Influence of Some Abiotic Risk Factors on Parental Forms in Some Registered Corn Hybrids (*Zea mays*, L)

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ABSTRACT

Corn is one of the most important crops, and yield may be affected by risks that manifest more strongly in recent years. In hybrid seed production activity, these risks are even greater importance for breeder and for hybrid seed multiplier. Considering the risks mentioned, the objectives are to test the reaction of certain genotypes in different phenophases with manifestation of abiotic factors (low temperatures and hail). Genotypes analyzed were parental forms of hybrids homologated by ARDS Turda, and inbred lines used in the creation of hybrids. The analyzed risk factors were frost in phenophases of 5-6 leaves and 7-8 leaves, and we simulated a soft hail in 8-10 leaves and after pollination, an average hail, a "defoliation" of 50% of the leaves and "defoliation" of 80-90% of the leaves. The effect of frost was almost insignificant in first phenophase, yield losses to 8% in hybrids, and 12% in inbred lines. In the second phenological phase, low temperatures losses of 51% in hybrids, and 70% in inbred lines. Hail causes insignificant losses before pollination of 1% in hybrids and 0.5% in inbred lines. Instead total defoliation of hail, produce 71% losses in hybrids, and 70% in inbred lines. If the phenomena occurring in the later phenophases, both hybrids and inbred lines respond negatively in terms of yield, thousand grain weight, and corn cob yield. For inbred lines, negative temperatures have a stronger effect compared to hail. For both hybrids and inbred lines, hail caused a greater damage compared with frost.

Keywords: *frost, hail, hybrids, inbred lines, Zea mays.*

INTRODUCTION

Corn is one of the most important crops worldwide and like other crops, the yield can be affected by risks which have been more and more severe in the recent years. In the activity of production of hybrid seed, either research stations, trading companies or other multipliers, these risks are of greater importance. On one side, there is the possibility of decreasing the yields obtained on the surface units due to the occurrence of risk factors, and on the other hand, there is the danger to lose valuable genotypes by the apparition of destructive phenomena.

Research on risk factors were made by Coulter *et al.*, (2011), Cristea *et al.*, (2004, 2013), Dwyer *et al.*, (1994), Egharevba *et al.*, (1976), Klein *et*

al., (2011), Petcu *et al.*, (2007), Robertson *et al.*, (2011).

Of tropical origin, corn is included in the group of thermophilic plants, sensitive to low temperatures. Spring temperatures are the most dangerous for corn. Adaptation to these conditions is explained by the temporization of the use of the reserve substances from the seed, moderate raising of the aerial part, the accumulation of the reserve substances in the young leaves as shown by Cristea *et al.*, (2004).

Under the influence of low temperatures, the concentration of cell sap decreases, as this is a feature of the corn forms which are not cold resistant, in the strong parental forms, this decrease is lower. Knowing the capacity of chill resistance,

it presents a particular importance both from the point of view of the stability of the optimal time for sowing, and of the microzoning works.

A severe loss of 50% has decreased the yield, due to a small number of grains on the cob. The decrease of the yield decreases with the minor loss of the leaves, according to Egharevba *et al.*, (1976).

The decrease in dry substance and grains yield due to hail is correlated with the temperature indexes needed for each genotype to reach maturity. For the situations when the hail occurs in the stage of wax-milk, the hybrids with delayed maturity are the most affected by hail, as shown by Dwyer *et al.*, (1994).

Corn retains the ability to compensate for lost plants through the late vegetative stages, indicating that current standards for assessing the effect of stand loss in corn should be re-evaluated according to Coulter *et al.*, (2011).

In Romania, in recent years, the frequency of the damage caused by hail, storm, torrential rain or even the apparition of tornadoes, especially after 2000 according to Groupama Asigurări (2012). The affected corn surface and the number of events with losses in 2012 for Groupama Asigurări, is the following:

- corn for consumption 10.845,23 ha; number of events 12;
- hybrid lots 2.548,50 ha; number of events 39.

In 2013 and 2014 however, there was a smaller number of losses for the corn crop. Therefore, most events occurred in June 2013, and July 2014, and the event which caused the most damages was hail, as reported by Groupama Asigurări, (2012, 2013, 2014); (Tab.1).

From the research done, very few authors studied this field, most of them abroad. There were no studies regarding the hail effect in Romania,

however studies were identified regarding the effect of negative temperatures on corn.

The goals of the study were:

- Knowing the resistance to low temperatures, the different simple hybrids, maternal and paternal parental forms of registered hybrids (Turda 201, Turda Star, Turda 200);
- Establishing the effect of low temperatures on seedlings with certain inbred lines of corn, parental forms of certain three-line registered hybrids (Turda 201, Turda 165);
- Determining the reaction of certain genotypes (simple hybrids and inbred lines) regarding the effect of the hail simulation in different vegetation stages.

MATERIAL AND METHOD

The biological material used in the researches was represented by:

- simple hybrids (2) parental maternal androsterile forms of the three-line hybrids Turda 201 and Turda Star;
- simple hybrid (1) maternal form of the double hybrid Turda 200;
- simple hybrid (1) paternal form of the double hybrid Turda 200;
- inbred lines (5) parental maternal and paternal forms of the hybrids Turda 248, Turda 332, Turda 201 and Turda Star.

Primary data come from 4 experiences, disposed in randomized blocks, 3 repeated, sowing density 70 000 plants/ha.

The effect of low temperatures was studied in 2 experiences, with two graduations:

- Factor A – simple hybrids and inbred lines (6)
- Factor B – natural phenomena (3) by simulating a frost in the stage of 5-6 leaves and 7-8 leaves

Tab. 1 Frequency of losses per calendar months and risks in 2013 and 2014

Year	Risk occurred	May	June	July	August	September	October	Total
2013	Hail	1	35	15	8	3	1	63
	Storm	3	18	7	3	2	4	37
	Torrential rain	1	4	5	2	3	1	16
	Total	5	57	27	13	8	6	116
2014	Hail	9	14	57	3			83
	Storm		9	3			1	13
	Torrential rain	5	9	5	1	1		21
	Total	14	32	65	4	1	1	117

(cutting the plants at the soil level) in relation with the Control sample (1)

The effect of hail was studied in two experiences, with 5 graduations:

Factor A – simple hybrids and inbred lines (6)

Factor B – natural phenomena (5) 1 Control; 2 soft hail in the stage of 8-10 leaves; 3 hail of average intensity, after the pollination; 4 exfoliation of a percent of 50% from the leaves after the pollination; 5 exfoliation of a percent of 80-90% from the leaves after the pollination.

For each of the studied genotypes there were observations regarding the date of the stigmata with the maternal forms and blooming with the paternal forms.

The observations and determinations in the case of the experimental system was done with plants and cobs, determining the production of

grains (kg/ha), humidity and dry matter of the grains at the harvesting time, the erect plants at the harvesting time (%).

RESULTS AND DISCUSSIONS

In terms of the simulation of low temperatures and hail in general, but also in terms of differentiating of the studied genotypes, the data obtained after the first year of experimenting were conclusive.

The genotypes reacted differently from the point of view of the yield, humidity and breaking resistance (Tab. 2, and Tab. 3).

For hybrids, the hybrid HS "M" cms Turda 201 recorded a yield of 12903 kg. In the case of simulation of the first frost, the yield increased to 13518 kilograms, and for the second frost, the yield decreased to 8511 kilograms, representing 66%

Tab. 2. Reaction of hybrids in case of low temperatures

Hybrid	Graduation	Grains yield		Dry matter (%)	Plant not broken (%)
		(kg/ha)	(%)		
HS „M“ cms Turda 201	Control	12903	100.0	80.6	82.7
HS „M“ cms Turda 201	simulation low temperatures (5-6 leaves)	13518	104.8	80.6	90.2
HS „M“ cms Turda 201	simulation low temperatures (7-8 leaves)	8511	66.0	78.5	95.8
HS „M“ cms Turda Star	Control	13823	100.0	78.9	95.5
HS „M“ cms Turda Star	simulation low temperatures (5-6 leaves)	12979	93.9	78.4	89.8
HS „M“ cms Turda Star	simulation low temperatures (7-8 leaves)	8028	58.1	76.2	89.4
HS „T“ Turda 200	Control	13456	100.0	81.4	52.6
HS „T“ Turda 200	simulation low temperatures (5-6 leaves)	10490	78.0	81.7	46.3
HS „T“ Turda 200	simulation low temperatures (7-8 leaves)	3375	25.1	80.7	71.0

Tab. 3. Reaction of inbred lines in case of low temperatures

Inbred line	Graduation	The yield of grains		Dry matter (%)	Plants not broken (%)
		(kg/ha)	(%)		
LC 660	Control	6861	100.0	78.6	78.1
LC 660	simulation low temperatures (5-6 leaves)	5080	74.0	79.9	84.6
LC 660	simulation low temperatures (7-8 leaves)	857	12.5	79.5	78.5
LC 733	Control	5095	100.0	83.3	79.3
LC 733	simulation low temperatures (5-6 leaves)	4733	92.9	83.8	84.8
LC 733	simulation low temperatures (7-8 leaves)	1645	32.3	82.9	84.7
LC 761 cms „C“	Control	7455	100.0	80.7	97.3
LC 761 cms „C“	simulation low temperatures (5-6 leaves)	7332	98.4	80.4	99.3
LC 761 cms „C“	simulation low temperatures (7-8 leaves)	3258	43.7	80.1	95.9

compared to the Control. The hybrid HS“M”cms Turda Star reacted better, as a Control with a yield of 13823 kg, in the case of the first frost the yield decreased to 12979 kg, and for the second frost, the yield decreased to 8028 kg, representing 58% din the yield recorded by the Control. The simple hybrid “T”Turda 200 was the most affected, compared to the Control where a yield of 13456 kg was recorded, the first frost produced a decrease of the yield to 10490 kg, that is 77% of the potential, and the second frost produced a decrease of the yield to 3375 kg, representing 25% from the potential. The hybrid HS“M” cms Turda 201 proved the best resistance to negative temperatures.

Inbred lines reacted to negative temperatures differently. The line 660 recorded a yield of 6861 kilograms in the case of the Control, of 5080 kg in the case of the first frost, and 857 kg in the case of the second frost, that is 12% from the potential.

The line LC 733 recorded a yield of 5095 in the case of the Control, a yield of 4733 kg in the case of the first frost, and 1645 kg in the case of the second frost, that is 32% from the potential. The line LC 761 cms C recorded a yield of 7455 kg in the case of the Control, a yield of 7332 kg for the first frost, and 3258 kilograms for the second frost, that is 44% from the potential. From the

inbred lines, the line LC 761 cms C was the most resistant to this phenomenon.

For the hail risk, the results obtained for the simple hybrids and inbred lines are described in Tab 4 and Tab 5.

The hybrid HS “M” cms C Turda 201 recorded a yield of 12791 kg, and the first phenomenon of hail simulation has lead to a decrease of the yield by 786 kilograms. The second factor has determined a decrease of the yield up to 11347 kilograms. The third factor has decreased the yield to 9098 kilograms, and the fourth phenomenon has decreased the yield to 3760 kilograms, representing 29% from the production potential.

The hybrid HS “M” cms Turda Star recorded a yield of 13956 kg ca Control, and the first phenomenon of hail simulation of hail has lead to a decrease of the yield cu 671 kilograms. The second factor has caused a new decrease of the yield up to 13183 kilograms.

The third factor has decreased the yield to 9764 kilograms, and the fourth phenomenon has decreased the yield to 3375 kilograms, representing 24% from the potential. The hybrid HS “T” Turda 200 has recorded a yield of 11549 kg to the Control, and the first phenomenon of hail simulation has lead to a increase of the hail has lead to an increase of the yield to 12186

Tab. 4. Reaction of hybrids in case of simulated hail

The hybrid	Graduation	The yield of grains (kg/ha)	(%)	Dry matter (%)	Plants not broken (%)
HS „M“ cms Turda 201	Control	12791	100.0	80.3	78.6
HS „M“ cms Turda 201	soft hail in the stage of (7-8 leaves)	12005	93.9	80.3	87.1
HS „M“ cms Turda 201	average hail after pollination	11347	88.7	80.6	78.6
HS „M“ cms Turda 201	exfoliation 50% after pollination	9098	71.1	80.2	85.1
HS „M“ cms Turda 201	exfoliation 80-90% after pollination	3760	29.4	81.3	15.8
HS „M“ cms Turda Star	Control	13956	100.0	78.3	83.3
HS „M“ cms Turda Star	soft hail in the stage of (7-8 leaves)	13854	99.3	78.2	85.1
HS „M“ cms Turda Star	average hail after pollination	13183	94.5	79.1	79.5
HS „M“ cms Turda Star	exfoliation 50% after pollination	9764	70.0	78.3	58.7
HS „M“ cms Turda Star	exfoliation 80-90% after pollination	3375	24.2	81.6	7.1
HS “T” Turda 200	Control	11549	100.0	80.4	73.1
HS “T” Turda 200	soft hail in the stage of (7-8 leaves)	12186	105.5	80.3	78.1
HS “T” Turda 200	average hail after pollination	10175	88.1	80.8	72.7
HS “T” Turda 200	exfoliation 50% after pollination	9040	78.3	80.3	62.9
HS “T” Turda 200	exfoliation 80-90% after pollination	3582	31.0	79.1	29.8

kilograms. The second phenomenon has caused a decrease of the yield up to 10175 kilograms. The third phenomenon has decreased the yield to 9040 kilograms, and the fourth phenomenon has decreased the yield to 3582 kilograms, representing 31% from the potential.

In the case of the inbred lines, the line LC A Turda 248 has recorded a yield of 5794 kilograms. The first phenomenon has decreased the yield to 5886 kilograms, the second phenomenon to 5623 kilograms, the third phenomenon to 4695 kilograms, and the fourth phenomenon to the yield of 2619 kilograms representing 45% compared to the Control. The line LC „A“ Turda 332 has recorded a yield of 9672 kilograms in the case of the Control. The first phenomenon has decreased the yield to 9425 kilograms, the second to 8341 kg, the third to 8219 kg, and the fourth to 1788 kilograms, representing 18% as compared to the potential. The line LC 761 cms C recorded a yield of 7080 kilograms as a Control. The first phenomenon did not affect the product capacity of 7151 kg, the second of 7044 kg, the third of 5796 kg, and the fourth of 2054 kilograms, representing 29% compared to the Control.

The breaking resistance. The poorest resistance to breaking has been recorded for the hybrids HS „M“ cms Turda Star and HS „M“

cms Turda 201 in the simulation of hail with exfoliation of 80-90% after pollination. Inbred lines have proved a better resistance to breaking, the poorest resistance being recorded by the corn inbred lines LC 761 cms „C“ and LC „A“ Turda 332 in simulating the hail with exfoliation of 80-90% after pollination. From the point of view of the dry matter accumulation, the analyzed genotypes have not presented important decreases in accumulating dry matter.

Physiological maturity. In the case of simulation of low temperatures, the hybrid HS „M“ cms Turda 201 has recorded a longer number of days for maturity, both for the first and for the second phenomenon of frost simulation.

The hybrid HS „M“ cms Turda Star has recorded, compared to the Control a number of 6 days more for the first simulation, respectively 3 days for the second simulation of the frost (7-8 leaves).

The hybrid HS „T“ Turda 200 has recorded up to maturity the same number of days as the Control, and for the second simulation it has recorded a maturity delay of 11 days.

For the inbred lines, the line LC 660, in simulating the second phenomenon, was more affected, the plants being abnormally developed, as they have not reached maturity.

Tab 5 Reaction of hybrids in case of simulated hail

The inbred line	Graduation	The yield of grains	(%)	Dry matter (%)	Plants not broken (%)
LC „A“ Turda 248	Control	5794	100	79.0	97.9
LC „A“ Turda 248	soft hail in the stage of (7-8 leaves)	5886	101.6	79.4	92.7
LC „A“ Turda 248	average hail after pollination	5623	97.0	79.7	94.8
LC „A“ Turda 248	exfoliation 50% after pollination	4695	81.0	81.6	79.0
LC „A“ Turda 248	exfoliation 80-90% after pollination	2619	45.2	82.3	61.6
LC „A“ Turda 332	Control	9672	100	77.7	98.1
LC „A“ Turda 332	soft hail in the stage of (7-8 leaves)	9425	97.4	78.6	97.4
LC „A“ Turda 332	average hail after pollination	8341	86.2	78.9	96.7
LC „A“ Turda 332	exfoliation 50% after pollination	8219	85.0	79.3	98.7
LC „A“ Turda 332	exfoliation 80-90% after pollination	1788	18.5	82.1	57.2
LC 761 cms „C“	Control	7080	100	80.8	97.4
LC 761 cms „C“	Soft hail in the stage (de 7-8 leaves)	7151	101.0	80.6	96.6
LC 761 cms „C“	average hail after pollination	7044	99.5	81.2	89.6
LC 761 cms „C“	exfoliation 50% after pollination	5796	81.9	82.8	87.1
LC 761 cms „C“	exfoliation 80-90% after pollination	2054	29.0	82.0	22.9

For the lines LC 733 si LC 761 cms "C", in simulating the low temperatures in the stage of 7-8 leaves a delay of the physiological maturity was recorded by 6 respectively 8 days as compared to the Control. In simulating the hail, for the hybrid HS "M" Turda 201, the simulation of the hail after pollination determined a maturity by 7 days earlier as compared to the Control.

The hybrid HS "M" cms Turda Star the physiological maturity for the hail simulation after pollination has determined a forced maturity by 12 days earlier as compared to the Control, and the hybrid HS "T" Turda 200, the physiological maturity was recorded 9 days earlier as compared to the Control.

In the case of inbred lines, in simulating the hail after pollination, a forced maturity was achieved, by 9 respectively 13 days as compared to the Control, for the lines LC 761 cms C, and LCA Turda 248, only the line LC A Turda 332 was more stable from the point of view of the number of days needed to reach physiological maturity.

CONCLUSIONS

From the point of view of the simulation of the resistance to low temperatures, hybrids proved a better resistance and a better capacity of yield as compared to inbred lines.

Among the hybrids, the best yields have been recorded by the hybrid HS "M" cms Turda Star, but from the point of view of the hail resistance, the most resistant was the hybrid HS "T" Turda 200, which was positively influenced by the hail simulation in the phase of 8-10 leaves.

Among the analyzed inbred lines, the line LC "A" Turda 332 was the most productive, but the most resistant to this phenomenon proved to be the line LCA Turda 248.

Comparing the reaction of the hybrids with the inbred lines, hybrids prove a better resistance to the hail risk as compared to the inbred lines.

The effect of the frost was insignificant in the case of the first stage (5-6 leaves), the yield losses being 8% in the case of hybrids, and 12% in the case of inbred lines.

In the stage of 7-8 leaves, the simulation of low temperatures has determined losses of 51% in the case of hybrids and 70% in the case of inbred lines.

Hail causes insignificant loses before pollination, 1% in the case of hybrids and 0.5% in the case of inbred lines.

Hail with exfoliation of 80-90% causes losses of 71% in the case of hybrids and 70% in the case of inbred lines. Corn succeeds to obtain yields even under maximum stress conditions, and in the case of apparition of negative temperatures or hail phenomena during the early stages.

Testing the resistance to falling proved that the plants where exfoliation is total after hail phenomena, have a very low resistance to breaking, as the plants fail to support by themselves when facing stronger winds.

RECOMMENDATION

Avoiding or preventing the risk consists in taking measures in order to decrease them to minimum, such as:

Surveying the areas where the risk factors and microzoning or placing the strategic crops on different parcels, at a distance from each others, especially for the parental forms which will be the basis to create hybrids;

Abandoning the cropping in certain areas of those genotypes which are particularly sensitive to hail or low temperatures, corroborated with the selection of a variety of stronger plants;

Creating hybrids resistant to abiotic limitative environment factors.

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