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Ecophysiological Characterization of Seven Cultivars of Maize (*Zea mays L.*), in the Valley of Tehuacan

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A B S T R A C T

The primary objective of this research was to evaluate the performance of seven maize genotypes function to five levels of nitrogen, in the spring-summer cycle 2014, for evaluating: leaf area index, biomass, yield and harvest index under a design randomized complete block factorial arrangement, low irrigation conditions on the premises Universidad Tecnologica de Tehuacán in Tehuacán Puebla México which is located at 18° 24'51" north latitude, 97° 20'00" west longitude and 1409 meters above sea levela climate Bs_1(w') eg, corresponds to a dry climate with annual mean temperature over 18°C and less than 27 °C, precipitation higher than 400mm and smaller than 600mm rain fall stations. Results indicate that the level of 180kgha^{-1}of N, It presents the maximum values of IAF, biomass and yield, whereas the cultivating Tehuacán, it reached maximum production of biomass and yield, nitrogen x cultivar interaction indicated that the implementationof180kgNha^{-1}in the cultivar Altepexi. Sample the maximum grain yield and this geno type that best suits to the environmental conditions in the study area.

Introduction

Maize (*Zea mays* L.) is considered as a basic crop for Latin American towns, Due to the multiple uses of which it is object within these one can cite: Preparation of tortilla, forage, extraction of syrup of high fructose, extraction of starch(Segovia y Alfaro, 2009; Robutti, 2004) and for the synthesis of biofuels such as bioethanol E_5 and E_{10} (Alvarez, 2009). This crop was domesticated by the ancient cultures that inhabited the valley of Tehuacán-Cuicatlan, as the studies of Richard McNeish in the sixties have shown

(Mc Neish, 1964),who excavating in the cave of the corn in Coxcatlán, Puebla, were able to recover maize germplasm, which when dated by the technique of ^{14}C, managed to locate it in the year 8000 b.c, making it evident that this area was domesticated (Carillo, 2009).The valley of Tehuacán-Cuicatlán, is between the neighboring states of Puebla and Oaxaca and has an extension of 490,186 hectares, the predominant climate is Bs_1 type with dominance of xerophyte scrub (Secretaria de Medio Ambientey Recursos Naturales, 2013).The ecophysiological characterization, this is a technique used to determine the qualities of a genotype to adapt to the environment of a region, due to genotype x environment interaction.

Because maize is a crop that presents a wide adaptability to the different climates and regions where it is planted, it is necessary to perform this characterization for the different materials, and to establish the proper agronomic management for the crop (Gordon, 2006; Perez, 2000).In this regard, Rocandio *et al*., (2014), mention that to understand the breadth of environmental adaptability of the maize crop, it is necessary to evaluate the morphological characters of these materials and classify them into populations to determine their uses.

On the other hand, Navarro *et al.*, (2012), indicate that it is important to characterize the creole materials of the coast of the state of Guerrero, due to its cultural, economic and adaptability to the ecological conditions of the area. Therefore, the main objective of this study was: to characterize seven maize cultivars in the Tehuacán Valley in response to nitrogen fertilization. The hypothesis was: nitrogen fertilization in combination with environmental factors will affect maize crop growth and yield in the Tehuacán Valley, Puebla.

Materials and Methods

The present study was carried out in San Pablo Tepetzingo Tehuacán, Puebla at 18° 24'51 " north latitude, 97° 20'00 " longitude west and 1409 meters of altitude. Under a climate Bs_1 (w ') eg, which corresponds to a dry climate, with annual average temperature higher than 18°C and lower than 27°C,Precipitation greater than 400 mm and less than 600 mm with rainy season from May to September, presence of intraestival drought, temperature fluctuation between the warmest and coldest month greater than 7°C and lower than 14°C and the warmest month occurs before the summer solstice, which occurs in April (Garcia, 2005). The germplasm consisted of seven cultivars of maize, five of free pollination: San Bartolo, San Antonio Cañada, Tehuacán, Cuayucatepec and Altepexi and two hybrids: H-Cimarron and H-7573, which were planted during the month of April 2013, in a vertisol soil with a pH of 7.9 and a C.E, 4.5 dS m^{-1} at 25°C, an initial nitrogen level of 5.4 mg kg^{-1} and 2.5% organic matter. The topological arrangement was (0.17x0.80) resulting in 7.3 plants m^{-2}. The whole experiment was fertilized with 90 kg ha^{-1} of triple calcium superphosphate (46% P_2O_5) and 60 kg ha^{-1} of potassium whose source was potassium chloride (60% K_2O).The response variables were: Index of leaf area which was determined with equation $LAI = \left(\frac{(LA)(PD)}{10000} \right)$ where: LAI, is the leaf area index; LA, Leaf area, PD, population density. The leaf area, was determined by the ratio LA = (L) (A) (0.75), where LA, leaf area; L, sheet length and A, sheet width, (Diaz *et al.*, 2010; Mendez, 1993); Biomass of the aerial part, subjecting the leaves to drying, stems, bracts, inflorescences in a forced air oven at 70° C until reaching constant weight; yield, weighing the ten-grain kernel and obtaining the corresponding average and harvest index,

with the equation, $HI=\frac{AY}{BY}$ where, HI, harvest index; AY, agronomic yield; BY, biological yield (Escalante and Kohashi, 1993).The experiment was evaluated under a randomized complete block design with factorial arrangement, under the mathematical model $Y_{ijk}= \mu+ A_i + B_j+ (AB)_{ij}+ \beta_k+ \varepsilon_{ijk}$ where: Y_{ijk}, is the response variable of the i-th nitrogen level (Factor A) in the j-th maize (Factor B) cultivar in the k-th block;μ, is the true overall mean; A_i, is the i-th level of nitrogen; B_j, is the j-th cultivar; $(AB)_{ij}$, is the interaction of the i-th level of nitrogen in the j-th maize crop; β_k, is the effect of the k-th block and ε_{ijk}, is the experimental error of the i-th level of nitrogen in the j-th maize cultivar in the k-th block (Cochran and Cox, 2008). The study factors were five nitrogen levels: 0, 60, 120, 180 and 240 kg ha^{-1} of N and seven cultivars of maize: San Bartolo, San Antonio Cañada, Tehuacán, Cuayucatepecy Altepexi and two hybrids: H-Cimarron and H-7573 and three replications (5x7x3)= 105 experimental units. To the response variables when these were significant, Tukey's multiple comparison test was applied at a significance level of 5% of error probability.

Results and Discussion

In table 1,we present the analysis of variance for the study factors levels of nitrogen and maize cultivars, in the it can be observed that for the factor nitrogen levels, there were highly significant differences for the variables LAI, biomass and yield. For the cultivars factor, there were only highly significant differences for biomass and yield. With respect to the interaction between both study factors, the nitrogen level per cultivar turned out to be highly significant for biomass and yield. Thus, the coefficient of variability ranged from 14.6 to 27.9%, indicating that the values were reliable, result of adequate data collection. The best response was achieved with the application of 180 kg $ha^{-1}$of N, yielding a yield of 1339.2 g m^{-2}, surpassing 240, 120, 60 and 00 Kg ha^{-1} of N, in percentages ranging from 6.9, 14.2, 23.6 and 29.4%, respectively. These results partially agree with what was reported by Zamudio *et al.*, (2015), who point out that nitrogen is a macro nutrient that significantly influences yield, also report that the maximum yield was obtained with 240 N, when evaluating five hybrids. Regarding biomass and LAI, the best level was 180 N, with 3624.9 g m^{-2} and 3.78 respectively, followed by 240 N level with 3311.6 g m^{-2}, and 3.33, the lowest production of biomass and LAI, was for the control with 2373.1 g m^{-2}, and 2.47 respectively. For the cultivars factor, Tehuacan presented the highest values for yield and biomass with 1350.2 and 3809.4 g m^{-2}, Followed by Altepexi, San Bartolo and San Antonio Cañada with regard to hybrids, H- Cimarrón, presented the highest value with 1070.9 g m^{-2}, Surpassing in an order of 10% to the H – 7573. This partially agrees, as reported by Morales *et al.*, 2014, who evaluated free and hybrid pollination maize in Toluca Mexico, Indicate that the criollos surpassed the hybrids, indicating that the meteorological conditions affect the expression of the genotype of the hybrids.

The interaction nitrogen x cultivar is presented in figure 1. In it is appreciated that the maximum production of dry biomass, was presented in the cultivars San Bartolo, H-Cimarron, Tehuacan and Altepexi when interacting with 180 kg ha^{-1} of nitrogen with 3,432.66, 3,668.00, 4,867.00 and 4,422.33 g m^{-2},while cultivars H-7573 and San Antonio Cañada assigned high biomass values with 240 kg ha^{-1} of N, Cuayucatepec assigned its high values when interacting with 120 kg ha^{-1} of N. Regarding the low values in the biomass allocation, these were presented in the witnesses for all the materials in question.

Table.1 Analysis of variance and comparison of means for seven maize cultivars in the Tehuacan Valley, Spring-Summer, 2014 Cycle

factor	LAI	BIOMASS g m^{-2}	YIELD g m^{-2}	HI
Levels N (A)	***	***	***	ns
00N	2.47 d	2373.1 d	944.9 b	0.38 a
60N	2.77 bc	2731.2 cd	1023.2 b	0.39 a
120N	3.17 bc	3035.1 bc	1149.7 ab	0.37 a
180N	3.78 a	3624.9 a	1339.2 a	0.53 a
240N	3.33 ab	3311.6 ab	1247.2 a	0.38 a
DSH $_{0.05}$	0.557	380	223.1	0.29
Cultivar (B)	ns	***	***	ns
San Bartolo	3.16 a	2885.5 c	1193.4 abc	0.37 a
San Antonio Cañada	3.23 a	3382.1 ab	1173.6 abc	0.35 a
H-Cimarrón	3.19 a	2288.7 d	1070.9 abc	0.45 a
H-7573	3.22 a	2138.4 d	966.3 c	0.43 a
Tehuacán	2.95 a	3809.4 a	1350.2 a	0.37 a
Cuayucatepe	3.05 a	3093.9 bc	973.7 bc	0.32 a
Altepexi	2.93 a	3508.1 ab	1257.7 ab	0.56 a
$SDH_{0.05}$	0.715	487.5	286.2	0.36
A*B	ns	**	**	Ns
CV %	20.8	14.6	22.6	27.9

¶Medias of treatments in the column, with the same literal, statistically they are the same, according to Tukey (P≤0.05); LAI, leaf area index; HI, harvest index; SDH, significant difference honest; CV, coefficient of variation. **;*; n.s, significant at 0.01; 0.05 and no significant.

Fig.1 Interaction between the factors Nitrogen level x cultivar in maize (*Zea mays* L.), for biomass production in the valley of Tehuacan, Puebla.Spring-Summer 2014 Cycle

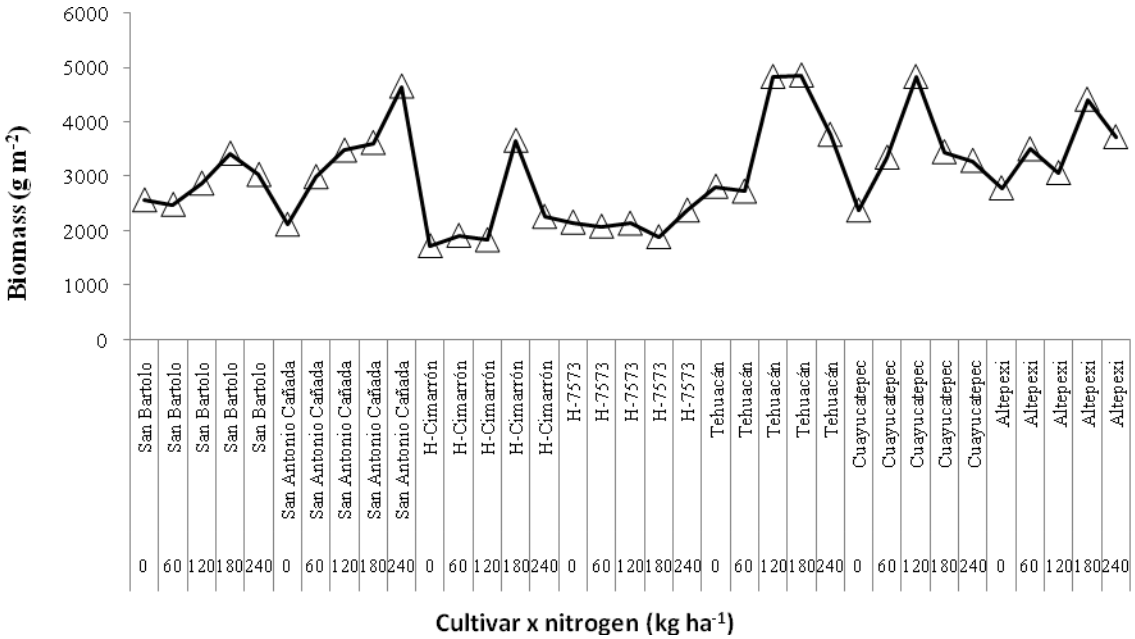
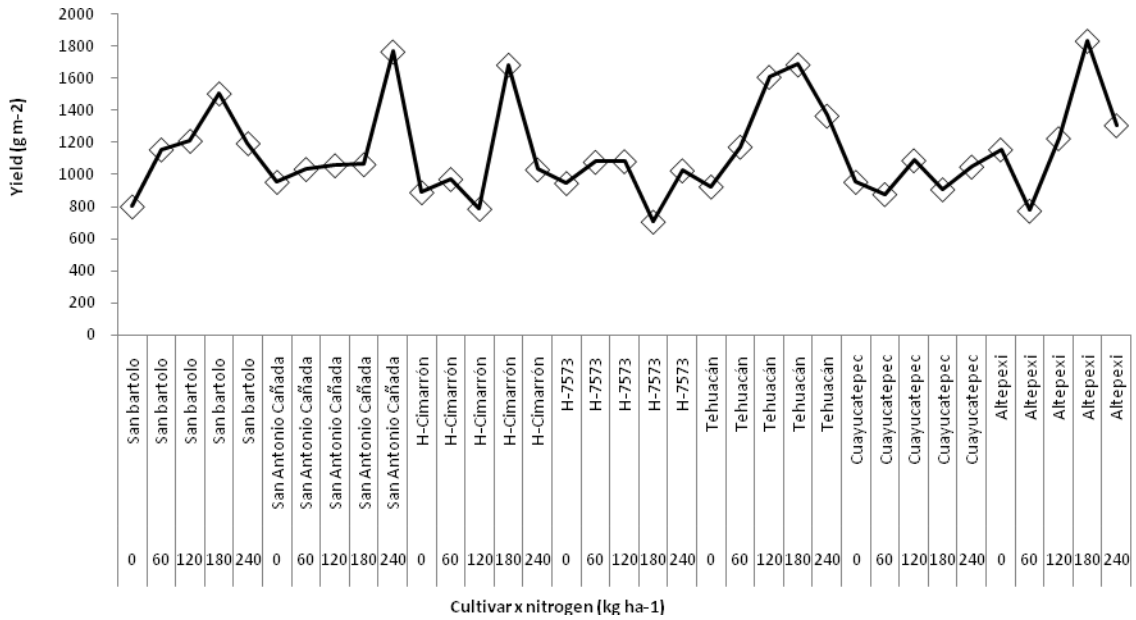


Fig.2 Interaction among the factors Nitrogen level x cultivar in maize (*Zea mays* L.), for agronomic performance in the valley of Tehuacan, Puebla.Spring-Summer 2014 Cycle



The interaction for the nitrogen x cultivar factors for agronomic performance is presented in figure 2. It is possible to observe that the maximum yield for the cultivars San Bartolo, Cimarron, Tehuacán and Altepexi was with a fertilization of 180 kg ha^{-1} of N, with 1503.86, 1682.43, 1684.1 and 1831.60 g m^{-2} respectively, while the cultivars San Antonio Cañada and Cuayucatepec obtained the maximum yields with the application 240 kg ha^{-1} of N, H-7573 only reached its maximum yield with 120 kg ha^{-1} of N with 1080.83 g m^{-2}.

In this respect the cultivar Altepexi surpassed in yield to the cultivars, Tehuacán and Cimarron in 8.05%, while to San Bartolo with 17.89%. These results differ with those reported by Ortiz *et al*., (2013), who worked with the cultivar Altepexi under the conditions of San Pablo Tepetzingo Tehuacán Puebla, Report a yield of 1159.20 g m^{-2} with a fertilization of 180 kg ha^{-1}, Being 36.6% less than reported in the present study, these differences may be due to the different years in which the present studies were carried out, as well as to the amount of rain that occurred in those years.

From the genetic materials and nitrogen levels evaluated in the present investigation, the following conclusions were derived:

The best nitrogen dose was 180 kg ha^{-1}, producing the highest LAI, biomass and yield values. From the cultivars factor, Tehuacán presented the highest biomass and yield expression. The cultivar x nitrogen interaction showed that Altepexi when interacting with a level of 180 kg ha^{-1} observed the highest yield, in addition to a better adaptability to the study area.

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