# THE BEHAVIOUR OF A MONSANTO MAIZE HYBRID - DEKALB 512 Bt TO THE ATTACK BY THE EUROPEAN CORN BORER *(Ostrinia nubilalis)* IN ROMANIA

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## ABSTRACT

**The European Corn Borer is a major pest in many areas of Romania, and by its attack during the late verticil phase and especially in the panicle, stem and peduncle of the cob, causes significant grain production losses. The basic method to prevent its attack is growing resistant hybrids, and several such hybrids were promoted, especially in the U.S.A.; lately there is a tolerant experimental hybrid in Romania, too. To promote genetically modified hybrids in Romania, Monsanto made available for testing the hybrid Dekalb 512 Bt. This paper presents the results. The experiment was performed under artificial infestation of plants, using 20 egg-masses per plant for at least 10 plants for each variant. For the infestation to take place under different vegetation phases and weather conditions, including the usual egg-laying period for moths under natural conditions, sowing and infestation were performed at several times. Together with the hybrid Dekalb 512 Bt, two widely-grown indigenous hybrids were used, caracterized by a lower attack of the borer, namely Fundulea 376 and Olt. Separately, the hybrid Dekalb 512 Bt was compared to a tolerant indigenous hybrid, HSF 1071-96 and a pest-susceptible indigenous hybrid, HSF 1147-96. The attack was assessed using a longitudinal cross-section of the plants during maize harvesting period and recording the attack cavity lengths and the count of live and dead larvae/plant. The results showed that, although the attack of the corn borer during the experimental period was rather low, due to unfavourable weather conditions for the pest, attack values gave the opportunity to note a significant differentiation in the reaction of the tested hybrids. The hybrid Dekalb 512 Bt showed in all cases a significant resistance to the attack of *Ostrinia nubilalis*, the attack values showing only sporadic traces of attack by the pest. The resistance of the hybrid Dekalb 512 Bt was satisfactory for the vegetation phase when the infestation was performed, including after the panicle has appeared, which corresponds to the period of evolution of the only generation that has economic significance in Romania. Although the indigenous hybrid in the experiment HSF 1071-96 had a low level of attack, the genetical hybrid Dekalb 512 Bt was not practically attacked by the corn borer.**


**Key words**: *Ostrinia nubilalis*, European Corn Borer, maize inbred line, resistance, egg-masses.

## INTRODUCTION

It is a well-known fact that the European Corn Borer (ECB) is one of the major corn pests in Romania, especially in the Central and Western Region of the Romania, in hilly areas and along the main rivers, in the Danube flooded plains and under irrigations. Its attack, in the later verticil phase of the leaves and especially in the panicle, stem and peduncle of the cob, can cause significant damage, reaching 60% of the grain production under particularly favourable conditions (Paulian et al., 1962).

The fact that, in the U.S.A., *Ostrinia nubilalis* has two generations that are dangerous to maize crops, has caused, as early as the first half of the last century, that complex and multiple studies be performed on this pest, especially on how to control it. Following the many years of research, it was proven that plant resistance is the most effective way to protect maize crops against both the first and the second generation (Hudson et al., 1989). Many hibrids that were created tolerant or resistant to the attack of the pest were made available for production and quickly became widespread and dominant, especially in the Corn Belt areas.

The high economic significance of the corn borer in the U.S.A. made it necessary that, once major breakthroughs were achieved in genetic engineering, a series of studies be started for the use of genetically modified maize hybrids and, within a short period, maize growers were given maize hybrids with the Bt gene. According to Edwards (1999), of the total area of 31,417,004 ha cultivated with maize in the U.S.A. in 1998, genetically modified hybrids occupied an area of 4,858,300 ha.

In Romania, the various studies performed especially during the last decades of the past century, regarding the resistance of maize against *Ostrinia nubilalis* attacks, lead to the development, by conventional means, of inbred lines with a certain degree of resistance, which at the same time have high combinative value and superior agronomic features (Bãrbulescu

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and Cosmin, 1997). By crossing some of these tolerant lines, maize hybrids were obtained during the past few years (Bărbulescu et al., 1999).

In order to promote the genetically modified maize hybrids in our country as well, Monsanto made available the hybrid Dekalb 512 Bt for testing under the conditions found in Romania, and the results that were obtained are mentioned in this paper.

## MATERIALS AND METHODS

The experiments were conducted during the period between 1998 and 2000, under artificial infestation conditions. The hybrid Dekalb 512 Bt was used together with the widely grown indigenous hybrids, Fundulea 376 and Olt, caracterized by a certain reduction of the attack degree. In a separate experiment, Dekalb 512 Bt was compared with an experimental hybrid HSF 1147-96, susceptible to the attack of ECB and with a tolerant hybrid HSF 1071-96, created from inbred lines with a certain degree of resistance to this pest.

In order to have the plants infested in various vegetation phases and under various climatic conditions that would usually include the egg - laying period under natural conditions sowin and tl startir ance after masse for at masse insert leave peare egg-r exper

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tation phases.

The attack was assessed in the fall, during the maize harvesting period, by cutting a longitudinal cross-section of the plants and recording the total length in cm of the attacked cavities for each plant, and the number of live and dead larvae/plant.

## RESULTS AND DISCUSSIONS

For the overall degree of attack produced by the corn borer during the experimental period (Tables 1 and 2), it was observed that, due to weather conditions that were generally unfavourable for the pest, a low degree of attack was recorded, compared with a year that was favourable to the evolution of the pest, such as 1988, when, in a susceptible corn line, the average length of cavities was 63 cm/plant, with the maximum value of 135 cm/plant, and the average lavae count was 7.3 per plant, up to 13.7 per plant (Bărbulescu, 1989). Nevertheless, the attack was more visible during the first year of the experiment and much reduced, almost sporadic, during the last year, when temperature during infestation and immediately thereafter was very high, frequently exceeding 35°C, and drought was also very severe.

*Table 2*. Reaction of maize hybrids to the attack of the corn borer as depending on infestation date and number of egg-masses per plant

| Date | | | Hybrid | Cavity length, cm/plant | | | | Larva count per plant | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Egg-masses per plant | | | | Egg-masses per plant | | | |
| Sowing | Infestation | Days S-I | | 5 | 10 | 15 | 20 | 5 | 10 | 15 | 20 |
| 05.07.1998 | 06.30 | 54 | Dekalb 512 Bt | 0 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0.1 |
| | | | F 376 | 6.1 | 5.6 | 4.7 | 5.9 | 1.0 | 1.6 | 0.5 | 1.2 |
| | | | Olt | 5.1 | 4.9 | 6.2 | 9.3 | 2.1 | 1.0 | 2.3 | 1.8 |
| | 07.07 | 61 | Dekalb 5 12 Bt | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | F 376 | 8.9 | 6.2 | 8.6 | 8.3 | 1.5 | 1.9 | 2.8 | 1.6 |
| | | | Olt | 10.2 | 10.9 | 7.5 | 9.3 | 3.1 | 3.4 | 1.9 | 1.8 |
| | 07.14 | 68 | Dekalb 512 Bt | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | F 376 | 17.2 | 16.9 | 16.1 | 22.2 | 1.9 | 5.1 | 5.4 | 6.4 |
| | | | Olt | 14.1 | 17.1 | 16.3 | 19.9 | 4.3 | 6.6 | 5.1 | 5.8 |
| | 07.21 | 75 | Dekalb 512 Bt* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | F 376* | 9.9 | 11.9 | 7.0 | 14.4 | 1.8 | 4.4 | 2.0 | 4.0 |
| | | | Olt* | 6.0 | 11.7 | 7.0 | 10.3 | 3.2 | 4.7 | 3.8 | 4.5 |
| | 07.28 | 82 | Dekalb* 512 Bt | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | F 376* | 5.0 | 7.0 | 7.0 | 2.8 | 0.5 | 0.9 | 1.4 | 1.7 |
| | | | Olt* | 7.0 | 9.0 | 4.9 | 7.4 | 1.0 | 1.6 | 2.7 | 3.9 |
| 05.03.1999 | 06.24 | 52 | Dekalb 512 Bt | 0 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0 |
| | | | F 376 | 1.7 | 2.8 | 0.8 | 1.1 | 0.4 | 0.3 | 0.1 | 0.3 |
| | | | Olt | 3.5 | 2.6 | 2.0 | 2.0 | 0.7 | 0.5 | 0.5 | 0.2 |
| 06.01.1999 | 07.15 | 44 | Dekalb 512 Bt | 0 | 0 | 0 | 0.8 | 0 | 0 | 0 | 0.8 |
| | | | F 376 | 14.4 | 13.6 | 9.2 | 16.0 | 2.4 | 2.2 | 1.8 | 2.5 |
| | | | Olt | 10.0 | 11.8 | 13.5 | 11.0 | 2.6 | 2.8 | 1.9 | 1.8 |
| MEAN | | | Dekalb 512 Bt | 0.02 | 0 | 0 | 0.17 | 0 | 0 | 0 | 0.12 |
| | | | F 376 | 9.02 | 9.14 | 7.62 | 10.10 | 1.35 | 2.34 | 2.05 | 2.52 |
| | | | Olt | 7.97 | 9.71 | 8.20 | 9.88 | 2.42 | 2.94 | 2.60 | 2.82 |

* Infestation with pins, as the panicle had appeared

infestation period of July 6, in similar environmental conditions, it was observed that higher attack values were recorded in the latter case, the difference in the attacks being caused by the different vegetation phases at the moment of infestation.

Considering the data on the infestation with a different number of egg-masses per plant (Table 2) it occured that the attack was not influenced by the infestation level, the attack values being similar regardless of the number of egg-masses used during the same infestation period. The differentiation of data in some cases by the infestation date (vegetation phase) was caused by oscillating environment conditions from one infestation period to another.

As for experimental hybrids, it is worth mentioning that, for the hybrid Dekalb 512 Bt, in all cases, regardless of the year conditions, sowing and infestation period - i.e. vegetation phase of the plants, of the number of egg-masses used for infestation, no attack values were found in the length of cavities or larvae count, while for the hybrids F 376 and Olt the attack was obvious, with high values, greatly differentiated from that of Dekalb 512 Bt.

Analysing the attack data on the behaviour of maize hybrids in the experiment depending on the vegetation phase of the plants, the same good behaviour of Dekalb 512 Bt to the corn borer attack was noted, even if pest attacked after the panicle appeared, a phase which corresponds to the evolution of the second generation in the conditions of the U.S.A. (Guthrie, 1971) and, at a much smaller scale, to some extent, with the evolution of the partial second generation in Southern Romania (Bãrbulescu et al., 1997).

The data obtained concerning the reaction of the two indigenous hybrids in the experiment and of the Dekalb 512 Bt to the attack of the corn borer showed very clearly that, although the indigenous hybrid considered tolerant HSF 1071-76 showed a lower attack degree compared with the susceptible indigenous hybrid HSF 1147-96, the genetically modified hybrid, Dekalb 512 Bt with the Bt gene included showed only sporadic traces of attack produced by *Ostrinia nubilalis* (Table 3).

*Table 3*. Reaction of the hybrid Dekalb 512 Bt to the attack of the corn borer, compared with a resistant hybrid and a susceptible one

| Hybrid | Experi-ment | Cavity length, cm/plant | Larvae count per plant |
|---|---|---|---|
| Dekalb 512 Bt | 1 | 0 | 0 |
| | 2 | 0 | 0 |
| | 3 | 0.2 | 0.4 |
| | 4 | 0.7 | 0.1 |
| HSF 1071 | 1 | 0.7 | 0.2 |
| | 2 | 2.2 | 0.2 |
| | 3 | 1.0 | 0.2 |
| | 4 | 1.3 | 0.2 |
| HSF 1147 | 1 | 9.0 | 2.3 |
| | 2 | 16.9 | 3.9 |
| | 3 | 20.2 | 3.9 |
| | 4 | 15.4 | 3.2 |

## CONCLUSIONS

Although the attack of the corn borer during the experimental period was low, due to weather conditions that were unfavourable for the pest, the attack values recorded gave the opportunity to make a definite differentiation on the reaction of the tested hybrids.

The hybrid Dekalb 512 Bt showed in all cases a significant resistance to the attack of *Ostrinia nubilalis*, the attack values showing only sporadic traces of attack by the pest.

The resistance of the hybrid Dekalb 512 Bt was satisfactory for the vegetation phase when the infestation was performed, including after the panicle had appeared, which corresponds to the period of evolution of the only generation that has economic significance in Romania.

Although the indigenous hybrid in the experiment HSF 1071-96 had a low level of attack, the genetically modified hybrid Dekalb 512 Bt was practically not attacked by the corn borer.

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Table 1. Soil manifests some physiological and enzymic potentials and chemical contents necessary for determining the soil fertility

| Main physiological potentials: | Main enzymic potentials: | Main chemical contents: |
|---|---|---|
| 1. Respiration | 1. Catalase | 1. Humus (Ct%) |
| 2. Biomass | 2. Saccharase | 2. Extractable carbon (Ce%) |
| 3. Cellulolyse | 3. Urease | 3. Humic acids (Cah%) |
| 4. Di-nitrogen fixation | 4. Total phosphatases | 4. Fulvic acids (Caf%) |
| 5. Proteolise | | 5. Total nitrogen – Kjeldahlization – (Nt%) |
| 6. Ammonification | | 6. Organical phosphorus (PO%) |
| 7. Nitrification | | 7. Acidity |
| | | 8. Base saturation |

Table 2. Absolute and relative values for respiration potential (mg CO2/100 g soil d.w./24 h), cellulolytic potential (g decayed cellulose / 100 g cotton tissue d.w. / 18 days) and Indicator of Vital Activity Potential (IVAP %) from different soil types

| Soil type | Absolute values | | | | |
|---|---|---|---|---|---|
| | Respiration (R) | Cellulosolyse (C) | R% | C% | IVAP% |
| Vermic – typical chernozem | b 33.45 | b 40.0 | 22.30 | 40.00 | c 31.15 |
| Cambic chernozem | a 40.70 | a 47.3 | 27.13 | 47.30 | b 3721 |
| Argiloilluvial chernozem | a 45.30 | a 59.4 | 30.20 | 59.40 | a 44.80 |
| Brown – reddish soil | b 33.50 | b 39.7 | 22.33 | 39.70 | c 31.01 |
| Albic luvisol | c 13.90 | c 15.3 | 9.27 | 15.30 | e 12.28 |
| Albic luvisol | a 39.80 | c 13.9 | 26.53 | 13.90 | d 20.22 |
| Maximum Empiric Value (MEV) | 150 | 100 | | | |
| LD 5% | 3.2 | 7.4 | | | 3.33 |
| 1% | 4.2 | 9.8 | | | 4.43 |
| | 5.5* | 12.7* | | | 5.76* |
| *) utilized LD for comparison | | | | | |

Table 3. Absolute and relative values for following potentials: catalase ($cm^3$ $O_2$/minute), saccharase (mg monoses / 24 h), urease (mg $NH_4$+ / 24 h) and total phosphatase (mg P / 24 h), all values are reported to 100 g soil d.w. and the Indicator of Enzymic Activity Potential (IEAP %) from different soil types

| Soil type | Absolute values | Relative values |
|---|---|---|

| | Catalase (K) | Sac-charase (Z) | Urease (U) | Phos-phatase (F) | K% | Z% | U% | F% | IEAP% |
|---|---|---|---|---|---|---|---|---|---|
| Vermic – typical chernozem | a 1607 | b 2744 | c 35.8 | b 2.81 | 80.35 | 78.40 | 23.87 | 11.24 | a 48.46 |
| Cambic chernozem | b 737 | b 2320 | a 81.1 | a 5.60 | 36.85 | 66.29 | 54.07 | 22.40 | a 44.90 |
| Argiloilluvial cher-nozem | b 870 | d 945 | c 32.4 | b 2.39 | 43.50 | 27.00 | 21.60 | 9.56 | b 25.41 |
| Brown – reddish soil | c 313 | e 699 | e 18.2 | b 2.36 | 15.65 | 19.97 | 12.13 | 9.44 | d 14.30 |
| Albic luvisol | c 364 | d 967 | d 30.3 | b 3.14 | 18.20 | 27.63 | 20.20 | 12.56 | c 19.65 |
| Albic luvisol | d 71 | c 1882 | b 43.3 | b 2.64 | 3.55 | 53.77 | 28.87 | 10.56 | b 24.19 |
| Maximum Empiric Value (MEV) | 2000 | 3500 | 150 | 25 | | | | | |
| LD 5% | 85 | 71 | 2 | 0.71 | | | | | 2.32 |
| 1% | 113 | 94 | 3 | 0.95 | | | | | 3.08 |
| 0.1% | 147* | 122* | 4* | 1.23* | | | | | 4.01* |
| * utilized LD for comparison | | | | | | | | | |

Table 4. Absolute and relative values from the soil chemical analyses: humus (Ct%), extractable carbon (Ce%), humic acids (Cah%), total nitrogen (Nt%), organical phosphorus (P mg/100 g soil d.w.) and pH-$H_2O$ and the Chemical Synthetic Indicator (CSI %)

| Soil type | Absolute values | | | | | | Relative values | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ct | Ce | Cah | Nt | PO | pH | Ct | Ce | Cah | Nt | PO | pH | CSI% |
| Vermic-typical chernozem | 1.56 | 0.56 | 0.41 | 0.19 | 6.56 | 7.97 | 36.71 | 40.00 | 51.25 | 76.00 | 25.23 | 96.02 | a 70.93 |
| Cambic cher-nozem | 1.55 | 0,74 | 0.59 | 0.14 | 7.46 | 7.29 | 36.47 | 52.86 | 73.75 | 56.00 | 28.69 | 87.83 | b 66.69 |
| Argiloilluvial chernozem | 1.27 | 0.61 | 0.43 | 0.15 | 13.97 | 6.74 | 29.88 | 43.57 | 53.75 | 60.00 | 53.73 | 81.20 | b 64.69 |
| Brown-reddish soil | 0.76 | 0.38 | 0.26 | 0.11 | 3.56 | 4.68 | 17.88 | 27.14 | 32.50 | 44.00 | 13.69 | 56.39 | d 41.72 |
| Albic luvisol | 1.32 | 0.80 | 0.28 | 0.11 | 4.79 | 4.89 | 31.06 | 57.14 | 35.00 | 44.00 | 18.42 | 58.92 | c 48.02 |
| Albic luvisol | 0.81 | 0.36 | 0.09 | 0.08 | 8.45 | 4.62 | 19.06 | 25.71 | 11.25 | 32.00 | 32.50 | 55.66 | d 39.88 |
| Maximum Em-piric Value (MEV) | 4.25 | 1.40 | 0.80 | 0.25 | 26 | 8.30 | | | | | | | |
| LD 5%<br>1%<br>0.15 | | | | | | | | | | | | | 1.91<br>2.55<br>3.32* |

* utilized LD for comparison

Table 5. Conversion of the Note of Humic Class (NHC) of humus horizons from the soil colour of qualitative description (Chiriþã, 1955), to the Interval of Soil Humus Content (ISHC)

| Note of | Soil colour description referring to the | Interval of Soil Humus |
|---|---|---|

| Humic class (NHC) | humus content of horisons in soil profile | Content (ISHC) Ct% |
|---|---|---|
| 1. | Soil without humus; very light colour in superior horizon; yellowish, whitish, whitish - grey | < 1 |
| 2. | Soil meagre in humus; brown – yellow-ish; yellowish – brown; brown - grey | 1 – 1.49 |
| 3. | Soil with moderate content in humus; chestnut, brown, reddish-brown, grey - brown | 1.5 – 1.99 |
| 4. | Soil rich in humus, black colour | 2 – 3 |
| 5. | Peaty soil, peat, swamp. Hardly one sees the minerals in organical matter | It is not used. They are not agricultural soil |

Example of calculation for Humic Global Index (HG) for a Vermi-typical chernozem:

HGI = 4 (2.5) + (0.5) + 2 (1.8) + 2 (2.2) = 19.5
Note: - figures in front of the parentheses = not of humic class horizons in soil profile
- figures into the parantheses = dimension in decimeters of horison
Transformation of Humic Global Index in Pedo-Genetical Indicator (PGI%):

$$PGI\% = \frac{HGIx100}{MEV}$$

MEV = 20 (a very fertile soil from Mileanca, Botoºani (county)

$$\text{Consequently, } PGI\% = \frac{19.5x100}{20} = 97.5$$

Table 6. Calculation made for determining Humic Global Index (HGI) and Pedo-Genetical Indicator (PGI%) for analysed soils

| Station and soil type | Horizon | Thickness dm | Humus Ct% | Humic group | HGI ?(2 x 4) | PGI% |
|---|---|---|---|---|---|---|

| | | | | | colons | $\frac{HGIx100}{MEV}$ |
|---|---|---|---|---|---|---|
| Colons | 1 | 2 | 3 | 4 | 5 | 6 |
| Valul lui Traian | Ap1 | 2.5 | 2.01 | 4 | | |
| Constanþa County | Ap 2 h | 0.5 | 1.55 | 3 | 19.5 | 97.5 |
| Vermic-typical cher-nozem | Am k | 1.8 | 1.49 | 2 | | |
| | Ac k | 2.2 | 1.09 | 2 | | |
| Fundulea | Ap | 1.8 | 1.72 | 3 | | |
| Cãlãraºi County | Ap h | 1.2 | 1.72 | 3 | 15.4 | 77.0 |
| Cambic cher-nozem | Am | 1.5 | 1.38 | 2 | | |
| | AB | 1.7 | 1.21 | 2 | | |
| Caracal | Ap 1 | 1.8 | 1.77 | 3 | | |
| Olt County | Ap 2 | 1.4 | 1.68 | 3 | 17.8 | 89.0 |
| Argiloilluvial chernozem | Am | 1.8 | 1.40 | 2 | | |
| | AB | 2.3 | 1.31 | 2 | | |
| ªimnic | Ap | 2.0 | 0.87 | 1 | | |
| Dolj County | Ao | 1.2 | 0.62 | 1 | 8.1 | 40.5 |
| Brown-reddish soil | AB | 1.7 | 0.39 | 1 | | |
| Albota | | | | | | |
| Argeº County | Ap + Er | 2.7 | 0.96 | 1 | 2.7 | 13.5 |
| Albic luvisol | | | | | | |
| Livada | | | | | | |
| Satu-Mare County | Ap + Er | 2.7 | 0.92 | 1 | 2.7 | 13.5 |
| Albic luvisol | | | | | | |

Table 7. Modular and synthetic indicators of fertility level of different soil types

| Soil type | IVAP (%) | IEAP (%) | BSI(%) = $\frac{IVAP + IEAP}{2}$ (Biological Synthetic Indicator) | CSI (%) | VETL(%) = $\frac{BSI + CSI}{2}$ (Vital, Energetic and Trophic Level) | PGI(%) (Pedo-Genetical Indicator) | SISF(%) = $\frac{VETL + PGI}{2}$ |
|---|---|---|---|---|---|---|---|
| Vermic- | c | a | a 38.17 | a | a 54.55 | 97.5 | a 76.02 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| typical chernozem | 31.15 | 48.46 | | 70.93 | | | |
| Cambic chernozem | b 37.21 | a 44.90 | a 41.05 | b 66.69 | a 53.87 | 77.0 | c 65.43 |
| Argiloilluvial chernozem | a 44.80 | b 25.41 | b 35.10 | b 64.69 | b 49.89 | 89.0 | b 69.44 |
| Brown-reddish soil | c 31.01 | d 14.30 | c 22.65 | d 41.72 | c 32.18 | 40.5 | d 36.34 |
| Albic luvisol | e 12.28 | c 19.65 | d 15.96 | c 48.02 | c 31.88 | 13.5 | e 22.74 |
| Albic luvisol | d 20.22 | b 24.19 | c 22.20 | d 39.88 | c 31.04 | 13.5 | e 22.27 |
| LD 5% | 3.33 | 2.32 | 1.86 | 1.91 | 1.35 | | 1.35 |
| 1% | 4.43 | 3.08 | 2.47 | 2.55 | 1.81 | | 1.81 |
| 0.1% | 5.76* | 4.01* | 3.32 | 3.32* | 2.35* | | 2.35* |

*) utilized LD for comparison