THE EFFECT OF YEAR ON THE FORMATION OF THE PRODUCTION POTENTIAL AND CROP OF CORN GROWN FOR GRAIN (*Zea mays L.)*

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Abstract

In years 2003-2005 we monitored the effect of the agricultural year on the formation of the production potential and the crop of corn. We used a late hybrid LG 24.8. The achieved results show an apparent relation between the agricultural year and the LAI which can be statistically proven. The agricultural year had an apparent influence both on the LAD and the increase of dry mass in the time of blooming, wax-milk ripeness and physiological ripeness. We achieved the highest increase of dry mass (2680,82 g.m^{-2}) and the highest levels of LAI, CGR and LAD in 2004. With the increasing weight of dry mass there was a linear increase of crop and also an increase of CGR. During the three monitored years we found a slight negative correlation between the crop and the LAI, RGR, LAD and CGR (± r -0,1772, ± r -0,1084 and ± r -0,2415, ± r 0,2791) and a medium positive correlation between the crop and the NAR (± r 0,6362).

Key words: corn of grain, year, production potencial, yield

INTRODUCTION

The complicated system of production and accumulation process of plants can be affected both by genetic potential and outside factors. High biological and economic crop can be granted only by those plants in which the factors affecting size, performance, assimilation apparatus, length of the active life period, transport speed, division of assimilates among organs, number and size of the seed and their activity in the accumulation assimilates are in harmony (7).

The formation of crop of corn grown for grain has some specifics when compared to wheat types which are sowed with high density. Corn is a plant with high production ability, which is determined by effective photosynthesis activity – photosynthesis type C_4 (2).

Biological crop is an integral of the growth speed of plants (CGR). It has been found out that when the plants are well supplied with water, nutrition, CO_2 and the index of leaf area coverage (LAI) is low, the speed of photosynthesis (Pn) of the corn plants does not reach the solar saturation. Therefore it is necessary to increase the LAI level which will increase the amount of the absorbed solar energy. The easiest way how to increase LAI is to increase the number of plants on 1 ha, but the possibilities to optimise mineral nutrition, water regime etc, can be considered as similar methods. However with the increasing LAI level decreases the level of NAR although the CGR still increases up to the LAI level opt.. With the increase of LAI not only the conditions for photosynthesis are reduced for the leaf area of a plant but also the number of fertilised eggs and grain decreases and so does crop. This means that the accumulation capacity for the storage of assimilates decreases (4).

Based on monitoring (1 and 6) have found that in dry years corn develops well during the first half of vegetation, but during the second half the high LAI causes higher demand for water and so corn gets into a water deficit which causes decrease of crop.

In relation to the biological production very high significance is given to the photosynthesis potential – leaf robustness (LAD). Its relation to crop is affected by clear efficiency of the photosynthesis (NAR) and the speed of fytomass gain (CGR), (3, 5).

The aim of this article is the monitoring of the production potential and the crop formation of corn grown for grain in relation to the course of weather conditions of a particular year.

MATERIAL AND METODS

Poly-factor field experiments with corn were founded in years 2003-2005, in a corn production area, situated in a very hot, dry sub-area with the average annual temperature of 9.7 °C and 116 m above sea level. The soil is clayey, medium heavy, medium supplied P (37,7-56,0 $mg.kg^{-1}$ of soil) and little or well supplied K (105-220 $mg.kg^{-1}$ of soil), humus content 4,53 %, neutral soil reaction (pH 6,5-7,2). Soil type is black soil.

The Graphs 1 and 2 show the weather conditions. We got the materials for agro-climatic analysis from the Hydro-meteorological station in Hurbanovo.

Experimental parcels were organized by the method of divided blocks in three repetitions. Their size was 37,5 m^2. The preceding plant in all years was winter wheat. Experiments were founded by sowing 75 000 sprouting seeds ha^{-1} in terms 26.IV.2003, 6.V.2004 and 2.V. 2005.

We used late hybrid LG 24.81 from the French company Limagrain in the experiment.

We monitored the level of the production potential at the level of fertilisation 6 tons of corn and biomass using leaf fertilizer Humix univerzal.

We took five plants following each other from three repetitions, 30mm above ground. The terms of sample collection are shown in Table 1. We got dry biomass by drying the mass in a laboratory dryer at 105 ^{o}C, for the drying period for a constant weight.

The measurements were made in these growing phases: growth of the third leaf, before blooming, at the beginning of waxy-milk ripeness and physiological ripeness (before harvest).

We set the size of leaf area (A) with the method of linear measurements. These measurements were made directly on the leaves by measuring the maximum length (a) and maximum width (b).

We calculated the leaf area by using the relation equation introduced by Zima (8):

$A= a \times b \times \text{coefficient}\ (m^2)$

The calculation coefficient for crop of corn is 0,75. We used a laser area meter to control the leaf area measurements at the Physiology of plants university department.

Based on our measurements we set these growth-production indicators:

- leaf area index (LAI) in $m^2.m^{-2}$
- net assimilation rate (NAR) in $g.m^{-2}.d^{-1}$
- relative growth rate (RGR) in $g.g^{-1}.d^{-1}$
- crop growth rate (CGR) in $g.m^{-2}.d^{-1}$
- leaf area duration (LAD) in $m^2.m^{-2}.d^{-1}$

To calculate the basic indicators of growth analysis these relations were used:

$LAI = A/P\ (m^2.m^{-2})$

A – actual leaf area (m^2)

P – area of land from which the sample was collected

$NAR = [(W_2 - W_1) / (t_2 - t_1)]\ .\ 1/A\ (g.m^{-2}.d^{-1})$

W_1 – weight of dry mass of leaves at the beginning of monitoring interval

W_2 – weight of dry mass of leaves at the end of the monitoring interval

t – time interval (day)

A – average leaf area (m^{-2})

$CGR= [(W_2 - W_1) / (t_2 - t_1)]\ .\ 1/P\ (g.m^{-2}.d^{-1})$

W_1 – weight of dry mass of leaves at the beginning of monitoring interval

W_2 – weight of dry mass of leaves at the end of the monitoring interval

t – time interval (day)

P – area of land from which we got W_1 and W_2

$RGR = (\ln W_2 - \ln W_1) / (t_2 - t_1)$ $(g.g^{-1}.d^{-1})$

W_1 – weight of dry mass of leaves at the beginning of monitoring interval

W_2 – weight of dry mass of leaves at the end of the monitoring interval

t_1 – the beginning of experiment interval

t_2 – the end of experiment interval

$LAD = A_1 + A_2 / t_2 - t_1$ $(m^2.m^{-2}.d^{-1})$

A_1 – leaf area at the beginning of experiment interval

A_2 – leaf area at the end of experiment interval

t_1 – the beginning of experiment interval

t_2 – the end of experiment interval

Table 1

Terms of sample collecting for monitoring the physiological indicators of the production process

phase of growth	date of sampling		
3rd leaf	15.V. 2003	28.V. 2004	24.V. 2005
before ear stage	1.VII. 2003	11.VII. 2004	10.VII. 2005
wax-milk ripeness	15.VIII. 2003	22.VIII. 2004	28.VIII. 2005
cropping maturity	1.X. 2003	26.IX. 2004	15.X.2005

We took biological material (cobs) to determine the economic crop at the time of physiological ripeness. We took samples from each parcel area from five plants following each other in three repetitions and we calculated it for 1hectare (ha).

The economic crop of corn we give as crop obtained by using the following equation:

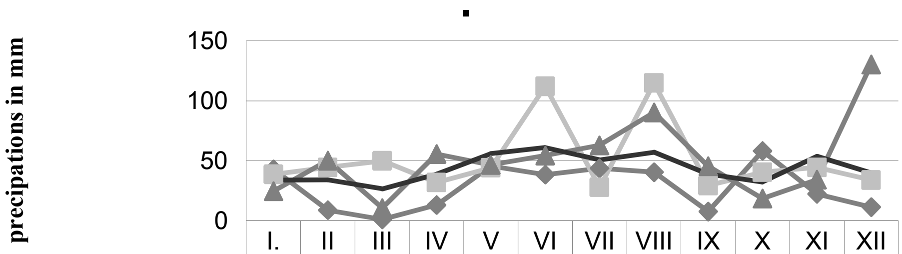
$$\text{Crop of grain in } t.ha^{-1} = \frac{1 \times 2 \times 3 \times 4}{10^5}$$

1- number of plants (m^2), 2- average number of cobs on one plant (in pieces), 3- number of grains on a cob (in pieces), 4- the weigh of 1000 grains (g),

We evaluated the variants with a multifactor analysis with the Tukey test in the Statgraphics program packet.

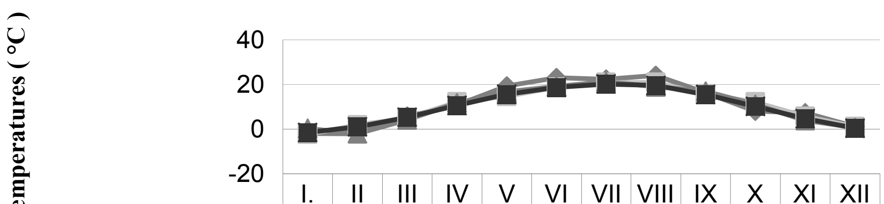
The relations between the production potential and the crop of grain were evaluated with the help of correlation coefficients.

Graph 1: The course of rainfall in Hurbanovo in particular years of cultivation



	I.	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2003	43	8,8	0,9	13	46	38	44	40	7,6	58	22	11
2004	39	44	50	32	44	112	28	115	29	40	44	34
2005	25	50	11	56	47	54	63	90	45	19	34	130
climatic normal	34	34	27	39	56	61	51	57	39	32	54	40

Graph 2: Average mounts temperatures in the years 2003, 2004 and 2005.



	I.	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2003	-2	-2	5,8	11	19	23	22	24	16	8,1	7,2	1,2
2004	-2	1,8	5	12	15	19	21	21	16	12	5,7	1
2005	0,4	-2	4,1	12	17	19	21	19	17	11	3,9	0,6

RESULTS AND DISCUSSION

From the point of view of production potential formation the monitored year 2003 can be considered as unfavourable. The amount of rainfall during vegetation (in months April-September) reached 188,3 mm which is only 62,4% cl.n.(climatic normal) The average temperature during the vegetation of corn was 19,2 ^{o}C, which represents only 115% of climatic norm. The Graph 1 shows that the period before vegetation was also less favourable from the aspect of rainfall (February and March – very dry or dry). In this year the dynamics of dry mass increase was the lowest when compared to the other monitored years (2151,45 g. m^{-2}) and at the same time the lowest crop of grain was achieved (8,66 t.ha-1) (see Table 3). Low rainfall also unfavourably affected the production process indicators. We found a strong negative correlation between the crop of grain and LAI (± r - 0,6812) (see Table 2).

The year 2004 with its temperature and rainfall can be characterized as normal. The rainfall during vegetation reached 359,7 mm (119,1 % cl. n.) and the average temperature during vegetation was 17,1°C that is 102,5 % cl. n. (Graph 1 and 2). In this year we reached the highest increase of dry mass (2680,82 $g.m^{-2}$) and from the production potential indicators LAI, CGR AND LAD reached the highest figures (see Table 2). Similarly to the previous year there was a strong negative correlation between the crop and LAI ± r -0,7666 (Table 2). All results support the findings stated by authors (3 and 5), that there is a certain dependence between crop and the dynamics of dry mass weight during vegetation. With the increase of weight of dry mass there was a linear increase of economic crop as well as CGR.

The year 2005 can be characterized as normal with favourable rainfall. The rainfall in May – September reached 83,3 – 158,01% cl.n. The average temperature during vegetation reached 17,4 °C - 104,4 % of the climatic norm (see Graph 2). The highest crop 12,19 $t.ha^{-1}$ was achieved in this year. From the production potential indicators NAR and RGR were the highest (see Table 2).

On average during the monitored years 2003 – 2005 we found a slight negative correlation between the crop and LAI, RGR, LAD and CGR (± r -0,1772, ± r -0,1084 and ± r -0,2415, ± r 0,2791) and a medium correlation between crop and NAR (± r 0,6362). This did not verify the findings of authors (3, 4, 5), who say that crop is in linear relation with LAI and LAD.

The achieved results show an apparent relation between the agricultural year and the LAI which can be statistically proven. The agricultural year had an apparent influence both on the LAD and the increase of dry mass during blooming, waxy-milk ripeness and physiological ripeness (see Table 4).

Table 2

The relation between indicator of production potencial of grain corn and yield in year 2003-2005

year	yield of grain t.ha^{-1}	LAI m^2.m^{-2} (1)	RGR g.g^{-1}deň$^{-1}$ (2)	CGR g.m^{-2}.deň$^{-1}$ (3)	NAR g.m^{-2}.deň$^{-1}$ (4)	LAD m^2.m^{-2}.deň$^{-1}$ (5)
2003	8,66	1,96	0,056	15,58	6,96	105,54
± r		-0,6812	-0,5083	-0,0575	0,2995	-0,6025
2004	11,04	2,9	0,051	22,05	7,44	129,61
± r		-0,7666	-0,4744	0,2986	-0,4310	-0,4628
2005	12,19	1,59	0,056	18,38	9,63	93,26
± r		0,9895	0,8877	0,9026	0,9997	0,2480
2003-2005	10,63	2,14	0,054	18,67	8,07	109,49
± r		-0,1772	-0,1084	0,2791	0,6362	-0,2415

(1) leaf area index, (2) relative growth rate, (3) crop growth rate, (4) net assimilation rate, (5) leaf area duration

Table 3

Increase of dry mass-aboveground (g.m^{-2}) during the monitored phases of growth of corn in 2003-2005

year	yield	3rd leaf	before ear stage	wax-milk ripeness	cropping maturity
2003	8,66	0,98	535,96	1316,2	2151,45
± r		0,7622	-0,9100	0,8456	-0,0613
2004	11,04	0,95	1050,34	2158,11	2680,82
± r		-0,8648	-0,9996	0,9639	-0,5116
2005	12,19	0,94	488,97	1449,12	2206,18
± r		0,3779	-0,6524	-0,98877	0,9973
$\bar{x}$ 2003-2005	10,63	0,95	673,83	1641,16	2346,21
± r		0,0784	-0,1857	0,0393	-0,0909

Table 4

Multifactor analysis of the range of correlation between the production potential and the years 2003-2005

parameter	factor	degree of freedom	average square	significance	$HD_{0,05}$ (1)
LAI (2)	ročník (12)	2	1,3646333	++	0,0001
LAD (3)	ročník	2	1005,6377	+	0,0068
aboveground					
before ear stage	ročník	2	290961,51	+	0,0233
wax-milk ripeness	ročník	2	614529,34	+	0,0010
cropping maturity	ročník	2	435078,58	+	0,0150

(1) Tukey`s test on the level α – 0,05, (2) leaf area index, (3) leaf area duration,

CONCLUSION

For three years we monitored the influence of the year on the formation of the production potential of crop of corn. We used a late corn hybrid LG 24.81. The level of fertilisation was 6 tons of corn and the given biomass and we used the leaf fertiliser Humix univerzal. The results of these three years of monitoring prove that there exist a relation between the crop and the dynamics of dry mass increase during vegetation.

The achieved results show an apparent relation between the agricultural year and the LAI which can be statistically proven. The agricultural year had an apparent influence both on the LAD and the increase of dry mass in the time of blooming, wax-milk ripeness and physiological ripeness. We achieved the highest increase of dry mass (2680,82 $g.m^{-2}$) and the highest levels of LAI, CGR and LAD in 2004. With the increasing weight of dry mass there was a linear increase of crop and also an increase of CGR. During the three monitored years we found a slight negative correlation between the crop and the LAI, RGR, LAD and CGR (± r -0,1772, ± r -0,1084 and ± r -0,2415, ± r 0,2791) and a medium positive correlation between the crop and the NAR (± r 0,6362).

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