INTERNATIONAL CONFERENCE ON

BALANCED NUTRIENT MANAGEMENT FOR TROPICAL AGRICULTURE

↗ 12-16th APRIL 2010

↗ SWISS GARDEN RESORT & SPA,
KUANTAN, PAHANG, MALAYSIA

ABSTRACT

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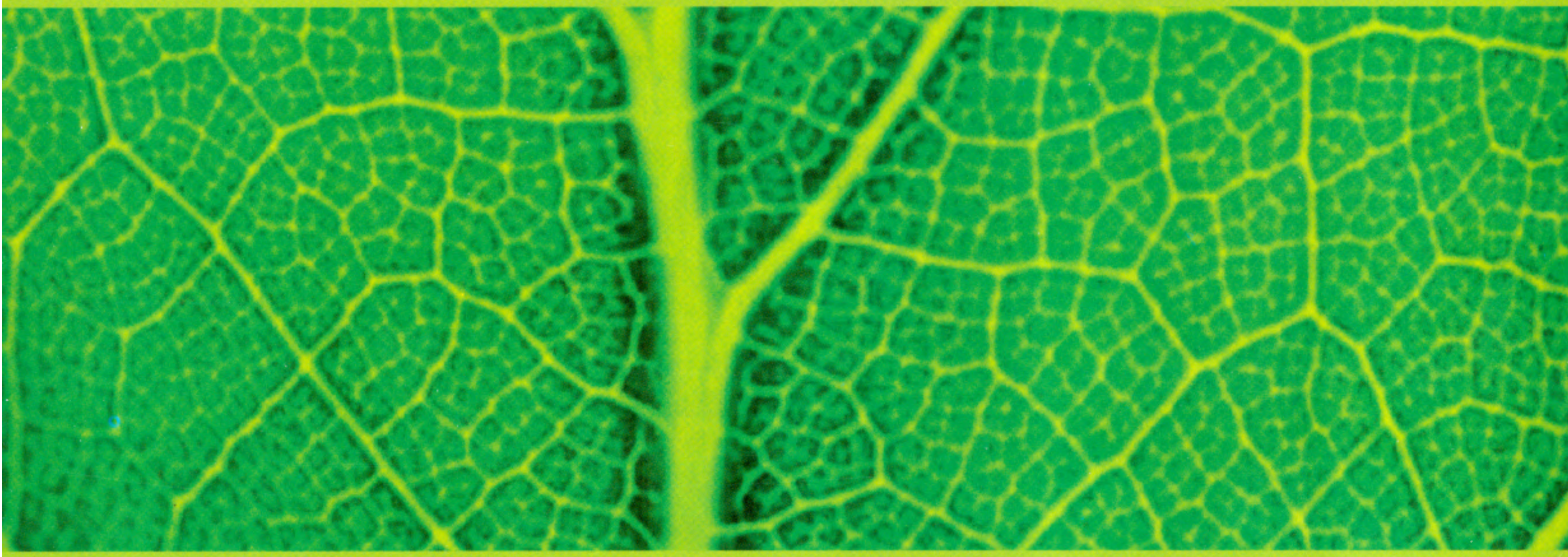

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POSTERS:

EMPIRICAL EQUATIONS TO SHOW THE RELATIONSHIP BETWEEN PLANTING DENSITY AND LEAF AREA INDEX, TOTAL DRY MATTER AND GRAIN YIELD OF MAIZE

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INTRODUCTION

Golestan Province is located in northern Iran near the Caspian Sea. It has a Mediterranean weather: cool in spring and warm in the summer. Corn is usually planted in two seasons per year: mid-April as a main crop and mid-June as a second crop after wheat harvest. Crowding stress or planting density is a major factor in determining the degree of competition between plants. Yield per plant decreases as the crowding stress increases. Reduction in yield is mostly due to lower ears (barrenness) (Hashemi-Dezfouli et al, 2005), fewer kernels per ear (Capristo et al., 2007), lower kernel weight (Monneveux et al., 2005), or a combination of these components. Grain yield per unit area is the product of grain yield per plant and planting density. The optimum plant population is influenced by planting date (Norwood, 2001), hybrid/variety (Edwards et al., 2005; Sarlangue et al., 2007), soil fertility (Polito, 1987), and water limitation (Nielsen et al, 2002). Many researchers observed a quadratic trend between planting density and TDM and grain yield per unit area in maize (Selamat, (1987); Duncan, (1984); Hashemi-Dezfouli et al, (2005), and Sarlangue et al., (2007)). The objective of this study was to develop the empirical equations to show the relationship between planting density and LAI, TDM, and grain yield of maize in northern Iran in without water and nutrient stress condition.

MATERIALS AND METHODS

Two field experiments were conducted as a Randomized Complete Block Design on 19th April (as a main crop) in 2007 and 2008 in Agricultural Research Center of Golestan - Iran (36° 53' N, 54° 21' E). A late- maturing hybrid (Sc 704) was planted in both experiments. In 2007, each experiment included three planting densities (0.16, 4.5, and 6.5 plants m^{-2}) with four replications and in 2008, each experiment included seven planting densities (0.16, 2.5, 4.5, 6.5, 8.5, 10.5 and 12.5 plants m^{-2}) with four replications. The low planting density (0.16 plants m^{-2}) was to obtain the potential growth and yield of maize without competition by other maize plants, single plants were planted next to the main experiment. Eight plants with 2.5 m distance of each other were planted in quadrate shape in both years. Four of eight plants were used to the harvest and the rest used for leaf area measurement. In the main experiment, each plot contained four rows with seven meters in length. The distance between rows was 75 cm and planting densities were changed with changing distance between plants row^{-1}. Distance between plants row^{-1} were 53.5, 30, 20, 15.7, 12.7, 10.7 cm for planting densities 2.5, 4.5, 6.5, 8.5, 10.5, and 12.5 plant ha^{-1}respectively. Both experiments were conducted without any water and nutrient limitation. Soil water was kept over 50% of field capacity during the growing season by furrow irrigation. Fertilizers were applied based on soil test results. A broadcast application of 60- 45-100 kg ha^{-1} (N-P-K) was incorporated into the seedbed. Additional 100 kg ha^{-1}N was applied as side dressing at 5 and 9-leaf stage (50 kg ha^{-1} in each stage). Weeds and insects were adequately controlled during the growing seasons. In order to measure leaf area index, four plants were cut from the end of two central rows considering border effect after flowering stage and leaf area measured using the equipment "Area Measurement System" (Delta-T Devices Ltd, Cambridge, UK). To calculate total dry matter and grain yield, 5 meters of two central rows considering border effect were harvested in each plot. After separating the different parts of the plants

including (stem + leaf + tassel), cob, husk and grain, the fresh weight were measured and a sample of each part then dried to a constant weight at 75°C for about three days. Dry weights were recorded based on 14% humidity in each part. Using Microsoft Excel 2007, the data of the second year experiment (the mean values of four replications of each trait in each planting density), were used to fit the best equations, to show the relationship between planting density and different traits including; LAI , TDM plant^{-1}, TDM m^{-2}, grain yield plant^{-1}, and grain weight m^{-2}.
To evaluate the accuracy of the developed equations data from the first year experiments were used. Models validity was tested using two goodness of fit indicators; the root mean square error (RMSE), and the index of agreement (*d*) (Willmott et al., 1985). Their formulae are as follows:

$$d = 1 - \frac{\sum_{i=1}^{N} |y_i - \hat{y}_i|}{\sum_{i=1}^{N} (|\hat{y}_i - \bar{y}| + |y_i - \bar{y}|)} \qquad RMSE = \sqrt{\frac{\sum_{i=1}^{N} (y_i - \hat{y}_i)^2}{N}}$$

Where y_i , $\hat{y}_i$ are the observed and predicted y values, respectively, and $\bar{y}$ is the mean of the entire N observed y values. Low values of RMSE illustrate high accuracy whereas high *d* indicates high accuracy.

RESULTS AND DISCUSSIONS

With increasing planting density LAI increased and its high value (6.22) observed in planting densities between 10.5 -12.5 plants m^{-2}. Using the second year experimental data, a quadratic equation with high R square ($R^2 = 0.99$) were fitted to show the relationship between planting density and LAI (Table 1 and Fig. 1). The developed equation using 2008 experimental data werê tested against first year experimental data using two goodness of fit indicators RMSE and *d*. The low values of RMSE (= 0.36) and the high values of *d* (= 0.91) showed that the developed equations can predict LAI with high accuracy in different planting densities (Table 1).

Table 1. The developed equations to show the relationship between planting density and LAI, TDM, and grain yield using second year experimental data. Root maen square error (RMSE) and the Index of agrement (*d*) were used to show the validity of the developed equations using the first year experimental data.

Traits	Equations	R^2	RMSE	*d*
LAI	$Y_1 = -0.0336 X^2 + 0.9468 X - 0.1421$	0.993	0.36	0.91
TDM (kg ha^{-1})	$Y_2 = -429.88 X^2 + 6493.2 X + 1111.8$	0.976	2416.9 (kg ha^{-1})	0.88
Grain (kg ha^{-1})	$Y_3 = -167.6 X^2 + 2672.2 X + 511.77$	0.992	405.8 (kg ha^{-1})	0.95

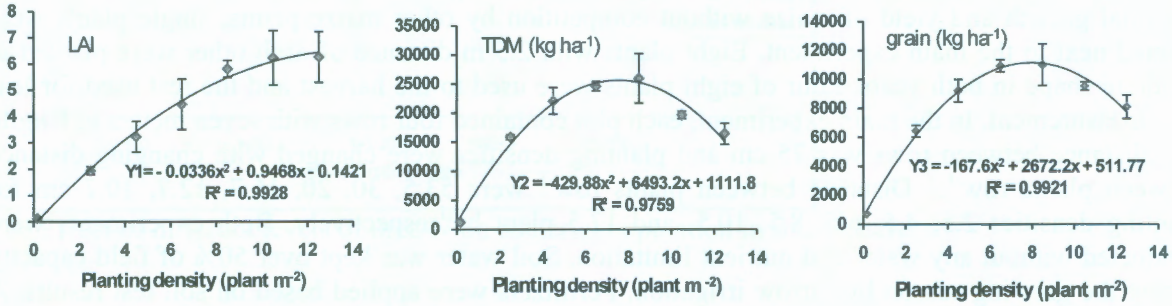

Fig 1. The relationship between planting density and LAI, TDM(kg ha^{-1}) and grain yield (kgha^{-1}).

Total dry mater per unit area increased when planting density increased. This trend continued until planting densities between 6.5- 8.5 plants m^{-2}(24600 – 25900 kg ha^{-1}), then TDM start to decrease with increasing planting density. Using the second year experimental data the best equation was fitted to show the relationship between planting density and TDM ha^{-1}. A quadratic trend was observed and the result showed that the slope of the fitted curve was zero between planting densities 6.5- 8.5 plants m^{-2} practically (Table 1 and Fig. 1). The developed equation using 2008 data were tested against first year experimental data. Low value of RMSE (2416 kg ha^{-1}) and high value of *d* (0.88) for the developed equation showed that this equation can predict TDM with high accuracy in different planting density (table 1). In consistent with this study, many researchers observed quadratic trend between planting density per unit area and TDM (Selamat, (1987); Duncan, (1984); Hashemi-Dezfouli et al, (2005), and Sarlangue et al., (2007)).

With increasing planting density grain yield per unit area increased until planting densities between 6.5- 8.5 plants m^{-2} then grain yield started to decrease with increasing planting density. Using the second year experimental data a quadratic function was fitted to show the relationship between yield ha^{-1} (Y_3) and planting densities (X) (Table 1, Fig 1). The result showed that the sloped of developed curve was almost zero in range 6.5- 8.5 plants m^{-2} and highest grain yield observed in this range (24600 – 25900 kg ha^{-1})The developed equation to show the relationship between planting density and grain yield were tested against first year experimental data. Low value of RMSE (406 kg ha^{-1}) and high value of *d* (0.95) for the developed equation showed that this equation could predict grain yield with high accuracy in different planting densities. Duncan, (1984); Selamat, (1987); Hashemi-Dezfouli et al, (2005); and Sarlangue et al., (2007) found the same relationship between planting density and grain yield.

CONCLUSION

High accuracy of the developed equations showed that the equations could be used to predict LAI, TDM, and grain yield of maize in northern Iran, in no water and nutrient stress condition. Because yield per unit area is highly depend on weather and soil condition, the developed equations could not be used to predict these traits in other regions and the same experiments should be conducted to develop appropriate equations in other regions.

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