摘　　要

北海道の秋播小麦にとって、耐冬性の問題は古くからの重要な育種目標であるが、特性が複雑な上、各種の雪腐病抵抗性が関与するため、積極的な育種をはばんできた。本報告は耐冬性の要因中、耐凍性と雪腐病抵抗性および春化要求度（秋播性程度）を研究の対象としたが、とくに耐凍性、雪腐大粒菌核病および雪腐小粒菌核病抵抗性の３要因を育種的にどこまで高めうるかを確かめようとして行われた。えられた結果を要約するとつぎのとおりである。

1．耐冬性の品種間差異

1）雪腐大粒菌核病の検定には、小麦を20cmの高畦で栽植し、11月中旬に子のう胞子散布を行い、さらに低濃度の薬剤防除と無防除の区を設けることによって、被害の激甚な年にも軽微な年にも確実な検定が可能となった。

2）雪腐小粒菌核病および紅色雪腐病の検定にはBruehlらの大量培養法に準じて病原菌を培養し、苗箱に栽植した小麦に接種した。品種間差異が明瞭になるのは、接種後２℃の低温恒温室にいれて、黒色小粒菌核病で50～60日、褐色小粒菌核病で90日、紅色雪腐病では60日の処理期間を要した。この方法による検定結果は多雪地帯のほ場検定との間に有意な相関を示した($r=0.555^{**}\sim0.633^{***}$)。

3）耐凍性の検定には地表露出法と冠部凍結法およびE.C.法を検討し、いずれも精度は高く、前２者間の相関は$r=0.733^{***}$で、後２者間の相関は$r=0.768^{***}$であった。E.C.法でみると、訓子府において11月中旬まで低温順化された小麦は、−11.5℃から凍結被害が現れ、−18℃以下になると強品種でも被害が増大する。−15℃が凍結処理温度として最適と見られた。

4）それぞれの検定結果、次の有用母材が見いだされたが、いずれの品種も農学的実用形質は貧弱である。

S. borealis 抵抗性：「Iohardi」「北海48号」。

T. ishikariensis 抵抗性：「C. I. 14106」、「P. I. 172582」、「P. I. 173438」。

T. incarnata 抵抗性：「C. I. 14106」、「P. I. 173438」、「農林62号」、「北系 628」。

F. nivale 抵抗性：「C. I. 14106」「P. I. 172582」、「P. I. 173438」。

耐凍性：「Lutescens 0329」、「Valujevskaja」。

5）耐凍性品種は *S. borealis* におおむね抵抗性を示したが（$r=0.443^{*}\sim0.550^{**}$)、「Lutescens 0329」、「Valujevskaja」はきわめて耐凍性でありながら、*S. borealis* にはあまり強くないし、*S. borealis* に強い「北海48号」の耐凍性はむしろ弱いなどの特異な反応を示す品種が認められた。

6）*Typhula* spp.および *F. nivale* 抵抗性と耐凍性あるいは *S. borealis* 抵抗性との間には、弱いが負の相関が認められ、*T. ishikariensis*、*T. incarnata* および *F. nivale* 抵抗性３者間には高い正の関係がみられた（$r=0.555^{**}\sim0.799^{***}$）。

7）どの要因にもすべて抵抗性という品種は認められず、上記の関係から25品種系統を４群に分類することができた（Fig. 3）。

A群（非耐冬型）：「Ibis」、「Gaines」、「タクネコムギ」。

B群（耐凍型）：「Lutescens 0329」ほか８品種。

C群（中間型）：「ホロシリコムギ」ほか道内の９品種・系統。

D群（耐雪型、*Typhula* spp.抵抗性）：「C. I. 14106」、「P. I. 172582」、「P. I. 173438」、「農林62号」、「北系 628」。

2．耐冬性の遺伝

1）*S. borealis*、*T. ishikariensis*、*T. incarnata* および凍害による被害度の平均値と分散は、いずれも組合せ間、親品種間に有意差が認められ、各F_2集団の平均値と分散はいずれも中間親の値に左右された。

2) ダイアレル分析の前提となる6条件のうち、抵抗性の遺伝行動が非対立遺伝子間の相互作用がないことを検定し、エピステーシス効果のない単純な相加一優性モデルが想定された。

3) 分析の結果、各要因とも相加的遺伝子効果が高かった。 *S. borealis* 抵抗性は部分優性、 *T. ishikariensis* 抵抗性と耐凍性は超優性であった。 *S. borealis* と *T. ishikariensis* 抵抗性は劣性遺伝子が支配的なのに対し、耐凍性では一定の傾向が認められなかった。

4) 狭義の遺伝力は *S. borealis* 抵抗性：90、*T. incarnata* 抵抗性：79、耐凍性：82%と高く推定された。また、F_2，F_3 集団の親子相関による遺伝力は *S. borealis* 抵抗性：84、*T. ishikariensis* 抵抗性：48%と推定された。

5) K＝（最大の親の値ー最小の親の値)^2 ／4D による有効因子数は、 *S. borealis* 抵抗性：1.88、*T. ishikariensis* 抵抗性：2.32 、耐凍性： 2.03 と推定され、関与する遺伝子数は2～3個以上と考えられた。

6) 遺伝相関（ｒＧ）は凍害と *S. borealis* ：0.520、 凍害と *T. ishikariensis* ：－ 0.819、*S. borealis* と *T. ishikariensis* ：－ 0.818と推定され、耐凍性に関与する遺伝子の中には *S. borealis* の抵抗性に関与する遺伝子が含まれていることが示唆されたのに対し、これらと *T. ishikariensis* 抵抗性に関与する対立遺伝子は互いに相異なるように考えられた。

7) *S. borealis* と *T. ishikariensis* に対して、無被害個体の出現率をF_2集団で比較すると、全体として $r=-0.592^{**}$ と負の関係が有意であるが、両病害に抵抗性個体を多く含み、耐凍性も強い有望な4組合せが認められ、このうち3組合せは道内品種・系統間の交雑であった。道内品種・系統がもつ耐冬性の遺伝的背景の重要性が示唆された。

3．耐冬性と体内成分の関係

1）地上部の乾物重、全炭水化物、糖類、粗デンプンおよび蛋白態窒素は秋から初冬まで急速に増加し、根雪直後最高に達する。可溶性窒素、リン酸、カリ、ケイ酸および灰分は秋季低温とともに減少する。

2）越冬前に測定した16形質では地域、時期、品種および越冬型の間に有意な差異が認められた。

3）訓子府は岩見沢より生育量は小さいが、水分が少なく、炭水化物や糖の蓄積が多く、その消耗も少ない。

4）*Typhula* spp.と *F. nivale* に抵抗性の品種は越冬前に多量の炭水化物を蓄積し、越冬後にもなお多量の炭水化物を維持した。また越冬後の可溶性窒素は著しく少なかった。

5）越冬前と越冬後の体内成分の相関は還元糖と粗デンプンを除くといずれも有意に高かった。全炭水化物の年次間相関は訓子府で越冬前 0.751^{***}、越冬後 0.767^{***} と高く、 年次が異なっても品種間差異はほぼ平行的であった。

6）凍害と浸透価、 *S. borealis* とリン酸および脂質の間にきわめて高い相関がみられ、*T. ishikariensis*、*T. incarnata* および *F. nivale* に共通して最も高い相関を示したのは蛋白態窒素と全炭水化物で、越冬前・後ともに蛋白態窒素が多いと被害が増大する。

7）植物体の生育量および越冬前後の体内成分の22形質を用いて主成分分析を行い、品種の生態的特性を4群に分類することができた（Fig.7 ）。このグループは第1章の越冬型の分類に非常によく適合した。

8）*Typhula* spp.および *F. nivale* に抵抗性の「C.I.14106 」、「P.I.172582」および「P.I.173438」は、他の越冬型の品種より炭水化物や糖の蓄積がきわめて多く、逆に蛋白態窒素、リン酸、脂質が少なく、浸透価が著しく低かった。このような事実は、これら3品種が凍害に弱く *S. borealis* に罹病性であることと関係し、特異な遺伝的特性に基づくものと思われた。

4．耐冬性と春化要求度の関係

1）緑体春化法により春化所要日数を推定すると、北海道の品種系統は40日の「タクネコムギ」から70日の「北海48号」まで分布し、さらに90日あるいは 100日を要すると思われる外国品種が存在した。春化要求度に基づき、供試品種を4つのグル

ープに群別した。

2）第１グループの「タクネコムギ」は春化要求度Ⅵに相当するが、Ⅶに相当する品種群は広い変異を示したので、「ムカコムギ」、「ホクエイ」で代表される第２グループ（春化所要日数50～60日）と「赤銹不知１号」、「農林８号」（同65日）の第３グループに分け、「北海48号」もこれに含めた。第４グループは60日低温処理では完全に出穂しないもので、耐凍性のソビエト品種「Moscow 1」、「Valujevskaja」、「Lutescens0329」と、*Typhula* spp.抵抗性の「P.Ⅰ.172582」、「P.Ⅰ.173438」、「C.Ⅰ.14106」の６品種であった。

3）これら品種の長期間の春化処理には、８℃の緑体春化より晩秋戸外の低温短日処理が効果的であった。また第４グループ品種は、従来の播性Ⅶないし春化要求度Ⅶをはるかに越えるものであり、Ⅷ以上に相当するものと考えられた。

4）春化要求度と耐凍性との関係では、密接な品種群と、小数ながら無関係の品種群が存在した。*T. ishikariensis* および *S. borealis* 抵抗性とは有意な関係は認められなかった。

5）「P.Ⅰ.173438」および「Valujevskaja」と「チホクコムギ」との交雑後代F_4 系統では、出穂まで日数の分布幅が45日におよび、緑体春化区戸外区を用いて５つに群別が可能であった。このことから両親品種の春化要求度の差異には複数の遺伝子が関与することが暗示された。

6）「Valujevskaja」に近い耐凍性系統、あるいは「P.Ⅰ.173438」並の *T. ishikariensis* 抵抗性が第１、３、４の各グループから同程度の頻度で見いだされたこと、また春化要求度との間に有意な相関が認められなかったことから、春化要求度の高い段階ではこれらの特性はそれぞれ独立と考えられた。

5．耐冬性の選抜実験

1）*T. ishikariensis* Ｂ型のほ場での接種検定は、やや区間変動が大きく精度に難点があるが、同病による単一発生がえられ、選抜法として有効と考えられた。

2）「P.Ⅰ.173438」／「ホロシリコムギ」//「北見42号」のF_6 91群 364系統の接種検定の結果、「P.Ⅰ.173438」並の抵抗性を示すものが13系統群認められた。いずれも群間の変異係数も小さく、十分な *T. ishikariensis* 抵抗性を持つと判断された。これらのうち、稈長、強稈性が「チホクコムギ」に近く、千粒重が「チホクコムギ」より重く、収穫指数が「ホロシリコムギ」以上の系統「WH 7, 8, 9, 10」は農学的特性が優れ有望とみられた。

3）耐凍性と *T. ishikariensis* 抵抗性の同時選抜を実施した「ホロシリコムギ」／「P.Ⅰ.173438」//「Valujevskaja」／「ホロシリコムギ」のF_5 980系統からは「Valujevskaja」並の耐凍性を持つものが91系統えられ、「P.Ⅰ.173438」並の*T. ishikariensis* 抵抗性系統は76えられた。さらに両者に対して抵抗性の系統は６系統で全系統の 0.6%であった。農学的特性は「ホロシリコムギ」に比較すると劣るが、「P.Ⅰ.173438」と「Valujevskaja」の改良型として有望とみられた。

4）*S. borealis, Typhula* spp.抵抗性および耐凍性の３要因を同時に満足する系統は得られなかった。「Moscow 1」／「ホロシリ」のF_7で *S. borealis* に抵抗性の超越分離がみられ、そのうち「WH 11,12」の２系統は「Moscow 1」並の耐凍性を示した。ただし農学的特性はなお若干の改良を要する。

5）耐凍性と *Typhula* spp.抵抗性およびその両者については、以上の系統を用いた育種計画で実用品種の育成は可能と判断されたが、*S. borealis* 抵抗性育種については遺伝子源が乏しく、将来の課題として残された。

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Studies on Methods of Breeding Wheat for Winter Hardiness

by

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Summary

Wheat is the crop most widely grown in the world. Such a broad adaptability is thought to be due mainly to differentialtion of growth habits. Spring wheat can be grown not only in the tropics but also in the Arctic. However in mild climatic areas farmers generally grow winter wheat, wh ch is more productive than spring wheat.

Winter wheat sometimes suffers from serious damage when it is exposed to extremely low temperatures and/or drought conditions, or remains too long under heavy snow cover. So winter hardiness, the ability to survive severe winter climatic conditions, is a main concern in wheat cultivation in such regions.

The causes of winter injury are usually various and complicated. In a particular region any one factor, such as①freezing,②heaving,③smothering,④physiological drought,⑤snow mold may predominate, but in most cases those factors interact with each other. So in breeding for winter hardiness, many factors must be taken into account.

Though Hokkaido is located in the southern part of the subarctic zone, snow persists comparatively long, for 130~170 days. So winter wheat cultivation has long suffered from winter damage. Winter injury in Hokkaido is directly caused by several types of snow mold and in rare cases by freezing, but freezing injury certainly indirectly affects the incidence of snow molds. Tomiyama(1955) clarified that the cause of winter injury was snow molds and developed chemical controls for these diseases. After that, winter damage has decreased remarkably, but in most cases effects of fungicide on these pathogens are still not absolute even in recent cultivation. There are five snow molds, namely *Typhula incarnata, T. ishikariensis, Fusarium nivale, Sclerotinia borealis* and *Pythium* spp. in Hokkaido, and except for *Pythium* spp.,which is localized in badly drained fields, each pathogen occurs over a wide area.

Breeding programs for winter hardiness in Hokkaido have dealt mainly with snow molds and freezing resistance. We have tried to improve the winter hardiness of Hokkaido wheat varieties by introducing snow mold and freezing resistance. In this paper we investigate①development of testing method for winter hardiness and identification of resistant varieties,②genetics of winter hardiness,③characteristics of accumulated substances in resistant varieties,④relationship between growth habits and winter hardiness,⑤ efficiency of selection for winter hardiness. The results obtained are as follows.

1) Varietal differences of 25 winter wheats in winter hardiness

In this experiment several methods for testing *Sclerotinia borealis, Typhula ishikariensis, Typhula incarnata, Fusarium nivale* and freezing injury were devised and using those methods, 25 varieties originating from U.S.S.R., U.S.A., Holland and Hokkaido were tested.

For the method of testing resistance to *S. borealis,* wheat plants were grown on the high ridge

conditions in the fields and sprayed with ascospores suspension of this pathogen. This was more effective than when plants were grown on level ground and in furrow ridge in the fields.

Inoculation of wheat with *Typhula* spp. and *F. nivale* was done in a snow mold chamber using techniques developed by Bruehl et al. (1967). The difference between varieties in resistance to *T. ishikariensis* and *F. nivale*, this inoculation method was applied and for *T. incarnata* a field test was done at Iwamizawa.

Natural exposure(−25℃), artificial crown-freezing(−14℃), and Electric Conductivity(−15℃) methods were applied to test cold hardiness. They were very effective.

As the results of screening for winter hardiness, the following wheat varieties were identified as being useful materials for breeding resistance to the various types of disease and injury. How − ever they are inferior to comercial varieties in other agronomic characteristics.

Iohardi, Hokkai 48, : resistant to *S. borealis*

C. I. 14106, P. I. 172582, P. I. 173438, : resistant to *T. ishikariensis* and *F. nivale*

C. I. 14106, P. I. 173438, Norin 62, : resistant to *T. incarnata*

Lutescens 0329, Valujevskaja, : resistant to freezing injury

None of these materials was found to have *S. borealis* and *Typhula* spp. resistance simultaneously. Correlation of resistance to the above two pathogens in 25 varieties was −0.339 and was not significant. Resistance to *S. borealis* and cold hardiness were closely related. And degrees of resistance to *T. ishikariensis, T. incarnata* and *F. nivale* were also highly correlated with each other.

2) Genetics of winter hardiness

In this experiment genetic mechanisms for resistance to *S. borealis, T. ishikariensis, T. incarnata* and freezing injury were analyzed. Diallel crosses were carried out among 7 varieties which had typical levels of resistance to those factors, and parents and F_2 population were examined under each testing method respectively, as mentioned in the previoius chapter. A randomised block design with 2 to 10 replications was used and resistance was expressed by the degree of injury.

According to analysis of the variance of means and the variance, differences between parents and F_2 populations were significant in every factor. The correlations of mean and the variance between F_2 populations and midparents were also highly significant. So the resistance of progeny was very likely to be influenced by that of the parent.

Variance analyses of Wr-Vr among replications and tests of regression of Wr to Vr confirmed the validity of the assumption of independent action of non-allelic genes. The hypothesis of diallel analysis was satisfied, so that (Vr, Wr) graphical analysis was done and the genetic variance components and parameters for each factor were estimated according to the method of Hayman and Jinks.

In every factor the additive effects of genes were significantly large, but the dominance effects differed according to each. Resistance to *S. borealis* had partial dominance and resistance to *T. ishikariensis* and freezing injury showed overdominant. The position of array points along the line of regression showed that resistant parents of *S. borealis* and *T. ishikariensis* had more recessive alleles. On the other hand, a clear tendency of frequencies of effective alleles did not exist in cold hardiness. In the case of *T. ishikariensis,* approximately equal numbers of dominant and reccesive alleles were present, but dominant and reccesive alleles were not distributed equally in the cases of *S. borealis* and cold hardiness.

The heritabilities in a narrow sense of *S. borealis, T. ishikariensis* and freezing injury were generally high, namely 90, 79, and 82 %, respectively. The number of alleles concerned with each factor was estimated to be 2 to 3, based on the formula, (maximum parent value−minimum parent value)^2/4D.

Genetic correlation of the mean of F_2 populations between *S. borealis* and *T. ishikarienses* was highly negative. This suggested that breeding for resistansce to both *S. borealis* and *T. ishikariensis* would be laborious work. F_2 populations of the cross between varieties bred in Hokkaido contained more non–damaged plants than the other crosses, so it was surmized that Hokkaido varieties, Norin 8, Muka, Horoshiri and Kitakei 628 had the more stable and satisfactory genetic backgrounds for winter hardiness. Resistant genes are also available in other varieties, such as P. I. 173438 and Moscow 1, so it seems possible to be able to improve the genetic background of winter hardiness in Hokkaido varieties by introducing specific resistant genes for other factors.

3) Relationship between accumulated substances and winter hardiness

In this experiment we dealt with regional and varietal differences of growth rates and accumulations or depletions of substances during winter, and relationships between reserve substances and resistances to freezing, *S. borealis, Typhula* spp., and *F. nivale.* The 25 varieties mentioned in chapter I were examined at Kunneppu and Iwamizawa in 1978–'79 and 1979–'80 seasons. Twenty characteristics measured four times before and after winter were used for analysis. The degree of resistance to freezing and snow molds obtained in previous experiments were taken into account.

Dry weight, percentage of dry matter, total carbohydrate, sugar, starch, and proteinous nitrogen in the shoot of the plant increased rapidly from autumn to early winter, and reached the maximum amount immediately after the beginning of permanent snow. Soluble nitrogen, phosphoric acid and silic acid, decreased with the decrease of temperature. Differences between locations, seasons, varieties, and wintering types shown in chapter I were significant in 16 characteristics measured before winter. Wheat plants in Kunneppu showed small growth rate, high accumulations of carbohydrate and sugar in the fall, and small depletions of them during winter than wheat plants in Iwamizawa. Varieties resistant to *Typhula* spp. and *F. nivale* entered winter with greater carbohydrate reserves and possessed much more of them after snow melts than susceptible varieties.

Correlations of reserve substances levels before and after snow cover were highly significant except for reducing sugar and starch. Correlation coefficients of total carbohydrate between years was 0.751***(before winter) and 0,767***(after snow melt) at Kunneppu. Highly significant correlations were also found between following resistances and characters. Freezing and osmotic value; *S. borealis* and phosphoric acid, lipid; *Typhula* spp., *F. nivale* and proteinous nitrogen, total carbohydrate.

Varieties were classified into four groups based on the principal component analysis using 22 characteristics of plant size and reserve substances. These groups coincided very well with the above mentioned wintering groups, namely, A(less hardy), B(cold resistant), C(intermediate), D(snow endurable). Resistant varieties to *Typhula* spp. and *F. nivale*,「C. I. 14106」,「P. I. 173438」 selected by Bruehl et al. accumulated more carbohydrate more rapidly in the fall than other varieties did. Nevertheless, their content of proteinous nitrogen, phosphoric acid, lipid, and their osmotic value were very low. These facts may be a reason why the above three varieties show susceptibility to freezing and *S. borealis*. These characteristics might be ascribed to genetic specificity.

4) Growth habits and winter hardiness

The 26 winter wheat varieties mentioned in chapter I and 「Chihoku」 were divided into four groups according to the degree of vernalization requirement(DVR). Among them a new group was recognized, which requires longer periods of vernalization compared to the Ⅶ group designated as an extreme winter habit growth type and/or DVR. In this group cold hardy varieties (Moscow 1, Valujevskaja, and Lutescens 0329) and snow mold resistant varieties (C. I. 14106, P. I. 172582. and P. I. 173438) were included. In order to identify DVR of a high level as with these varieties, treatment with short-day photoperiods and low temperatures(0～2℃) were more effective than that of continuous illumination under comparatively high temperatures(8℃) for green plants.

Wheat lines with various high groups of DVR were developed from two crosses of very high DVR varieties (P. I. 173438 and Valujevskaja) with a variety of DVRⅦ(Chihoku). In each level of DVR, wheat lines having resistance to cold injury or *Typhula ishikariensis* were found. It was suggested that high DVR traits are under the control of several genes and their actions are independent of cold hardiness and snow mold resistance, because there are not any correlations between DVR and cold hardiness or resistance to *S. borealis* and *Typhula* spp. in the 26 varieties nor in the many lines obtained from the crosses mentioned above.

5) Efficiency of selection for winter hardiness

To improve the winter hardiness of Hokkaido wheat, we intended to introduce resistant genes for two traits. One is resistance to *Typhula* spp, and *F. nivale* represented by 「C. I. 14106」, 「P. I. 173438」, and the other is freezing resistance represented by 「Valujevskaja」, 「Moscow 1」. For that object we operated series of selection experiments.

(1) Series 1 : (Cross 1051 : P. I. 173438/Horoshiri//Kitami 42)

We performed a selection in this cross using pedigree method from F_2 to F_4 at Kitami where *S. borealis* usually occur. We also referred to the results of snow mold tests conducted at Shibetsu, where incidence of snow molds, especially *Typhula* spp. is high. In F_5, progeny lines were exposed to natural selection at Sapporo where *Typhula* spp. usully occurs. In F_6, we retreatd 91 selected lines with *T. ishikariensis* inoculation in the field at Kitami. The inoculation of sclerotia of *T. ishikariensis* was effective in the field at Kitami. Finally 4 prospective lines which are resistant to *Typhula* spp. and have fairly good agronomic characteristics were identified.

(2) Series 2 : (Cross 1050 : Horoshiri/P. I. 173438//Valujevskaja/Horoshiri)

Hybrid populations were grown as a bulk during F_2 and F_3 generation at Shibetsu for natural selection to winter hardiness. 20 and 15 percent of plants were killed by *Typhula* spp. in each generation. In F_4, 3,000 plants were planted at Kitami, but there was no winter kill. So 980 plants were sampled randomly. In F_5, 980 lines were treated with *T. ishikariensis* inoculation and freezing tests, respectively. 76 lines (7.8%) out of 980 were recognized as lines resistant to *T. ishikariensis* and 91 lines (9.3%) were as hardy as 「Valujevskaja」 in freezing resistance. Six lines (0.6%) were identfied as the materials resistant to both traits, but these selected linese were inferior to 「Horoshirikomugi」 in other agronomic traits.

(3) Series 3 : (Cross 1 : Moscow 1/Horoshiri, Cross 2 : Muka/Horoshiri, Cross 3 : C. I. 14106/Horoshiri)

Hybrid populations were grown as a bulk in F_2, F_3 and F_4 generation at Kitami. During these generations winter kill was very rare and in F_4, 184(Cross 1), 161(2) and 177(3) plants were sampled randomly in each cross. From F_5 to F_7 generations those lines were treated with freezing, *Typhula* spp. and *S. borealis* tests. In every trait differences in resistance among crosses were significant and the average degrees of damage in each trait were as follows,

Freezing(E. C. value) : Cross 3(497)>Cross 2(438)>Cross 1(393)

S. borealis(%) : Cross 3(62)>Cross 2(48)>Cross 1(43)

Typhula spp.(%) : Cross 1(68)>Cross 2(57)>Cross 3(31)

Five prospective lines, three being resistant to *S. borealis* from cross 1 and 2, and two being resistant to *Typhula* spp. from cross 3, were identified. These selected lines were inferior to 「Horoshirikomugi」 in other agronomic charactereistics.

From the materials of these three series, following 12 lines were identified as genetic resources for winter hardiness.

Resistant to *T. ishikariensis* : WH 3, 5, 6, 7, 8, 9, 10.

Hardy to freezing : WH 1, 2, 3, 4, 6, 11, 12.

Resistant to *S. borealis* : WH 11, 12.

The degree of resistance to *S. borealis* of above mentioned two lines are not seemed to be satisfactory under actual practices, so further investigations are necessary for getting good genetic resources for that trait.