morphological diversity. If the lines are not genetic uniform, the results may represent an average between sub-lines with different susceptibility. In in-homogen lines with low susceptibility, it may therefore be possible to select lines with a lower susceptibility than average. The project intend to follow up investigating the susceptibility of the lines with low bunt frequency based on single head selection to avoid in-homogeneity.
Only few plants were grown and assessed at each variety in this screening experiment. Priority in this field trial was given to a preliminary scoring of many varieties rather than a detailed scoring of fewer varieties. The repeatability of common bunt is normally very high, and it is believed that the experiment does give valuable information about the rough susceptibility of the varieties, making it possible to select relevant candidates for more detailed studies.

Aknowledgement
I which to thank G.B.Hartmanns Forskningsfond for funding the project, and the following for providing seed: Fabio Mascher and Geert Kleijer, Agroscope Changins-Wädenswil Research Station (ACW), NordGen (NGB), Hans Larsson, SLU (HL), Gartersleben Genebank (IPK), Jean-François Berthellot, Réseau Semences Paysannes (JFB), Petr Konvalina, University of South Bohemia (RICP), Géza Kovács, Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár (MUGB) and Per Grupe (PG)

References

Banada, J., J. Milotov, og A. Pospíšil 1995: Odrůdová citlivost pšenice vůči sněti mazlavé a ječmene vůči pruhovitosti a prašné sněti. (*Varietal sensitivity to common bunt in wheat and to stripe disease and loose smut in barley*). Rostinná Výroba (*Plant production*). **41**(4):185-188.

Blažkova, V og P. Bartoš 1997: Reaction of winter wheat cultivars registered in the Czech Republic to common bunt (*Tilletia tritici* (Bjerk.) Wint. and *T.laevis* Kühn) and sources of resistance. Cereal Research Communications **25**(4):985-993.

Borgen, A. and L. Kristensen 2003: Macroscopic leaf symptoms in wheat infected by Tilletia tritici. Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz. **110**(5):432-436

Buttress, F.A. & R.W.Dennis, 1947: The early history of cereal seed treatment in England. Agricultural History **21**:93-103.

Cobb, N.A. 1902: Comparative observations on the brush of fifty varieties of wheat. Agr.Gaz.N.S.Wales **13**(6):647-9.

Darnell-Smith, G.P. 1910: Observations upon the disease of wheat known as “bunt”. Rpt. Govt. Bur. Mcrobiol. **1909**:64-69.

Fischer, G.W., og C.S. Holton 1957: Biology and control of the smut fungi. The Ronald Press Company, New York. 622 sider.

Hecke, L 1906: Die Brandkrankheiten und ihre bekämpfung. Wiener Landw. Ztg. **56**(33):318-9

Hecke, L 1907: Die Triebinfection bei Brandpilzen Versuchsw. Oesterr. **10**(6):572-4

Huber og Buerstmayr 2006,

Johnsson,L 1990: Brandkorn i Bibeln, stinksot i vetet och *Tilletia* i litteraturen - en kortfattad historik från svensk horisont. Växtskyddsnotiser **54**:76-80

Kirschner, O. (1916): Ueber die verschiedene Empfänglichkeit der Weizensorten für die Steinbrandkrankheit. Ztschr. Pflanzenkrank. **26**(1):17-25

Kühn, J.G. 1880: Beobachtungen über den Steinbrand des Weizens. Oesterr.Landw.Wehnbl.VI 1-2.

Liatukas, Þ. og V. Ruzgas 2005: Genetic resources for organic wheat breeding impact on resistance to common bunt. Biologija 3:62-6

Nielsen, B.J. 2005: Resistens mod stinkbrand i vinterhvede. I: "Sortsforsøg 2005. Korn, bælgsæd og olieplanter", eds. G. Deneken and J. B. Pedersen. p. 19.

Nielsen, B.J. 2006: Resistens mod stinkbrand i vinterhvede. I: "Sortsforsøg 2006. Korn, bælgsæd og olieplanter", eds. G. Deneken and J. B. Pedersen.

Piorr, H.P. 1991: Bedeutung und Kontrolle saatgutübertragbarer Schaderreger an Winterweizen im Organischen Landbau. Bonn 1991. pp 166.

Pye, H. 1909: Diseases and pests of cereals. Jour.Dept.Agr.Victoria **7**(6):368-373.

Polišenská, I., A. Pospíšil og J. Benada 1998: Effects of sowing data on common bunt (*Tilletia caries*) infection in winter wheat at lower inoculum rates. Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz. **105**(3):295-305.

Tschaner, N.E. 1764: Von Brand und van dem Rost im Getreide. Abhandl.u. Beobacht.Oekonom.Gesell., Biol.Abt.,Bd.2, Hedt 2 p 179-372.

Tubeuf, C.v. 1902: Weitere Beiträge zur Kentniss der Brandkrankheiten des Getreides und ihre Bekämpfung. Arbeiten aus der Biologischen Abteilung für Land- und Forstwirtschaft am Kaiserlichen Gesundheitsamte **2**:437-467.

Wächter, R, F. Waldow, K-J. Müller, H.Spiess, B-Heyden, U.Furth, J.Frahm, W.Weng, T. Miedaner, D.Stephan og E.Koch 2007: Charakterisierung der Resistenz con Winterweizensorten und -zuchtlinien gegenüber Steinbrand (*Tilletia tritici*) und Zwergsteinbrand (*T. controversa*) Nachrichtbl.Deut.Planzenschutzd 59(2):30-39

Woolman, H.M. & H.B.Humphrey 1924: Summery of literature on bunt, or stinking smut, of wheat. United States Department of Agriculture, Department Bulletin No. 1210. 44 s.

Table text: Susceptibility of different wheat species to common bunt (*Tilletia tritici*) and rust (*Puccinia* sp.). Rust infections were scored on a scale from 1-10. 1 indicate no visible symptoms, and 10 indicating 100% loss of photosynthesis at heading stage.

Specie	name	Origin of seeds	rust	N	bunt infection, %
T.spelta	6357-blå	HL	n.o.	24	4,2
T.spelta	Golden	HL	1	23	4,3
T.spelta	Hvid spelt	HL	3	51	5,9
T.spelta	Ostburgerdorfer	HL	2	60	6,7
T.spelta	TS 1268	ACW	2	66	7,6
T.spelta	Albin	HL	2	45	8,9
T.spelta	6357	HL	1	27	11,1
T.spelta	TS-2123	ACW	n.o.	73	15,1
T.spelta	NGB-9027	NGB	n.o.	31	16,1
T.spelta	TS 1267	ACW	2	85	16,5
T.spelta	TS 1205	ACW	n.o.	46	17,4
T.spelta	Brun spelt	HL	2	52	19,2
T.spelta	TS 1068	ACW	1	87	19,5
T.spelta	TS 1103	ACW	1	51	19,6
T.spelta	TS 1247	ACW	n.o.	58	24,1
T.spelta	TS 0987	ACW	1	57	24,6
T.spelta	TS 1253	ACW	2	52	25,0
T.spelta	TS 0073	ACW	1	28	25,0
T.spelta	TS 1077	ACW	1	37	27,0
T.spelta	dunet	AB	n.o.	37	27,0
T.spelta	NGB-9055	NGB	3	50	28,0
T.spelta	Oberkulmer Rotkorn	PG	2	64	31,3
T.spelta	6357-Vit	HL	1	38	31,6
T.spelta	TS 1193	ACW	n.o.	47	31,9
T.spelta	TS 1099	ACW	1	39	33,3
T.spelta	TS 2113	ACW	2	40	35,0
T.spelta	Jš-1-CB 107	RICB	3	40	35,0
T.spelta	TS 1137	ACW	1	51	35,3
T.spelta	TS 2117	ACW	2	79	35,4
T.spelta	6357-klyvn	HL	1	28	35,7
T.spelta	TS 1159	ACW	2	53	35,8
T.spelta	TS 1136	ACW	1	47	36,2
T.spelta	TS 1235	ACW	n.o.	46	37,0
T.spelta	TS 1089	ACW	1	48	37,5
T.spelta	NGB-9028 brun glat	NGB	2	34	38,2
T.spelta	NGB-9056	NGB	5	39	38,5
T.spelta	TS 1117	ACW	1	33	39,4
T.spelta	TS 1035	ACW	1	38	39,5
T.spelta	TS 1171	ACW	4	58	39,7
T.spelta	Børst spelt	HL	2	25	40,0
T.spelta	Bellarus	SA	n.o.	35	40,0
T.spelta	TS 1261	ACW	2	49	40,8
T.spelta	TS 1109	ACW	1	44	40,9
T.spelta	TS 1242	ACW	5	31	45,2
T.spelta	TS 1115	ACW	1	42	45,2
T.spelta	Vit spelt Alnarp	HL	2	37	45,9
T.spelta	TS 1225	ACW	1	54	46,3
T.spelta	TS 0061	ACW	6	28	46,4
T.spelta	2. B 13869105	HL	3	34	47,1
T.spelta	TS 1142	ACW	5	53	47,2
T.spelta	K23291	VIR	n.o.	56	48,2
T.spelta	TS 1177	ACW	4	31	48,4
T.spelta	TS 1265	ACW	2	71	49,3
T.spelta	TS 1285	ACW	2	42	50,0
T.spelta	TS 1083	ACW	1	45	51,1
T.spelta	NGB-9004	NGB	3	41	51,2
T.spelta	TS 0955	ACW	2	39	51,3
T.spelta	TS 2115	ACW	2	37	51,4
T.spelta	TS 0041	ACW	6	30	53,3
T.spelta	TS 0097	ACW	2	43	53,5
T.spelta	NGB-10883	NGB	1	28	53,6
T.spelta	TS 1146	ACW	1	57	54,4

Specie	name	Origin of seeds	rust	N	bunt infection, %
T.spelta	Jš-4-CB 108	RICB	3	29	55,2
T.spelta	TS-2122	ACW	n.o.	36	55,6
T.spelta	TS 1219	ACW	1	36	55,6
T.spelta	TS 1243	ACW	6	36	55,6
T.spelta	6357-brun	HL	6	43	55,8
T.spelta	TS 1127	ACW	2	48	56,3
T.spelta	TS 2116	ACW	2	53	56,6
T.spelta	3. Lv. Gotland 6	HL	1	38	57,9
T.spelta	TS 1197	ACW	n.o.	43	58,1
T.spelta	TS-2119	ACW	n.o.	41	58,5
T.spelta	NGB-16081	NGB	2	29	58,6
T.spelta	TS 2114	ACW	2	46	58,7
T.spelta	TS-2118	ACW	1	27	59,3
T.spelta	NGB-4781	NGB	5	32	59,4
T.spelta	TS 1231	ACW	1	40	60,0
T.spelta	TS 1239	ACW	4	52	61,5
T.spelta	TS-2121	ACW	n.o.	37	62,2
T.spelta	Jš-3-CB 107	RICB	5	29	65,5
T.spelta	TS 1123	ACW	1	38	65,8
T.spelta	TS 1255	ACW	2	51	66,7
T.spelta	NGB-5149	NGB	1	27	66,7
T.spelta	TS-2120	ACW	n.o.	38	68,4
T.spelta	TS 1017	ACW	1	29	69,0
T.spelta	TS 1151	ACW	3	56	69,6
T.spelta	TS 1072	ACW	1	27	70,4
T.spelta	NGB-9700	NGB	n.o.	33	75,8
T.spelta	NGB-5148 brun	NGB	2	17	82,4
T.spelta	NGB-9005	NGB	2	25	84,0
T.carthlicum	NN	JFB	8	17	70,6
T.compactum	NN	Karensminde	1	17	82,4
T.dicoccon	MuGB-192	MUGB	5	33	0,0
T.dicoccon	MuGB-187	MUGB	5	22	0,0
T.dicoccon	NGB-9681	NGB	n.o.	5	0,0
T.dicoccon	NGB-8190	NGB	7	30	10,0
T.dicoccon	NGB-7208	NGB	6	30	16,7
T.dicoccon	NGB-8206 Blå Vit	NGB	7	19	47,4
T.karamyschevii	497	MUGB	10	13	15,4
T.macha	IPK-13598	IPK	8	69	0,0
T.macha	IPK-4511	IPK	7	60	0,0
T.macha	IPK-1867	IPK	8	37	0,0
T.macha	IPK-1868	IPK	6	20	0,0
T.macha	IPK-9648	IPK	6	39	0,0
T.macha	NGB7199	NGB	6	41	0,0
T.macha	351	MUGB	7	64	0,0
T.macha	IPK-13602	IPK	6	48	2,1
T.macha	IPK-13596	IPK	6	44	2,3
T.macha	NN	JFB	5	39	2,6
T.macha	IPK-19326	IPK	6	35	2,9
T.macha	IPK-4510	IPK	6	24	12,5
T.macha	IPK-13603	IPK	5	36	13,9
T.macha	IPK-4567	IPK	6	42	19,0
T.macha	JIC-9559	JIC	6	41	36,6
T.macha	IPK-13595	IPK	6	39	43,6
T.macha	IPK-17260	IPK	3	26	46,2
T.macha	IPK-13597	IPK	6	30	50,0
T.polonicum:	NN	JFB	6	5	100,0
T.timopheevii	NGB-7198	NGB	n.o.	29	0,0
T.timopheevii	NGB-8217	NGB	3	21	0,0
T.timopheevii	NGB-4819	NGB	1	27	0,0
T.vavilovii	NN	JFB	9	15	0,0
Triticum sp	Pudsig	AB	n.o.	6	66,7