PRODUCTION POTENTIAL OF THREE MAIZE HYBRIDS AS INFLUENCED BY VARYING PLANT DENSITY

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A field experiment to evaluate the production potential of three maize hybrids namely Pioneer-30D55, Pioneer-3062, and Pionerr-3012 to varying plant density of P_1 (15 cm x 70 cm or 95238 plants m^{-2}), P_2 (25 cm x 70 cm or 57142 plants m^{-2}), and P_3 (35cm x 70 cm or 40816 plants m^{-2}) was conducted at Govt. Agricultural Extension Farm, Bahawalpur, Pakistan, during 2005 and 2006. Experiment was laid out in randomized complete block design with split plot arrangement, including maize hybrids in main plot and plant density levels in sub plots with four replications. Maize hybrids responded differently to plant density due to their different genetic potential. Pioneer-30D55 surpassed other hybrids *i.e* Pioneer-3062 and Pioneer-3012 in crop growth rate (22.28 g $m^{-2}day^{-1}$), grain yield (6.16 t ha^{-1}), crude protein (7.76 %) contents in grains, where as Pioneer-3012 surpassed other hybrids in crude starch (72.40 %) and oil contents (5.41 %) in grains with significant variation between them. Among various plant density levels, crop planted at 95238 plants ha^{-2} significantly increased crop growth rate (24.93 g m^{-2} day^{-1}), grain yield (6.37 t ha^{-1}), crude starch (71.79 %) and protein content (7.45 %) in grains than rest of the plant density levels *i.e* P_2 (57142 plants m^{-2}), and P_3 (40816 plants m^{-2}). However, crude contents (5.18 %) in grains were significantly decreased in 95238 plants m^{-2} than rest of the plant density levels. Thus, Pioneer-30D55 at plant density 95238 plants m^{-2} exhibited the best production potential for growth, grain yield, and crude starch contents in grains.

Keywords: Maize hybrids, plant density, growth, yield and quality attributes

INTRODUCTION

Maize *(Zea mays* L.*)* forms major dietary part of the millions of the people in the form of bread, cake and porridge. Besides being an important food grain for human consumption, maize has also become a major component of livestock and poultry feed (Witt and Pasuquin, 2007). Maize oil is used in cooking, bakery products, oleomargarine, salad dressing and pharmaceutical. Maize starch is used for producing bio-fuel (as ethanol) after its fermentation (Rajoo, 1998), making plastics, cellophane, photographic films, dying of clothes, manufacturing of paper and paper boards and tanning of the hides. A large quantity of maize is being used in the manufacturing of shortening compounds, soaps, ammunition, varnishes, paints and similar other products (Martin *et al.,* 1975).

Maize grain yield is more affected by variations in plant density than other members of the grass family (Vega *et al.*, 2001). Maize hybrids differ in their response to plant density (Luque *et al.*, 2006). Early maturing maize hybrids tended to be lower in growth rate than the later maturing maize hybrids (Azadgoleh and Kazmi, 2007; Pagano and Maddonni, 2007). Their potential to grain yield significantly differ under varying plant density levels due to difference in their genetic potential (Liu *et al.,* 2004a). Correspondingly maize hybrids also respond differently in quality parameters likecrude starch, protein, and oil, contents in grains (Munamava *et al*., 2006; Letchworth and Lambert, 1998).

Plant density has been recognized as a major factor determining the degree of competition between plants (Tetio-Kagho and Gardener, 1988). Ma *et al.* (2007) stated that dry matter accumulation per unit area was increased, as the number of plants per unit area increased. Although grain yield per plant is decreased (Luque *et al*., 2006), in response to decreasing light and other environmental resources available to each plant (Pagano and Maddonni, 2007), but grain yield per unit area is increased (Bahadur *et al.,* 1999). Grain yield per plant is also affected by hybrids (Sener *et al.,* 2004; Varga *et al.,* 2004). Crowding stress increased crude protein (Borras *et al*., 2003) in grains (Mihajlvoic, 1982), but decreases crude starch contents and oil in grains, however, the reason have not yet been traced out (Maddonni and Otegui, 2006).

Keeping in view the above facts, a field experiment was conducted to compare the grain yield and quality of three maize hybrids under different plant density levels.

MATERIALS AND METHODS

The experiment was conducted on a sandy clay loam soil at Government Agricultural Extension Farm, Model Town–A, Bahawalpur, Pakistan during 2005 and 2006. The experiment was quadruplicated in randomized complete block design with split plot arrangement having a subplot size of 3.5 m x 7 m. The maize hybrids H_1: Pioneer-3012, H_2: Pioneer-3062 and H_3: Pioneer-30D55 were randomized in main plots and plant density P_1 (15 cm x 70 cm, or 95238 plants ha^{-1}), P_2 (25 cm x 70 cm or 57142 plants ha^{-1}) and P_3 (35 cm x 70 cm or 40816 plants ha^{-1}) in sub-plots.

The crop was planted on 3 August, 2005 and 7 August, 2006. The crop was sown with the help of single row-drill using seed rate of 30 kg ha^{-1}. First thinning was done, when the crop was 30 cm tall, and the second thinning was done when crop the crop attained the height of 60 cm, to bring at the desired level of plant density.

The NPK was applied @ 300-200-100 kg ha^{-1}, respectively. Urea, DAP and sulphate of K were used as sources of N, P and K fertilizers, respectively. Half dose of N and complete dose of P and K were applied at the time of sowing. The remaining half N was top dressed at first irrigation. In addition to rainfall received during the growing period of the crop, a total of four irrigations were applied through flooding at different development stages of the crop. All other agronomic operations except the ones under study were kept normal and uniform for all the treatments.

Crop was harvested manually on 11 November, 2005 and 16 November, 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 ears were separated from the stalks and allowed to dry in sunshine for a few days before threshing.

Dry matter accumulation per unit area was determined at biweekly intervals by collecting ten plants at random from each subplot. The sampling was initiated 30 DAS and terminated 90 DAS. Soon after harvest each sample was weighed to determine the fresh weight. Each plant sample was chapped, thoroughly mixed and then sun dried. Thereafter, samples were placed in an oven at 70°C± 5°C to dry the plant material to their constant dry weight. Then dry weight per plant was calculated. Crop growth rate (CGR) was calculated by the formulae given by Beadle (1987).

$$CGR = \frac{W_2 - W_1}{t_2 - t_1}\left(g\,m^{-2}\ day^{-1}\right)$$

Where W_2=dry weight (DW) m^{-2} at second harvest, W1=DW m^{-2} at first harvest, t_2= time corresponding to second harvest, t_1=time corresponding to first harvest.

Seed yield was recorded on subplot basis and then converted into tones per hectare (t ha^{-1}). Crude starch contents in grains were determined by using the method given by Juliano (1991).

Nitrogen content of maize grain samples was determined by using micro-kjeldhal distillation method (Anonymous, 1980) and then the crude protein contents in grains were calculated by using the following formula. Crude protein = Nitrogen x 6.25. Crude oil contents in grains were determined by Soxhlet method described by Low (1990).

The data were analyzed by using "Mstat" statistical package on a computer (Freed and Smith, 1986). When a significant "F" value was obtained for treatment effect, least significant differences (LSD) test at 0.05 P was applied to determine the significance of the treatment means (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

The data on periodic growth rate of different maize hybrids and plant density levels during both years are given in Fig. It was observed during 2005 that CGR was slow in the beginning (30-45 DAS) and the differences among different treatment means were not pronounced enough. However, during the interval of 45-60 DAS, CGR increased to its maximum value showing significant variations among maize hybrids and plant density levels and thereafter, it declined sharply moved to its maturity. Similar trends were observed in 2006. Similar situations were observed by Ma *et al*., (2007) and Pagano and Maddonni (2007), when they increased plant density in different maize hybrids.

Pioneer-30D55 produced significantly higher CGR against in Pioneer-3062, and Pioneer-3012. Significant differences among hybrids on CGR have been reported previously by Azadgoleh and Kazmi (2007), Monneveux *et al.* (2005), Pagano and Maddonni (2007), and Stehli *et al.* (1999).

Plant density also exhibited significant variation among them in respect of CGR. Crop planted at plant density 95238 plants ha^{-1} gave significantly higher CGR. Interactive effects of maize hybrids and plant density levels on CGR were non significant. The results are in accordance with the findings of Bahadur *et al.* (1999), Ma *et al.* (2007), Pagano and Maddonni (2007), and Tetio-Kagho and Gardener (1988). They reported that CGR was increased with increased plant density.

Effects of maize hybrids and plant density levels on grain yield were significant. Pioneer-30D55 gave significantly higher grain yield per hectare than rest of the two maize hybrids, which also varied significantly from each other. The results are in agreement with the findings of Liu *et al.* (2004a & b), Luque *et al.* (2006), Sener *et al.* (2004), and Varga *et al.* (2004). They attributed these differences due to their genetic variation in number of grains cob^{-1}, number of cobs $plant^{-1}$, 1000- grain weight and better root development.

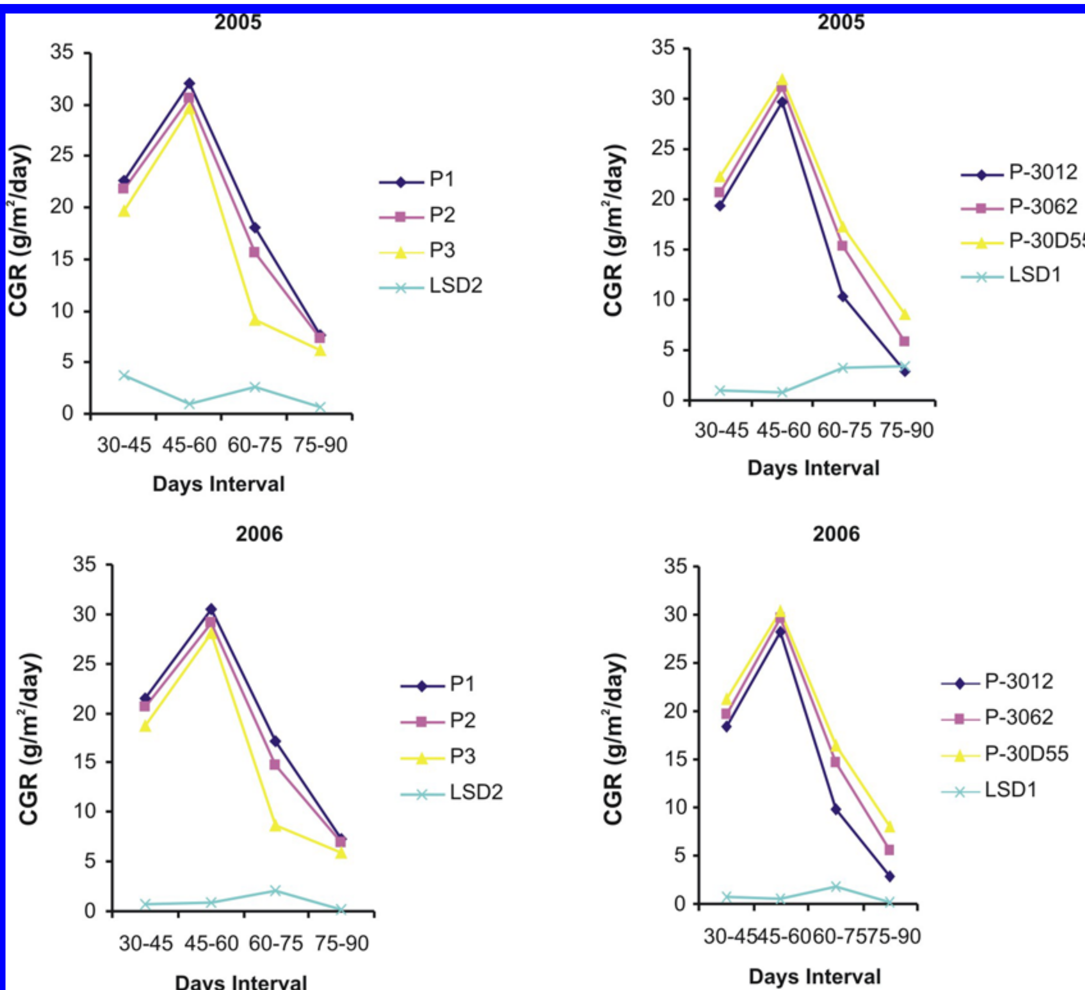

Fig. Periodic Crop Growth Rate as influenced by varying maize hybrids and Plant Density during 2005 and 2006

Crop planted at plant density of 95238 plants ha^{-1} produced significantly higher the grain yield than rest of the plant density levels, which also statistically varied from each other. Interactive effects of maize hybrids and plant density on grain yield were not significant. The results are in line with the findings of Abolhassan *et al.* (2005), and Shah *et al*. (2000).

Significantly higher grain crude starch contents were recorded in Pioneer-3012 than Pioneer-3062, and Pioneer-30D55, which also differed significantly from each other. The results are quite in line with the findings of Letchworth and Lambert (1998), and Munamava *et al.* (2006) who reported that significant genetic differences existed among maize hybrids for crude starch content in grains.

The crop was planted at plant density of 95238 plants ha^{-1} resulted in higher crude starch contents in grains than crop planted at 57142 plants ha^{-1} or at 40816 plants ha^{-1}, which also differed significantly from each other. Interaction effects of maize hybrids and plant density levels on crude starch contents in grains were not significant. The results are in harmony with the findings of Maddonni and Otegui (2006), who stated that increase in plant density increased crude starch contents in grains.

Pioneer-30D55 (7.76 %) produced significantly more crude protein contents in grains than that Pioneer-3062 and Pioneer-3012. The difference between Pioneer-3062 and Pioneer-3012 was also significant. The results are in conformity with the findings of Letchworth and Lambert (1998), and Munamava *et al.* (2006).

Crop planted at plant density of 40816 plants ha^{-1} produced significantly higher crude protein (7.45 %) contents in grains than the crop planted at plant density of 57142 plants ha^{-1} and 95238 plants ha^{-1}, respectively. The interaction between maize hybrids

Table: Production potential of three maize hybrids as influenced by varying plant density (Mean of two years data)

Treatment	Grain yield (t ha^{-1})	Crude starch contents in grains (%)	Crude protein contents in grains (%)	Crude oil contents in grains (%)	Crop Growth Rate (g m^{-2} day^{-1}) (30-90) DAS
Hybrid (H)					
H_1:Pioneer 3012	5.58c	72.40 a	6.89c	5.41 a	19.31c
H_2:Pioneer 3062	5.82b	71.51b	7.14b	5.23b	21.31b
H_3:Pioneer 30D55	6.16a	70.60 c	7.76a	5.07 c	22.28a
LSD=0.05	0.1420**	0.09944**	0.1242**	0.02812**	0.6207**
Plant Density (PD)					
P_1: 15cmx70cm (95238 plants ha^{-1})	6.37a	71.79a	7.45 a	5.18c	24.93a
P_2: 25cmx70cm (57142 plants ha^{-1})	5.85b	71.51b	7.27 b	5.23b	21.18b
P_3: 35cmx70cm (40816 plants ha^{-1})	5.34c	71.21c	7.07 c	5.30a	16.78c
LSD=0.05	0.2028**	0.08070**	0.08683**	0.01851**	0.7122**
Interaction (H x P) N.S					
CV=%	5.91	0.70	2.05	0.63	5.80

Means followed by different letters in a column are significantly different at 0.05P.
N.S. = Non Significant, ** = Highly Significant

and plant density on crude protein contents in grains were not significant. The results are in accordance with the findings of Letch worth and Lambert (1998), and Maddonni and Otegui (2006), who stated that crude protein contents in grains were increased under higher plant density.

Pioneer-3012 produced significantly more crude oil contents in grains than Pioneer-3062 and Pioneer-30D55, which also varied significantly from each other. The results are supported by the findings of Letchworth and Lambert (1998), Munamava *et al.* (2006). They attributed the difference to differential genotypic capability to synthesize the oil contents in grains.

Crop planted at plant density of 40816 plants ha^{-1} produced significantly more crude oil contents (5.30 %) in grains that rest of crude oil contents at plant density levels. Interactive effects of maize hybrids and plant density levels on crude oil contents in grains were not significant. The results are in line with the findings of Maddonni and Otegui (2006), and Mihajlvoic (1982). They stated that crowding stress in maize hybrids decreased crude oil contents in grains.

Pioneer-30D55 surpassed maize hybrids Pioneer-3062 and Pioneer-3012, because of genetic variations in growth rate, grain yield and quality parameters. It expressed its, over all, best performance at plant density 15 cm x 70 cm (95238 plants m^{-2}). However, there is need to invetsigate these hybrids at other different planting geometry patterns, too.

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