Genetic resources for maize breeding programmes to improve ear rot resistance in Poland

Seweryn Frasinski[a], Elzbieta Czembor[a], Krzysztof Wojcik[b] and Jozef Adamczyk[c]

[a]Plant Breeding and Acclimatization Institute – NRI, Radzikow, 05-870 Blonie, Poland;
[b] Plant Breeding Smolice Ltd, Poland.
[c] Malopolska Plant Breeding Raising HBP Ltd, Poland

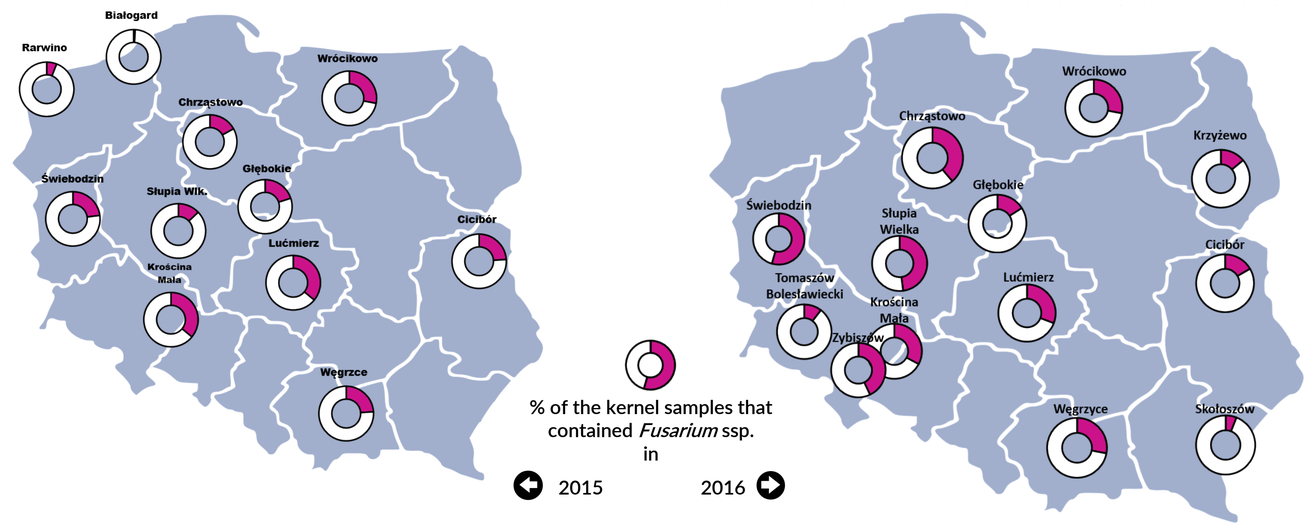
- In Poland, during the last years the maize growing area has significantly increased because of the high demand from fodder industry - total area is about 1200K ha.
- Red and pink ear rots caused by Fusarium spp. are important factors affecting the yield and it's quality, mainly because of it's contamination with mycotoxins produced by fungi. It was observed, that during the last years contamination of these toxins increase also in Poland

STUDY OBJECTIVE

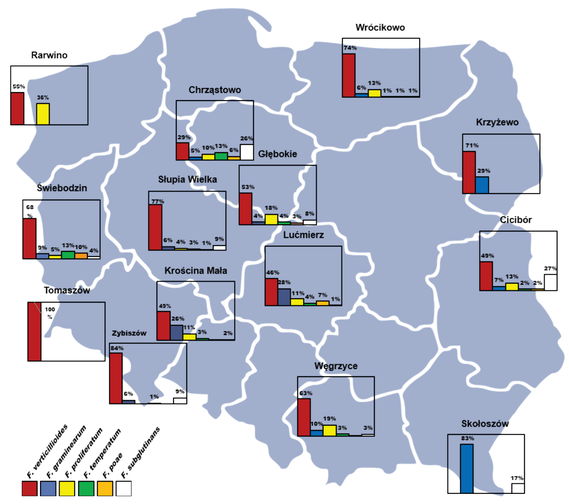
This research was coducted to determine effectiveness of the recurrent selection to develop maize flint and dent genotypes resistant to the ear rot based on genetic resources used in Polish breeding programmes.

MATERIALS AND METHODS

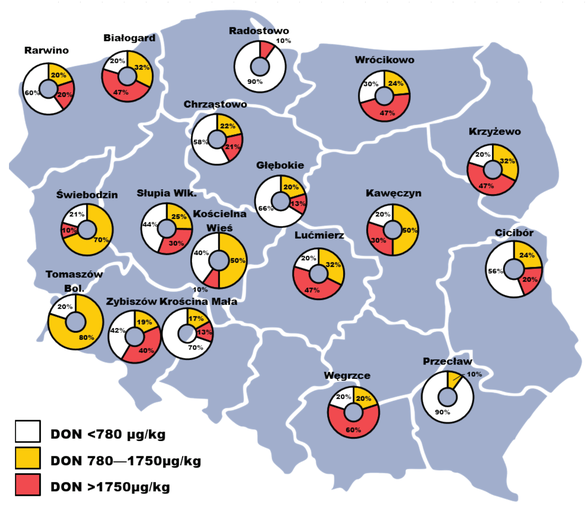
- Plant material
  - 2 separated gene pools KOB and SH
- Field experiments were conducted in Central Poland (Radzikow)
- Fusarium graminearum (GER) ear rot severity tests
  - Because of different ears morphology - kernel inoculation method was used (11 days after silking). Disease development was visually assessed during harvesting time using 1 - 7 scale.
- Inbreed selection from $S_{0:1}$ through $S_{1:2}$, $S_{2:3}$, $S_{3:4}$ using GER kernel inoculation (due to different ears morphology) and deasease development visal assesion.
  - All genotypes scored within the range 2-3 were selected to continue the selfing procedure
  - Evaluation of selection efectivness among gene pools
- Ear rot resistance of S_4 lines. For each genotype eight plants were inoculated with GER and 8 plants were used as a control in each replication.
- Mycotoxin content
  - DON content was evaluated in grain samples with RIDA®QUICK SCAN using immunochromatographic tests.
  - Selected S_4 SH – 9 populations and S_4 KOB – 15 populations was tested
- Ears morphology
  - anthocyanin content in corncobs and silks was described
- Relationships between disease severity, DON contamination and anthocyanin content were calculated using Pearson correlations.



- Based on our study conducted in 2015 and 2016, when 102 samples of commercially grown maize cultivars were collected in 14 localities throughout Poland, it was possible to determine that *F. verticillioides* was the most abundant species, followed by *F. proliferatum* and *F. graminearum* (60%, 11% and 12% of all *Fusarium* isolates, respectively). A number of minor species were also present: *F. temperatum* (5,0%), *F. poae* (2%), *F. subglutinans* (8%), *F. sporotrichioides* (1,0%). DON contamination in 22% of evaluated grain samples exceeds 1750 µg/kg, FUM in 5% of evaluated grain samples exceeds 1000 µg/kg and ZEA contamination in 7% samples was higher than 350 µg/kg. Differences between localities and varieties were significant.



Fusarium species occurrence in Poland 2015-2016

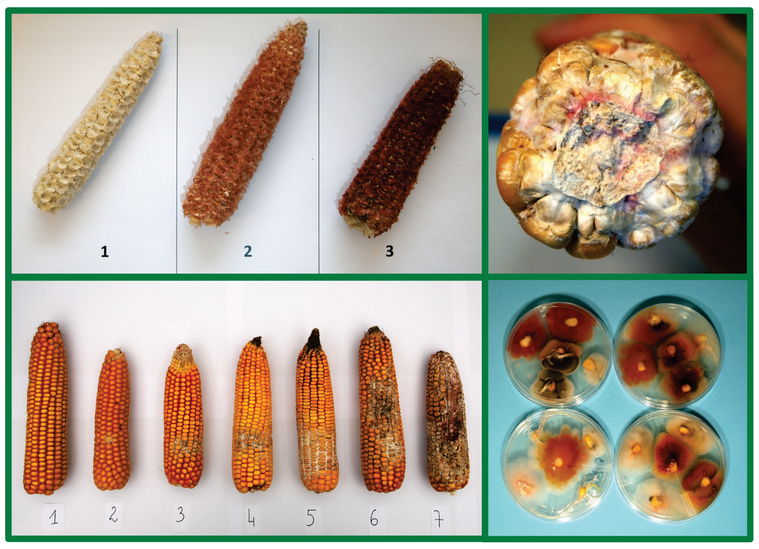


DON contamination in Poland 2013-2016

Tab. 1. Responses of pedigree selection for ear rot resistance carried out in 2015–2017 for several maize populations based on GER visible symptoms on the ears of self-pollinated plants.

kernel type	variable	$S_{0:1}$			$S_{1:2}$		$S_{2:3}$				Total genetic gain [%]**
		earliness	anthocyanin content	sources of resistance for GER* [%]	anthocyanin content	sources of resistance for GER* [%]	earliness	anthocyanin content		sources of resistance for GER* [%]	
			cobs		cobs			silks	cobs		
flint	mean	81	1,0	65,3	1,0	76,1	74	1,5	1,0	76,5	11,2
	min	75	1	47,8	1	66,7	66	1	1	50,0	-
	max	87	1	81,0	1	90,0	80	3	2	92,3	34,4
dent	mean	87	1,9	77,2	2,2	59,1	81	1,0	1,9	85,0	7,8
	min	80	1	68,4	2	28,6	66	1	1	75,0	3,5
	max	94	3	86,7	3	92,3	87	1	3	100,0	13,3

∗ plants scored as a moderate and highly resistant (in a range 1 – 4, using 1 – 7 scale) ∗∗ (mean sources of resistance for GER $S_{2:3}$) - (mean sources of resistance for GER $S_{0:1}$)



Tab. 2. DON contamination for cobs samples collected from $S_{4:5}$ generation selected in 2013–2016 based on GER visible symptoms on the ears of self-pollinated plants that belong to $S_{0:1}$, $S_{1:2}$, $S_{2:3}$ and $S_{3:4}$ generation after inoculation with *F. graminearum*

gene pool	infection type	number of evaluated lines	GER*/**	% of lines with DON content (mg x kg^{-1})		
				<10	10,1-40,0	>40
SH	inoculated	34	highly resistant	29,4	20,6	-
			moderate resistant	29,4	20,6	-
	natural infection	34	highly resistant	76,5	14,7	5,9
			moderate resistant	-	2,9	-
KOB	inoculated	41	highly resistant	63,4	-	-
			moderate resistant	36,6	-	-
	natural infection	41	highly resistant	51,2	29,3	19,5
			moderate resistant	-	-	-
AVERAGE	inoculated	75	highly resistant	48,0	9,3	-
			moderate resistant	33,3	9,3	-
	natural infection	75	highly resistant	62,7	22,7	13,3
			moderate resistant	-	-	-

∗ highly resistant - level of GER resistance scored in the range of 1 – 3 (using scale 1-7; 1: no symptoms of the disease)
∗∗ modearte resistant – level of GER resistance scored for 4 (using scale 1-7; 1: no symptoms of the disease)

CONCLUSIONS

- The best method to improve GER resistance in hybrids is using evaluated and selected highly resistant inbreed. Pedigree selection for reduction fusarium toxin contamination in maize conducted under field condition take a long time.
- Responses of pedigree selection for ear rot resistance carried out in 2015–2017 for several maize populations based on GER visible symptoms on the ears of self-pollinated plants was higher in the flint group than in the dent forms (tab. 1). On average, for flint forms frequency of genotypes which belong to the $S_{2:3}$ generation and scored as a highly or moderate resistant was about 11,2% higher than within $S_{0:1}$ generation and about 7,8% among dent forms.
- On average, materials of the $S_{2:3}$ generations were more than 6 days earlier than the $S_{0:1}$ generation (tab. 1).
- Pedigree selection for ear rot resistance is effective, but should be supported by toxin content evaluation (tab. 2).
- Disease severity and DON contamination in cob samples collected from $S_{4:5}$, negatively correlated with anthocyanin content (r=-0,47**, P=0,05) and positively correlated with earliness.
- Recently, NGS technologies, SNP markers have shown their full potential with novel approaches combing SNP discovery and genotyping and they should be used as indirect method of selection. P=0,05

Acknowledgements
This work was funded by Polish Ministry of Agriculture and Rural Development Proj. No. 4-1-06-3-01 (33)