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AGRO-PHYSIOLOGICAL TRAITS OF THREE MAIZE HYBRIDS AS INFLUENCED BY VARYING PLANT DENSITY

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ABSTRACT

Production potential of maize hybrids is determined through their yield and yield contributing attributes, but sometimes maize hybrids are evaluated on the basis of their agro-physiological traits particularly when they are subjected to different plant density levels. For this purpose, an experiment was conducted on a sandy clay loam soil at Government Agricultural Extension Farm, Model Town – A, Bahawalpur. The experiment was laid out in randomized complete block design with split plot arrangement, randomizing maize hybrids (30 DSS, pioneer 3012 and pioneer 3062) in main plots and plant density levels in subplots with four replications. The data were analyzed by the "Mstat" statistical package. It was observed that Pioneer-30D55 surpassed all other two hybrids (Pioneer-3012 and Pioneer-3062) with respect to all agro-physiological traits i.e leaf area index at 75 DAS, leaf area duration (30-90 DAS), and dry matter accumulation (30-90 DAS) with significant variation between them. All the aforementioned traits increased progressively with periodic time period of 15 days, with increase in plant density from 40816 to 95238 plants ha^{-1} and reverse was found to be true for net assimilation rate. Interactive effects of maize hybrids and plant density levels on all the traits under study were found to be non significant. It is suggested that among these three hybrids Pioneer-30D55 should be preferably cultivated at plant density level 98235 plants ha^{-1}.

Key words: Maize hybrids, plant density levels, agro-physiological traits

INTRODUCTION

Maize grain yield is more affected by variations in plant density than other members of the grass family due to its monoecious floral organization, its low tillering ability and the presence of a brief flowering period (Vega *et al.,* 2001). At present in Pakistan, diverse maize genotypes, *i.e*. single cross and double cross hybrids, synthetics and composites are being grown. These genotypes respond differently to various agro management practices especially plant density in the form of different agro-physiological parameters. This variable response is mainly due to differences in Leaf Area Index (LAI) (Azadgoleh and Kazmi , 2007), Leaf Area Duration (LAD) (Liu *et al*., 2004, Stehli *et al*., 1999), intra-specific competition in maize plants (Maddonni and Otegui, 2006), crowding stress tolerance (Tollenaar and Lee, 2002), Dry Matter Accumulation (DMA) (Din *et al*., 2008, Brenda *et al*., 2006, Monneveux *et al*., 2005) and net assimilation rate (NAR) (Luque *et al*., 2006) of different maize hybrids. These genotypes have the ability to with stand high plant density due to more because of their genetic potential.

Plant density exerts a strong influence on maize growth, because of its competitive effect both on the vegetative and reproductive development (Singh and Chaudhry, 2008). Grain yield increases linearly with plant density until some competitive effects become apparent (Abolhassan *et al.,* 2005). Effects of plant density normally refer to number of plants per unit area, but spatial arrangement of plants should also be considered (Ma *et al*., 2007, Naeem, 1998). Plant density effects are highly pronounced in crops such as maize, where there is no possibility of filling gaps between plants by branching or tillering. With increase in plant density tends to decrease in LAI per plant but increase LAI per unit area (Luque *et al*., 2006, Liu *et al*., 2004), thus increasing LAD (Ma *et al*., 2007, Maddonni *et al*., 2001) and DMA per unit area (Reddy and Reddi, 2004, Maddonni *et al*., 2001, Andrade *et al*., 1999). However, NAR is progressively decreased (Mohsan, 1999, Naeem, 1998). So, an appropriate plant stand may help in harnessing all the renewable and non renewable resources in a more and efficient manner towards higher crop yields (Sparlangue *et al.,* 2007).

In view of immense importance of LAI, LAD, DMA and NAR in proper plant density for maximizing maize productivity, the present study was designed to study the effect of different plant density levels on agro-physiological traits of different maize hybrids under site specific conditions of Bahawalpur, Pakistan, so that maximum potential of these maize hybrids could be exploited.

MATERIALS AND METHODS

The experiment was conducted on a sandy clay loam soil at Government Agricultural Extension Farm, Model Town – A, Bahawalpur. The climate of the region is semi-arid and subtropical. The experimental area is located at 30°.12' North, 71'.26' East and at an altitude of 120 meters above sea level. As soil of the experimental area was quite uniform, a composite and representative soil sample to a depth of 30 cm was obtained with soil auger, prior to sowing of the crop. Percentage of sand, silt and clay was determined by Bouyoucos hydrometer method using one percent sodium hexametaphosphate as a dispersing agent. Textural class was determined by using the international textural triangle (Moodie *et al.*, 1959). Soil was analyzed for its various chemical properties by using the methods as described by Homer and Pratt (1961). The soil was sandy clay loam containing 65% sand, 15% silt and 20% clay. Its chemical characteristics included saturation 36%, pH 7.9, EC_e 1.3 dS m^{-1}, organic matter 0.83%, total nitrogen 0.083%, available phosphorous 1 ppm, and available K 125 ppm.

The experiment was laid out in randomized complete block design with split plot arrangement, randomizing maize hybrids (H_1= Pioneer-3012, H_2= Pioneer-3062, H_3= Pioneer – 30D55) in main plots and plant density levels (P_1 = 15 cm x 70 cm (95238 plants ha^{-1}), P_2 = 25 cm x 70 cm (57142 plants ha^{-1}) and P_3 = 35 cm x 70 cm (40816 plants ha^{-1}) in subplots with four replications. The net plot size measured 3.5m x 7m.

Before seed bed preparation, presoaking irrigation of 10 cm was applied. The seed bed was prepared by giving four cultivations with a tractor mounted cultivator. Each time soil was cultivated to a depth of 8-10 cm. Planking was given, after every two times cultivations. The crop was planted on August 3, 2005 and August 7, 2006. The seed was drilled with the help of single row-hand drill using seed rate 30 kg ha^{-1}. The NPK was applied @ 300, 200, 100 kg ha^{-1}, respectively. Urea, diammonium phosphate and sulphate of potash were used as sources of N, P and K fertilizers, respectively. All potash, phosphatic and half dose of N fertilizer was applied at the time of sowing, while the remaining N was top dressed at first irrigation stage of the crop. In addition to rainfall received during the growing period of the crop, six irrigations were applied as and when needed at different plant developmental stages till the physiological maturity of the crop. Every irrigation turn was of 7.5 cm. The first irrigation was given ten days after sowing (DAS).

The crop was kept free of weeds by hoeing twice and hand weeding to avoid weed crop competition. Sunfuran was applied @ 20 kg ha^{-1} with second irrigation against stem borer control. All other agronomic operations except the ones under study were kept normal and uniform for all the treatments. Crop was harvested manually on November 11, 2005 and November 16, 2006. After harvesting, the plants were left in the field for two days and thereafter, tied into bundles and stalked for 4 weeks. Then the cobs were separated from the stalk and allowed to dry in sunshine for a few days before threshing.

Procedures used for recording the data pertaining to the above mentioned parameters were the same during both years and are detailed as under.

Net assimilation rate (NAR) was determined by the formula given by Hunt (1978).

$$NAR = \frac{TDM}{LAD}\left(g\ m^{-2}\ day^{-1}\right)$$

Where TDM = Total dry matter, LAD= Leaf area duration and

$$LAD = (LAI_1 + LAI_2) \times (t_2 - t_1) \times ½, \text{ (Hunt, 1978).}$$

Where LAI_1 = Leaf area index at t_1, LAI_2 = Leaf area index at t_2, t_1= Time of first observation, t_2= Time of second observation,

Leaf Area Index (LAI) was calculated from the following formula:

$$LAI= \frac{\text{Leaf area}}{\text{Land area}} \text{ (Watson, 1952).}$$

The data were analyzed through analysis of variance technique (Freed and Eisensmith, 1986). Least significant differences (LSD) test (P<0.05) was applied to determine the significance of the treatment means. Simple correlation coefficients and regression equations for leaf area duration and dry matter accumulation were also computed (Steel *et al.*, 1997). The computer Hard Graphics was used to prepare the graphs.

RESULTS AND DISCUSSION

Leaf Area Index (75 DAS): LAI of a crop at a particular growth stage indicates its photosynthetic potential or the level of its DMA. The more LAI, the higher will be the DMA potential of the crop and vice versa. The data on periodic LAI of the crop as affected by different maize hybrids and plant density levels during 2005 and 2006 are depicted in Fig. 1. The LAI was low in the beginning (30 DAS), but with significant variation among the maize hybrids and plant density levels in both years. It increased progressively with the advancement of the growth period and reached the maximum at 75 DAS and thereafter declined at 90 DAS.

LAI of maize crop as affected by various maize hybrids and plant density levels are depicted in Table.

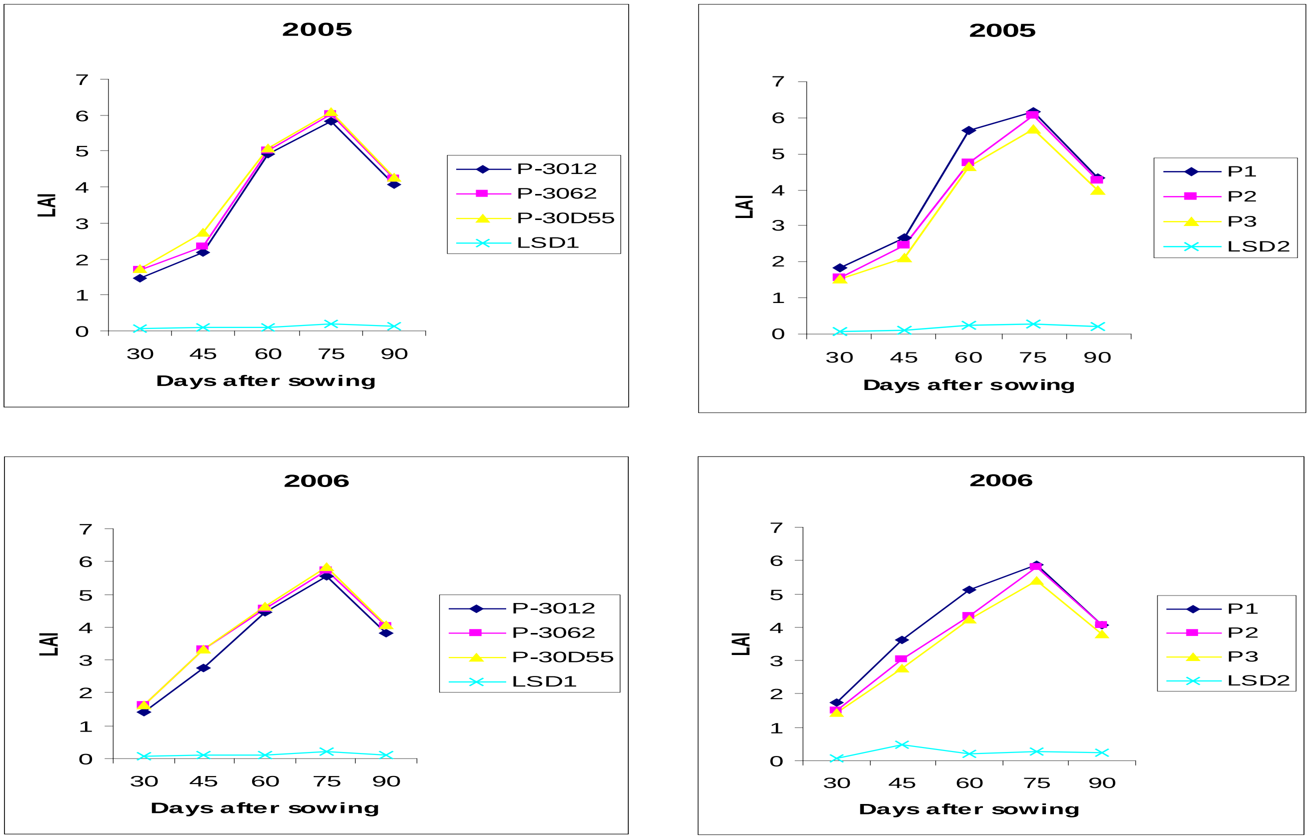

Fig. 1 Periodic Leaf Area Index as influenced by maize hybrids and Plant Density during 2005 and 2006

Pioneer-30D55 (5.82) exhibited significantly more LAI than Pioneer-3012 (5.55), which was also at par with Pioneer-3062 (5.74). Likewise, Pioneer-3062 was also at par with Pioneer-3012. The lowest LAI for Pioneer-3012 was attributed to the smallest LA plant^{-1} (data not shown) due to less number of leaves plant^{-1} and less leaf breadth. Differential response of maize hybrids regarding LAI has also been reported by Azadgoleh and Kazmi (2007), Luque *et al.* (2006) Liu *et al.* (2004), and Stehli *et al.* (1999).

LAI was significantly affected by various plant density levels. Crop planted at plant density 95238 plants ha^{-1} significantly increased LAI (5.88) than LAI (5.41) in crop planted at plant density 40816 plants ha^{-1}, but at par for LAI (5.82) at plant density 57142 plants ha^{-1}. Although increase in plant density caused significant reduction in LA plant^{-1} (data not shown) due to small leaf size yet ground area per plant decreased more steeply with increasing number of plants per unit area that led to an increase in LAI. Interactive effects of maize hybrids and plant density levels on LAI were, however, non-significant in both years. The results are in accordance to the findings of the Ma *et al.* (2007), Maddonni *et al.* (2001), Mohsan (1999) and Naeem (1998), who reported that by increasing plant density, LAI was also increased correspondingly. In addition to this, it increased plant sterility, when it exceeded above a certain limit.

Leaf Area Duration (30-90 DAS): The data pertaining to Leaf Area Duration (LAD) recorded at fortnightly interval by different maize hybrids and plant density levels are depicted in Fig. 2. LAD increased in a linear fashion with progressive increase in growth period and reached its maximum values during 75-90 days crop growth intervals showing significant variation among maize hybrids and plant density levels.

LAD was significantly higher in Pioneer-30D55 than Pioneer-3062 and Pioneer-3012 with corresponding values of 176.33, 168.26 and 161.34, respectively. These results are in agreement with the findings of Luque *et al.* (2006), Liu *et al.* (2004), and Stehli *et al.* (1999), who stated that maize hybrids differed for their LAD due to different genetic potential.

There was significant variation among the plant density levels in respect of LAD. Crop planted at plant density 95238 plants ha^{-1} significantly produced more LAD (188.33) against 165.16 and 155.96 at plant density 57142 plants ha^{-1}and at plant density 40816 plants ha^{-1}, with significant variation between them. Interactive effects of maize hybrids and plant density levels on LAD were, however, non significant in both years. These results corroborate with the findings of Ma *et al.* (2007), Maddonni *et al.* (2001), Mohsan (1999) and Naeem (1998), who stated that increase in plant density decreased leaf efficiency to do photosynthesis due to shading effect, on account of which LAD also decreased.

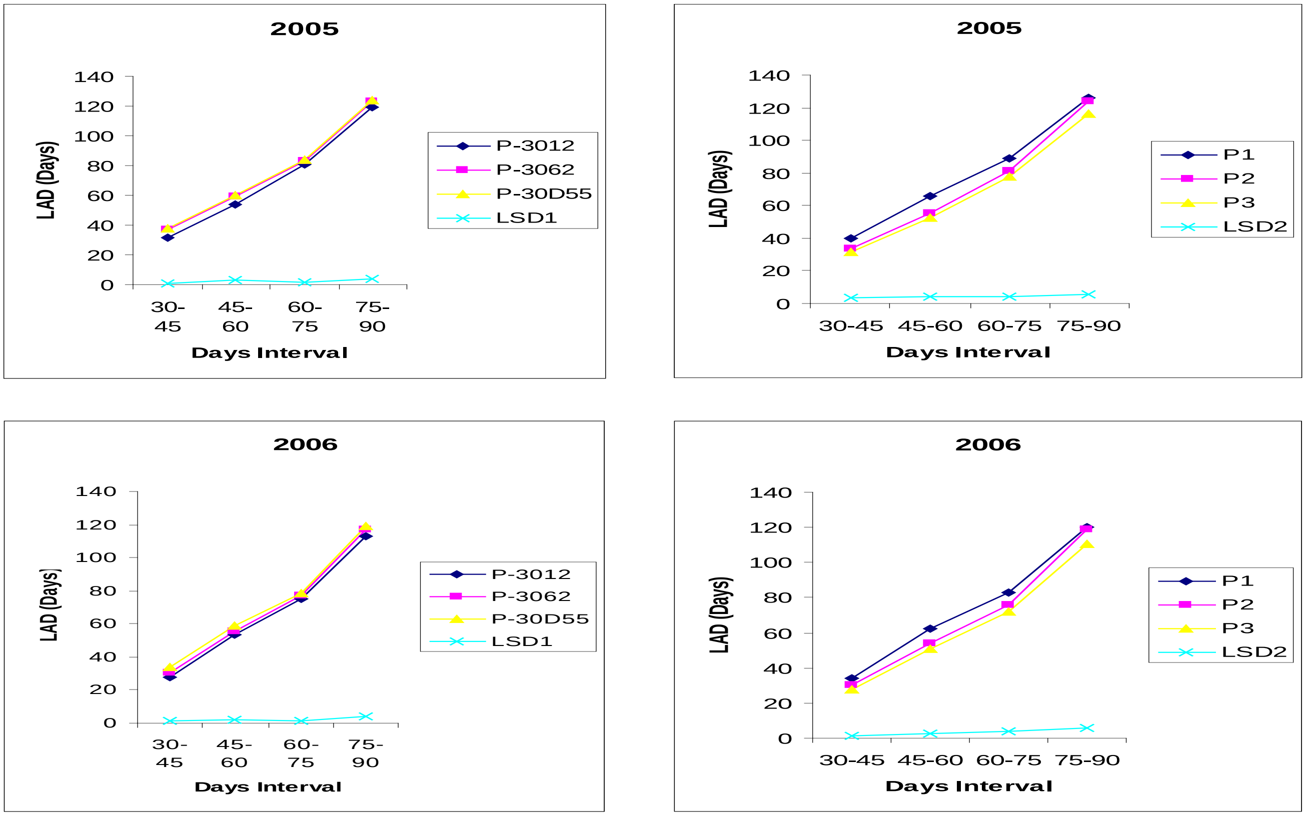

Fig. 2 Periodic Leaf Area Duration (Days) as influenced by maize hybrids and Plant Density during 2005 and 2006

Dry Matter Accumulation (30-90 DAS): The data pertaining to DMA recorded at fortnightly interval by different maize hybrids and plant density levels for both years are depicted in Fig. 3. The DMA increased in a linear fashion with progressive increase in growth period by different maize hybrids and plant density levels and reached its maximum value at 90 DAS.

There was significant variation among the maize hybrids with regard to DMA (as shown in Table). Pioneer-30D55 produced significantly more DMA (1324.18 g m^{-2}) against 1220.62 g m^{-2} and 1064.91 g m^{-2} in Pioneer-3062 and Pioneer-3012 with significant variation between them. These results corroborate with those of Din *et al*., (2008), Azadgoleh and Kazmi (2007), Brenda *et al.* (2006), Monneveux *et al.* (2005) and Stehli *et al.* (1999), who reported that maize hybrids differed with each other due to difference of their ability of DMA.

Different plant density levels also exhibited significant variation among themselves in respect of DMA. Crop planted at plant density 95238 plants ha^{-1} produced significantly more DMA (1329.12 g m^{-2}) against 1252.36 g m^{-2} and 1100.44 g m^{-2} at plant density 57142 plants ha^{-1} and at plant density 40816 plants ha^{-1}, with significant variation between them. Although increase in plant density resulted in substantial reduction in DMA per plant (data not shown), yet DMA per unit area increased significantly due to higher number of plants per unit area. Interactive effects of maize hybrids and plant density on DMA were, however, non significant. These results are in harmony with the findings of Andrade *et al.* (1999), Ma *et al.* (2007), Reddy and Reddi (2004), Maddonni *et al.* (2001), Mohsan (1999), Naeem (1998), and Singh and Choudhary (2008), who reported that increase in plant density increased DMA, due to more LA per unit area as the canopy expanded more rapidly, more radiation was intercepted and more dry matter produced.

Net Assimilation Rate (30-90 DAS): There was significant variation among maize hybrids with regard to NAR (as shown in Table). Pioneer-30D55 significantly produced more NAR (4.51 g m^{-2} day^{-1}) than 4.29 g m^{-2} day^{-1} and 4.32 g m^{-2} day^{-1} for Pioneer-3012 and Pioneer-3062, respectively. These results are in agreement with the findings of Azadgoleh and Kazmi (2007), Luque *et al.* (2006) and Stehli *et al.* (1999), who stated that maize hybrids differed in their LA, DMA and improved partitioning of assimilates from roots to cob.

Different plant density levels also exhibited significant variation among themselves in respect of NAR. Crop planted at plant density 40816 plants ha^{-1}, produced significantly more NAR (4.81 g m^{-2} day^{-1}) against 4.53 g m^{-2} day^{-1} and 3.79 g m^{-2} day^{-1} at plant density 57142 plants ha^{-1}and at plant density 95238 plants ha^{-1}, respectively, with significant variation between them. Low NAR at high plant density was ascribed to proportionally less increase in DMA per unit area as compared to increase in LAD and LAI.

These results are in line with the findings of Ma *et al.* (2007), Maddonni *et al.* (2001), Mohsan (1999) and Naeem (1998), who stated that increase in plant density decreased NAR.

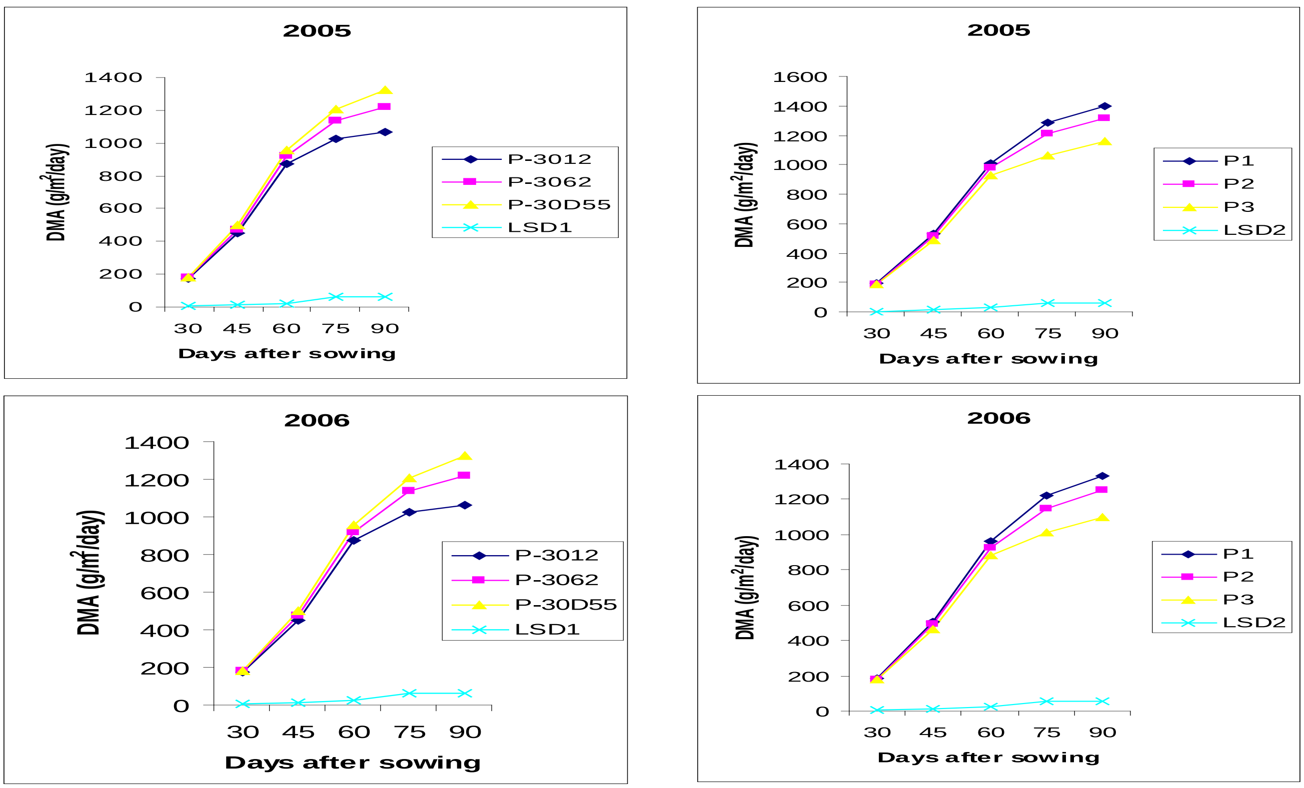

Fig. 3 Periodic Dry Matter Accumulation (g m^{-2}) as influenced by maize hybrids and Plant Density during 2005 and 2006

The simple linear correlation analysis applied to measure the degree of linear association between DMA and LAD was highly significant and positive during both years. It was in linear fashion with interdependence of two characters with regression accounted 0.6610 and 0.7768 during 2005 and 2006, respectively as shown in Fig. 4. It was obvious from the regression line that with an increase in LAD , there was a corresponding increase in DMA, as the sufficient time was made available to leaves to do photosynthesis to prepare assimilates.

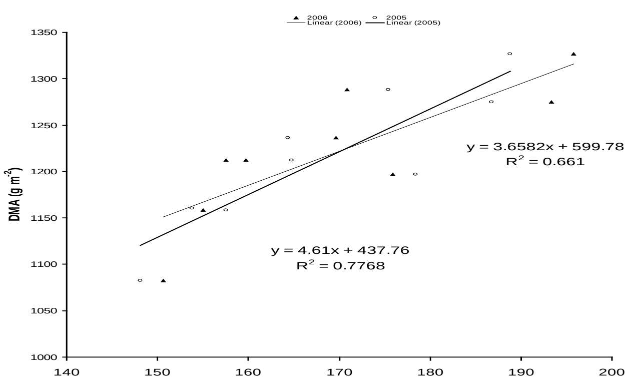

Fig. 4 Relationship between dry matter accumulation and leaf area duration during 2005 and 2006

Table 1. Agro-physiological Characteristics of three maize hybrids to varying plant density (Mean of two years)

Treatment	Max. Leaf Area Index (75 DAS)	Mean Leaf Duration (Days) 90 DAS	Max. Dry Matter Accumu-lation ($g\ m^{-2}$)	Net Assimilation Rate (30-90 DAS) ($g\ m^{-2} day^{-1}$)
A- Maize Hybrids (H)				
H_1:Pioneer 3012	5.55^{b}	161.34^{c}	1064.91^{c}	4.29^{b}
H_2:Pioneer 3062	5.74^{ab}	168.26^{b}	1220.62^{b}	4.32^{b}
H_3:Pioneer 30D55	5.82^{a}	176.33^{a}	1324.18^{a}	4.51^{a}
LSD (a)	0.1947^{*}	5.5941^{*}	64.0611^{*}	0.1652^{*}
B- Plant Density Levels (PD)				
P_1: 15 cm x 70 cm (95238 plants ha^{-1})	5.88^{a}	188.33^{a}	1329.12^{a}	3.79^{c}
P_2: 25 cm x 70 cm (57142 plants ha^{-1})	5.82^{a}	165.16^{b}	1252.36^{b}	4.53^{b}
P_3: 35 cm x 70 cm (40816 plants ha^{-1})	5.41^{b}	155.96^{b}	1100.44^{c}	4.81^{a}
LSD (b)	0.2779^{*}	9.9151^{*}	56.7838^{*}	0.1328^{*}
C-Interaction (H × PD) N.S				
CV= %	9.32	6.81	7.26	9.51

Any two means not sharing common letter differ significantly with each other at 5 % level of probability N.S= Non significant

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