Bulgarian Journal of Agricultural Science, 19 (No 3) 2013, 454-460
Agricultural Academy

MAIZE GRAIN YIELD RESPONSE TO N FERTILIZATION, CLIMATE AND HYBRIDS

A. MIKOVA, P. ALEXANDROVA and I. DIMITROV
"N. Pushkarov" Institute of Soil Science, Agrotechnologies and Plant Protection, BG - 1080 Sofia, Bulgaria

Abstract

MIKOVA, A., P. ALEXANDROVA and I. DIMITROV, 2013. Maize grain yield response to N fertilization, climate and hybrids. *Bulg. J. Agric. Sci.,* 19: 454-460

The relationship between soil-climate conditions, rate of nitrogen application, two maize hybrids and maize grain yield under continuous corn production and irrigation was investigated during 17 years period in eight soil climatic regions in Bulgaria. The experiment was monofactorial with four levels of N fertilization. Maize hybrids from two FAO groups (400 and 700) cultivated under irrigation as a monoculture were used. Statistical analyses were performed in order to describe some relations between maize yield and variables, connected with maize growth. According to the results from ANOVA analysis factor "N rate" had the highest effect on the variability of maize yield (72.03 %). The influence of "Hybrid" and "Station" – environmental conditions (soils and climate) was quite low – 9.51% and 2.01% respectively. Multiple regression analyses showed that N rate, temperature sum and total water use could be successfuly used as yield predictors.

Key words: maize yield, maize hybrids, N rate, soil climatic conditions, Statistical analyses

Introduction

Crop growth, crop development and crop yield variations are influenced by many factors and their combination. In the extensive plantations, soil and climate play the main role. Intensive agriculture leads to minimization the effect of the nature on crop. Irrigation, fertilization and tillage are the most important factors causing an increase of dry biomass accumulation and crop yield.

Some research has indicated that crop N requirements are lower for irrigated versus rainfed soils Oberle and Keeney (1990), unless rainfed condition results in water stress. Zand-Parsa and Sepaskhah (2001) worked out equations to describe corn yield as a function of irrigation water and N fertilizer. In a sub-Saharan environment, Pandey et al. (2000) reported a linear yield response for corn with deficit irrigation at all N levels. Generally, the greater the N supply, the more yield was reduced by deficit irrigation.

According to Nathan Derby et al. (2004), nitrogen fertilizer applications for irrigated corn (Zea mays L.) established before planting may result in under- or overapplication of N because of weather-induced variations in yield potential from year to year. They present a regression model for corn grain yield prediction at a midpoint in the growing season based on the current year's cumulative thermal factors and N fertility levels.

Nathan Derby et al. (2005) develop a linear model to describe the interactions of N fertility, weather, soil, and irrigation on corn (*Zea mays* L.). Nitrogen fertility has a major role in maintaining maximum corn grain yields; however, a number of other factors limit yields even when N fertility is optimal.

Hollinger and Hoeft (1986) proved that the effect of nitrogen fertilizers depended heavily on weather conditions; hot and dry conditions could reverse the effect of fertilizer on corn growth and, thus, could amplify the adverse effect of weather and climate on yield. These results demonstrate persistent climate effects on corn growth and yield. Water is required for nutrient utilization Huzsvai and Nagy (2005). In years with poor or medium water supplies, moderate fertilizer rates are more effective, compared to higher rates in years with better water supplies.

O'Neill et al. (2004) also reported a greater yield response for corn with N application under adequate soil water conditions and a lower one under deficit water conditions.

Strong correlations are found between historical crop yields and annual N application rates (Sinclair and Horie,

E-mail: an15mi11@yahoo.com

1989). However, crops have responded differently to N supply. According to Stoyanov (2007), maize grain yield increases with increasing of N rates. However, this increase happens up to a certain level. Hihgt N rates have a negative effect on yield and they are unprofitable.

Many studies have shown the increase in grain yield (from 28% to 400%) for maize (Muchow, 1988; Wolfe et al., 1988 and Uhart and Andrade, 1995) in response to N fertilizer application when initial soil N level is low. The increase of grain yield (205–865 g m^{-2}) in maize at low N levels was mostly associated with increase of biomass (500–1900 g m^{-2}).

It is evident that the effect of fertilization on crop yield was observed in many studies; the trials however show that the strength of the effect may differ. Soil conditions, climatic factors and weather conditions in a given year also significantly influence yield production (Benjamin et al., 2003; Cai and Qin, 2006). Locally specific effects of field trials are often a limiting factor for drawing correct conclusions. A short-term effect can be inconsistent with the results of long-term observations. Agricultural research, as well as other kind of research, is usually based on short-term studies, but a sustainable agriculture requires long-term fields and laboratories experiments, capable of determining the complex soil - plant - climate - management interactions (Army and Kemper, 1991).

The aim of this work is to evaluate long-term effects of different soil – climatic conditions, maize hybrid and N rate of fertilization on maize grain yield and to work out regression models for yield prediction.

Materials and Methods

Experiment: Long term field experiment started in 1973 was conducted in eight field – research stations of the N. Pushkarov Institute of Soil Science, situated in eight soil climatic regions of Bulgaria. For the purpose of this study data from seventeen years period was used. Information about climatic conditions depending on region is given in Table 1.

Winter at the stations situated in the Moderate-continental climate sub region can be assessed as cold with a mean January air temperature of -1.5 - -2.0^{0}C. Climatic region of the high fields in the West Bulgaria is the coolest with mean air temperature for January -2^{0}C and yearly precipitation 647 mm. Gorni Lozen is situated on the highest altitude – a reason for the shortest length of the period with mean air temperature above 10^{0}C (188 days and 3 174^{0}C temperature sum respectively) Nord climatic region of the Danube Plain is also cool. The amount of precipitation here is lower, especially during growing period. Station Kovachica is characterized with the shortest period with air temperatures above 10^{0}C – 204 days.

Stations Tsalapitsa, Sredec and Sadievo are situated in the driest and hottest (especially Tsalapitsa) region – Transitional-Continental Climatic Sub Region – Climatic region of

Table 1
Climatic parameters of the field research stations

Station	Altitude	January air temp. ^oC	July air temp. ^oC	Period with air temperature above 10^{o}C				Precipitation mm		
				beginning	end	days	Σ t^{o}C	IV-IX	X-III	Year
Moderate continental climatic sub region										
Nord climatic region of The Danube Plain										
Kovatchitsa	95	-1,8	23,6	4.IV/3	25.X/26	204	3802	289	259	548
Slivo Pole	25	-1,8	24	2.IV/3	31.X./30	212	3980	338	247	585
Middle climatic region of The Danube Plain										
G.Dabnik	150	-1,7	23,6	3.IV/4	29.X./27	209	3908	342	236	578
Bejanovo	190	-1,5	23	6.IV/11	29.X./28	206	3766	404	235	639
Climatic Region of the High fields in the West Bulgaria										
G. Lozen	586	-2	20,8	16.IV/13	21.X./17	188	3174	367	278	647
Transitional-Continental Climatic Sub Region										
Climatic region of The East Middle Bulgaria										
Tsalapitsa	160	0,2	23,6	2.IV/4	1.XI/29	213	3931	247	267	512
Sredec	170	1	23,8	4.IV/3	3.XI/6	212	3927	320	238	561
Sadievo	155	1,2	22,8	8.IV/3	1.XI/31	207	3712	307	256	563

The East Middle Bulgaria. The amount of precipitation here is from 247 to 320 mm. Tsalapitsa like Kovatchitsa from the above region falls into an orographic shadow, which causes a rainfall decrease.

The field research stations are situated on the following soil types according WRBSR, 2002 (Teoharov, 2004): Kovatchitsa - Calcic Chernozem; Slivo pole - Haplic Chernozem; Gorni Dabnik - Haplic Chernozem; Bejanovo - Luvic Phaeozem; Sredec - Haplic Vertisol; Sadievo - Chromic Luvisol; Gorni Lozen - Vertic Luvisol ; Tsalapitsa - Mollic Fluvisol. Information about some physical and chemical soil properties (Stoychev, 1997) is given in Table 2.

Maize hybrids from 2 FAO groups (400 and 700) cultivated as a monoculture and under irrigation were used. Irrigation rate and time were determined according to water balance experiment and according to compensation lysimeters. Three to four irrigations were applied during the growing season. The irrigation rate was at an average of 400 -770 m^3/ha depending on soil-climatic conditions. During the years crop density was 55000-70000 plants per hectare depending on the hybrid characteristics. Tillage was done according to crop requirements.

The experiment was monofactorial with four variants of fertilization and one variant without fertilization (control) marked as B_1, B_2, B_3, B_4 and B_5 examined in 6 replications with a sample plot of 100.8 m^2. Fertilization was set as a factor in order to determinate it interacts with climate and soil as components of the ecosystem. The experiment was carried out according to an identical scheme at all station during the whole period.

At Variant B_3 (norm) a full compensation of the nitrogen (N) uptake by maize yield (about 10000 kg per ha) was kept. The norm varied according to different fields from 187 to 242 and from 44 to 82 kg/ha for nitrogen and phosphorous respectively. The control variant B_1 was not fertilized and it gave an impression about natural soil fertility. The other variants were fertilized as follows: B_5 – 50% of B_3, B_4 75% of B_3 and B_2 – 125% of the norm. The last variant was not included in this study. The rate of phosphorous (P) was planned for full compensation of its uptake and for an increase of the soil phosphate level. Potassium was not applied, because of the good supply of this element in soils.

Ammonium nitrate was applied in spring before sowing and during the stages "3-4 leaf", "6-7 leaf". Triple super phosphate was applied each autumn.

The following soil types and fertilization rates by variants were included in the experiment: Gorni Lozen - Vertic Luvisol- N (0; 224; 168; 112; $kg.ha^{-1}$) and P (0; 65; 49; 33; $kg.ha^{-1}$); Tsalapitsa – Mollic Fluvisol – N (0; 226; 170; 113 $kg.ha^{-1}$) and P (0; 82; 62; 41 $kg.ha^{-1}$); Sadievo - Chromic Luvisol – N (0; 222; 166; 111 $kg.da^{-1}$) and P (0; 57; 42; 29 $kg.ha^{-1}$); Sredec - Haplic Vertisol – N (0; 242; 182; 121 $kg.ha^{-1}$) and P (0; 52; 39; 26 $kg.ha^{-1}$) ; Kovatchitsa - Calcic Chernozem – N (0; 187; 140; 94 $kg.ha^{-1}$) and P (0; 44; 33; 22 $kg.ha^{-1}$);.Gorni Dubnic - Haplic Chernozem – N (0; 225; 169;112 $kg.ha^{-1}$) and P (0; 65; 49; 33; $kg.ha^{-1}$); Slivo pole - Haplic Chernozem – N (0; 217; 163; 108 $kg.ha^{-1}$) and P (0; 61; 46; 30 $kg.ha^{-1}$) ; Bejanovo - Luvic Phaeozem – N (0; 221; 166; 110 $kg.da^{-1}$) and P (0; 65; 49; 33 $kg.ha^{-1}$).

Statistics: All data were subjected to several statistical analysis procedures using Statgraphics Centurion XV, including analysis of variance, correlation and regression. In order to investigate the influence of soil climatic conditions (variable "Station") , hybrid (variable A_1 – **hybrids** with middle **early** ripeness - **400 FAO** and late ripeness **hybrid -** FAO 700 - variable A_2) and rate of N fertilization (variable N rate) on maize yield, multifactor ANOVA analysis of variance was used. F values for main treatment effects and their interaction were considered significant at the $P<0.05$ level. Whenever the N rate and climatic conditions or the interaction between them significantly influenced the dependent variable (grain yield), a regression analysis for each environment (Station) and each hybrid was performed and the linear effects were calculated.

Table 2
Soil properties

Station	pH $H2_2O$	Total N%	C/N	Sorb. capacity mequ/100g	Sand <0,01%	Clay <0,001%
G.Dabnik	6.1	0.159	11.2	31.90	52.3	28.4
Sredec	7.9	0.160	11.9	64.61	66.0	50.4
Tsalapitsa	6	0.052	7.8	7.92	27.3	11.4
Sadievo	7.0	0.166	9.8	30.60	53.3	30.6
Slivo pole	6.1	0.121	11.2	27.70	52.1	30.0
Bejanovo	6.2	0.140	9.2	31.51	61.4	43.3
Kovatchitsa	8.0	0.100	11.8	15.74	38.5	18.1
G.Lozen	6.6	0.132	7.1	27.90	58.4	42.0

Results and Discussion

Generally, treatments without N fertilization differed markedly from the other treatments. The lowest yield was obtained at control plots at all sites. The highest yield from both hybrids with nitrogen fertilization was reported at Sredec and G. Dabnik stations and the lowest – at station Gorni Lozen and Kovatchitsa. (Figures 1 and 2). Differences between yield from B_3 and B_4 (fertilization rate – 100 and 75 %) were of the order of 50-100 kg. The late hybrid's yield was

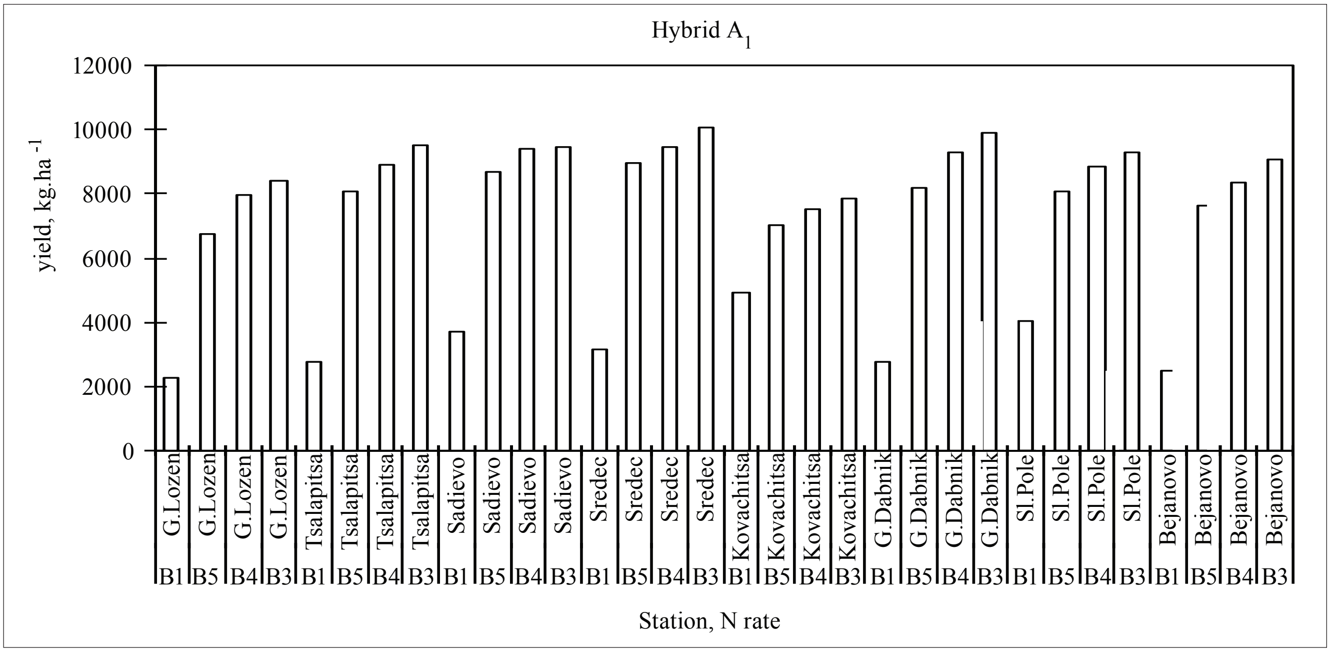

Fig. 1. Maize grain yield for different rates of N fertilization in 8 soil-climatic regions Hybrid A_1 (400 FAO)

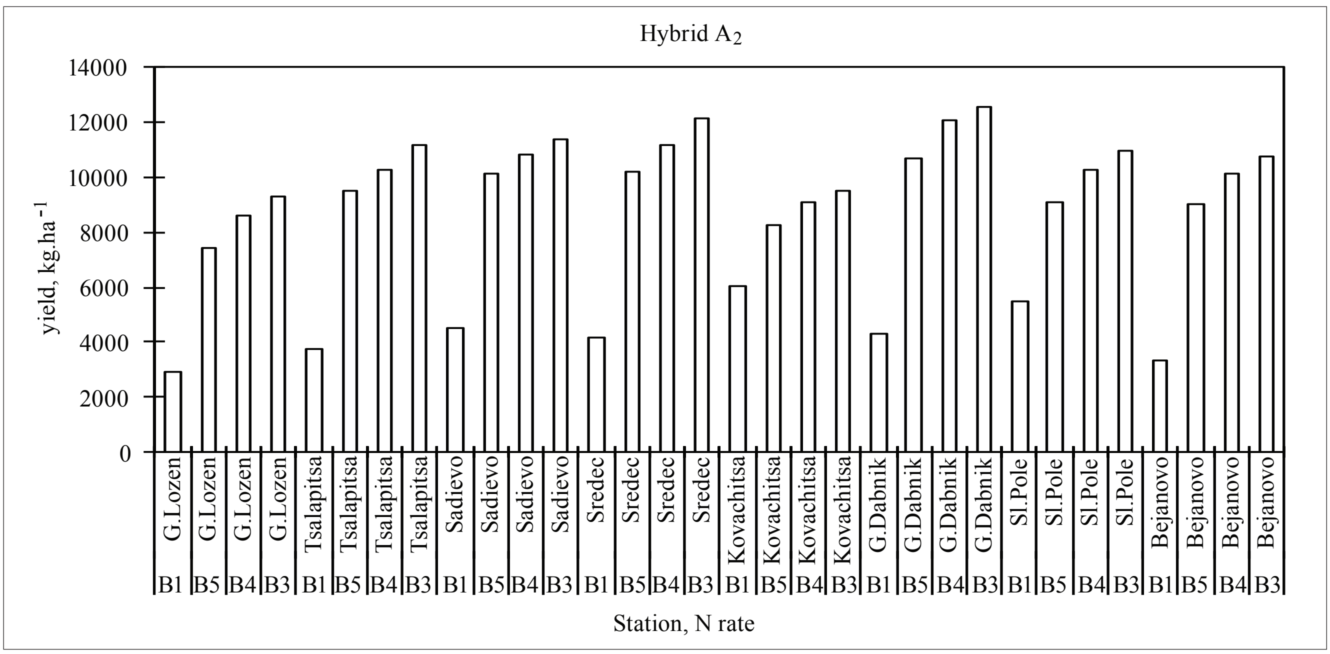

Fig. 2. Maize grain yield for different rates of N fertilization in 8 soil-climatic regions Hybrid A_2 (700 FAO)

higher. In respect of this index, the stations could be set in the following descending order:

Hybrid A_1(400 FAO): Sredec, G.Dabnik, Tsalapitsa, Sadievo, Slivo Pole, Bejanovo, G. Lozen and Kovatchitsa (Figure 1).

Hybrid A_2 (700 FAO): G.Dabnik, Sredec, Sadievo, Tsalapitsa, Slivo Pole, Bejanovo, Kovatchitsa and G. Lozen (Figure 2).

Multifactor ANOVA Analysis of variance (Table 3) was performed in order to investigate the influence of hybrid, soil climatic conditions and rate of N fertilization on maize grain yield.

Factor "N rate" appeared to have the strongest effect on maize yield. Its contribution represented 72.03% of the total variation in yield. The influence of "Hybrid" and "Station" (soil climatic conditions) was quite low – 9.51% and 2.01% respectively (Table 4). Interaction between "N rate" and "Station" also had a statistically significant effect on yield at the 95.0% confidence level, followed by "Station" x "Hybrid" and "N rate" x "Hybrid". Interaction of the tree factors had no influence on the observed variable (Table 3).

The balanced fertilization and cultivation equalize soil differences to some extent as they bring appropriate soil conditions (good stock of nutrition and right soil structure). Irrigation, on the other hand, moderates the influence of climate. Because of these reasons, the contribution of factor "Station" (different soil types and different climatic regions) for variability of maize yield is lowest. If the same analysis for B_1 (control variant, without fertilization) is performed, the effect of climate and soils (marked as "station") is even two time higher than the effect of the hybrid (Table 5).

Table 3
Analysis of Variance for Maize yield - Type III Sums of Squares

Source	Sum of squares	Df	Mean square	F-Ratio	P-Value
Main effects					
A:N rate	6.54E+12	3	2.18E+12	1174.23	0.0000
B:Station	4.27E+11	7	610145.	32.86	0.0000
C:Hybrid	5.47E+11	1	5.47E+11	294.81	0.0000
Interactions					
AB	3.36E+11	21	159850.	8.61	0.0000
AC	182243.	3	60747.8	3.27	0.0206
BC	459378.	7	65625.4	3.53	0.0009
ABC	87369.5	21	4160.45	0.22	0.9999
Residual	1.86E+12	1000	18569.3		
Total (corrected)	9.82E+12	1063			

Table 4
Analysis of Variance –Maize Yield

Source	Sum of squares	Df	Mean square	Var. Comp.	Percent
Total (corrected)	9.82E+12	1063			
Nrate	6.57E+12	3	2.19E+11	81334.9	**72.03**
Station	7.63E+11	28	272424.	2266.77	2.01
Hybrid	6.31E+11	32	197118.	10739.8	9.51
Error	1.86E+12	1000	18569.3	18569.3	16.45

Table 5
Analysis of Variance – Maize Yield (witout fertilization)

Source	Sum of squares	Df	Mean square	Var. Comp.	Percent
Total (corrected)	4.78e+11	265			
Hybrid	746876.	1	746876.	4466.58	21.51
Station	2.14e+11	14	152531.	8721.25	**42.00**
Error	1.89e+11	250	7576.69	7576.69	36.49

Table 6
Regression equations

Station	Hybrid A_1	Hybrid A_2
G. Lozen	Yield = -336,91 + 28,41*Nrate + 0,21*SumT R^2=**0.76**	Yield = -1373,91 + 28,82*Nrate + 0,5*SumT + 0,45*TWU R^2=**0.72**
Tsalapitsa	Yield = 2047,4 + 30,3*Nrate - 0,5*SumT R^2=**0.78**	Yield = -239,698 + 33,28*Nrate + 1,03*TWU R^2=**0.76**
Sadievo	Yield = 555,08 + 26,9*Nrate - 0,03*SumT R^2=**0.82**	Yield = -2,09+ 31,51*Nrate + TWU R^2=**0.72**
Sredec	Yield = 1039,89 + 28,98*Nrate - 0,19*SumT R^2=**0.80**	Yield = 408+ 33,16*Nrate + 0,14* TWU R^2=**0.81**
Kovachitsa	Yield = 2248,6 + 16,14*Nrate - 0,52*SumT R^2=**0.48**	Yield = 1135,47 + 19,30*Nrate - 0,16*SumT R^2=**0.49**
G.Dabnik	Yield = 106,752 + 32,58*Nrate + 0,36* TWU R^2=**0.79**	Yield = -1053,53 + 37,72*Nrate + 0,28*SumT + 0,93*TWU R^2=**0.87**
Sl.Pole	Yield = 691,8 + 24,7*Nrate - 0,07*SumT R^2=**0.74**	Yield = 673,42 + 25,87*Nrate - 0,16* TWU R^2=**0.67**
Bejanovo	Yield= 133,2 + 30,4*Nrate+ 0,05*SumT R^2=**0.81**	Yield = 211,61 + 34,34*Nrate + 0,06*SumT R^2=**0.74**

N rate - rate of nitrogen fertilization - kg/ha
Sum T - sum of temperatures above 10 ^{0}C - ^{0}C
TWU - total water use by crop (precipitation+irrigation rate) - mm.

Regression analysis

Regression analysis for each station were performed in order to evaluate equations (Table 6) for corn yield prediction in stage "wax ripeness". Total water use (TWU) - (precipitation + irrigation rate), temperature sum (Tsum) and N rate as predictors were tested.

N rate and T sum are linearly related to grain yield of the A_1 hybrids at most of the locations and the regressions account for 74% (Sl. Pole) to 82% (Sadievo) of cases. Only for Kovatchitsa the coefficient of determination is lower - 0.48. In the station of G. Lozen and Bejanovo, Tsum appears to be a limitation factor for grain yield.

Beside the above two factors, the TWU also plays an important role for yield formation of hybrid A_2 and it is present as a third predictor in the equations. The coefficients of determination here explain from 67 (Sl. Pole) to 87 % (G. Dabnik) of yield variability. This coefficient is the lowest at Kovatchitsa again.

Conclusions

The highest yield from both hybrids is reported at Sredec (Pellic Vertisol, Climatic region of The East Middle Bulgaria) and G. Dabnik (Haplic Chernozem, Middle climatic region of The Danube Plain) stations and the lowest - at G.Lozen (Vertic Luvisol, Climatic Region of the High fields in the West Bulgaria) and Kovatchica (Calcic Chernozem, Nord climatic region of The Danube Plain).

Factor "N rate" has the highest effect on the total variation of maize yield (72.03 %). The influence of "Hybrid" and "Station" – soil-climatic conditions" is quite low – 9.51% и 2.01% respectively. The high level of agro-technology minimizes the effect of climate and soils on yield variation.

Maize grain yield in the investigated regions at this level of agro-technology is dependent on N rate, temperature sum and total water use. These variables can be successfuly used as yield predictors. The equations are valid for the concrete regions which are objects of the present investigation.

References

Army, J. T. and D. W. Kemper, 1991. Support for long-term agricultural research. *Agronomy Journal*, **83** (1): 62-65.

Benjamin, J. G., D. C. Nielsen and M. F. Vigil, 2003: Quantifying effects of soil conditions on plant growth and crop production. *Geoderma*, **116:** 137–148.

Cai, Z. C. and S. W. Qin, 2006: Dynamics of crop yields and soil organic carbon in a longterm fertilization experiment in the Huang- Huai-Hai Plain of China. *Geoderma*, **136:** 708–715.

Dagdelen, N., E. Yilmaz, F. Sezgin and T. Gurbuz, 2006. Water–yield relation and water use efficiency of cotton (Gossypium hirsutum L.) and second crop corn (*Zea mays* L.) in western Turkey. *Agric. Water Manage.*, **82:** 63–85.

Evett, S. R., T. A. Howell, A. D. Schneider, D. R. Upchurch and D. F. Wanjura, 2000. Automatic drip irrigation of corn and soybean. In: Proceeding of the Fourth Decennial National Irrigation Symposium, November 14–16, Phoenix, AZ.

Evett, S. R., T. A. Howell, A. D. Schneider, D. F. Wanura and D. R. Upchurch, 2001. Water use efficiency regulated by automatic drip irrigation control. In: Proceeding of the International Irrigation Show, October 31–November.

Hollinger, S. E. and R. G. Hoeft, 1986. Influence of weather on year-to-year yield response of corn to ammonia fertilization. *Agron. J.,* **78**: 818–823.

Howell, T. A., J. A. Tolk, A. D. Scheider and S. R. Evett, 1998. Evapotranspiration, yield, and water use efficiency of corn hybrids differing in maturity. *Agron. J.*, **90:** 3–9.

Howell, T. A., 2001. Enhancing water use efficiency in irrigated agriculture. *Agron. J.*, **93:** 281–289.

Huzsvai, L. and J. Nagy, 2005. Effect of weather on maize yields and the efficiency of fertilization. *Acta Agron. Hung.*, **53:** 31-39.

Muchow, R. C., 1988. Effect of nitrogen supply on the comparative productivity of maize and sorghum in a semi-arid tropical environment. III. Grain yield and nitrogen accumulation. *Field Crops Res.,* **18:** 31–43.

Nathan, E. Derby*, Francis X. M. Casey, Raymond E. Knighton and Dean D. Steele, 2004. Midseason Nitrogen Fertility Management for Corn Based on Weather and Yield Prediction. *Agron. J.* **96**: 494-501.

Nathan, E. Derby, D. D. Steele, J. Terpstra, R. E. Knighton and F. X. M. Casey, 2005, Interactions of Nitrogen, Weather, Soil, and Irrigation on Corn Yield. *Agron. J.,* **97:** 1342-1351.

Oberle, S. L. and D. R. Keeney, 1990. Factors influencing corn fertilizer N requirements in the northern U.S. *Corn Belt. J. Prod. Agric*., **3** (4):527–534.

Oktem, A., M. Simsek and A. G. Oktem, 2003. Deficit irrigation effects on sweet corn (*Zea mays saccharata* Sturt) with drip irrigation system in a semi-arid region I. Water-yield relationship. *Agric. Water Manage*., **61**: 63–74.

O'Neill, P. M., J. F. Shanahan, J. S. Schepers and B. Caldwell, 2004. Agronomic responses of corn hybrids from different areas to deficit and adequate level of water and nitrogen. *Agron. J.*, **96:** 1660–1667.

Pandey, R. K., J. W. Maranville and A. Admou, 2000. Deficit irrigation and nitrogen effects on maize in a Sahelian environment. I. Grain yield and yield components. *Agric. Water Manage*., **46:** 1–13.

Sinclair, T. R. and T. Horie, 1989. Leaf nitrogen, photosynthesis, and crop radiation use efficiency: a review. *Crop Sci.,* **29:** 90–98.

Stoyanov, P., 2007. Agroecological potential of maize grown on typical for maize production soils in Bulgaria. Habilitation thesis, Sofia, 226 pp. (Bg).

Stoychev, D., 1997. Ecological aspects of anthropogenic loading of soils. Abstract of thesis Sofia, 76 pp. (Bg).

Teoharov, M., 2004. Correlation of soils reflected on the map and Bulgarian classification with the World Reference Base for Soil Resources (WRBSR, 2002). *Soil Science, Agrochemistry and Ecology*, (4): 3-13 (Bg).

Uhart, S. A. and Andrade, 1995.Nitrogen deficiency in maize. I. Effects on crop growth, development, dry matter partitioning, and kernel set. *Crop Sci.,* **35:** 1376–1383.

Wolfe, D. W., T. C. Henderson, T. C. Hsiao and A. Alvino, 1988. Interactive water and nitrogen effects on senescence of maize. I. Leaf area duration, nitrogen distribution, and yield, *Agron. J.,* **80:** 859–864.

Zand-Parsa, S. and A. R. Sepaskhah, 2001. Optimal applied water and nitrogen for corn. *Agric. Water Manage*., **52:** 73–85.

Received July, 7, 2012; accepted for printing February, 2, 2013.