# Plant Density Effect on Silage Yield of Maize Cultivars

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## Abstract

In order to study of plant density effect on silage yield of new maize hybrids an experiment was conducted in factorial on the basis of randomized completely block design with four replications at agricultural research station in Qarakheil (Qaemshahr) in 2014 in Iran, after wheat harvesting. New hybrids are SC703 and SC705 that were compared with SC704. Four densities were 75,000, 85,000, 95,000 and 105,000 plant per hectar. Eeach plant planted in four rows with intera-row spacing of 75 cm. Silage yield, plant height, ear height, kernel number in ear row, kernel row number,dry silage yield, kernel, stem and leaves protein were measured. Result showed that SC704 had the highest silage yield with 70.96 t/ha. SC705 and SC703 had 64.67 and 60.22 t/ha silage yield. Density of 105,000 and 95,000 plant per hectar had higher silage yields in compare of other densities with 67.04 and 66.20 t/ha respectively. Result showed that SC704 had the highest dry silage yield with 43.19 t/ha. SC705 and SC703 had 38.69 and 36.75 t/ha dry silage yield respectively. Density of 105,000 and 95,000 plant per hectar had higher dry silage yields in compare of other densities with 67.04 and higher dry silage yields in compare of other densities with 67.04 with increasing of density, crude protein (in kernel, stem and leaves) decreased.

Keywords: corn, crude protein, cultivars, silage yield

# 1. Introduction

Corn (Zea mays L.) is the most important grain-forage crop in Iran (Hashemi et al., 2005). The average silage yield of corn is more than 50 t/ha and it increase annually. Produce of new hybrids for each area will increase corn yield (Allard, 1960). Forages are major component in the feeding rations for ruminants, especially for dairy. Forage quality can vary depending on variety (Jung et al., 1998), stage of maturity at harvest (Coors et al., 1997; Bal et al., 2000), crop management and hybrid (Orosz et al., 2003; Bíro et al., 2007) and hygienic quality (Suchý & Straková, 2006). From the point of global importance maize represents in all forms elementary and important feed for farm animals. Feed products from maize are characterized by high energetic nutrients and relatively low content of crude protein with low biological value (Mlynár et al., 2004). Maize is generally cultivated in wide spaced rows. Plant density per unit area is one of the important yield determinants of crops. Plant density is an efficient management tool for maximizing grain yield by increasing the capture of solar radiation within the canopy (Monneveux et al., 2005). An optimum plant population for maximum economic yield exists for all crop species and varies with cultivar and environment (Bruns & Abbas, 2005). Increases in plant population density often result in higher maize forage yield, but this is dependent on a number of factors, including climatic conditions of the growing region, plant size and leaf area, and plant maturity. Silage quality may also be affected by population density, as increased plant densities have resulted in reduced maize forage quality, (Cox & Cherney, 2001). Optimal plant densities for maize forage production vary widely from 45,000 to 125,000 plants ha<sup>-1</sup>, depending on growing region (Baron et al., 2006).

Among of new produced hybrids can be named SC703 and SC704. These hybrids can be planted in total erea of Iran as second and silage crop. In order to optimize the use of moisture, nutrients and solar radiation, corn seeds must be planted under optimum density (Farnham, 2001; Olson & Sander, 1988). Intensive production of field crops practiced until recently to achieve high yields required intensive tillage and application of other high-technology inputs. Farmers approach production in terms of the cost effectiveness of the applied system (Kisic et al., 2010). For 4,500 years, corn has had a special and importance role in the lives, the religious rituals and customs, and the development of the cultural history of the peoples of South, Central, and North Americas

(Kiniry et al., 1992). Corn yield was affected by plant density (Sarlangue et al., 2007). Plant density has notable effects on corn kernel yield (Widdicombe Thelen, 2002). Only in suitable density, plant can be had highest yield (Monneveux et al., 2005). In determine of density, hybrid type is high effective (Subedi et al., 2006). Nielson (1988) reported that with an increase in plant density from 44444 to 88888 plants per hectare, corn yield rose by about 2.7 percent. Andrade et al. (2002) found that corn yield response to decreased row spacing was negatively correlated to radiation interception at pollination time with the wider spacing. Widdicombe and Thelen (2002), however, found that higher yields were attained for corn grown in narrow rows vs. wide conventional rows irrespective of hybrids and plant populations tested in Indiana and Michigan. Corn grain yield typically exhibits a quadratic response to plant density, with a near-linear increase across a range of low densities, a gradually decreasing rate of yield increase relative to density increase, and finally a yield plateau at some relatively high plant density (Duncan, 1984; Ottman & Welch, 1989; Thomison & Jordan, 1995). Higher plant density combined with narrower row spacing results in a more equidistant planting pattern that is expected to delay initiation of intraspecific competition (Duncan, 1984) while early crop growth is increased (Bullock, 1994). The optimum row spacing varies among plant genus, yields will generally be maximized by sowing in rows that result in an equidistant spacing among plants (Sharratt Brenton & Mcwilliams Denise, 2005). Narrow-row corn has been advocated in recent years as a technique to enhance grain yield (Orchard, 1998). Paszkiewicz (Paszkiewicz, 1997), for example, found that corn grown in narrow rows to the north of Interstate 90 (44°N latitude) resulted in an 8% higher grain yield while that grown in narrow rows to the south of Interstate 90 resulted in a 4% higher grain yield compared with corn grown in wide conventional rows. Crop row spacing can also influence soil water utilization (Sharratt Brenton & Mcwilliams Denise, 2005). For each cultivars in each area, suitable density can be produced highest yield (Widdicombe & Thelen, 2002).

### 2. Materials and Methods

The study was conducted at the Agricultural Research station of Mazandran at Qaemshahr (31°28'N, 52°35'E) in Iran. Weather conditions in the experimental site are summarized (Table 1).

Month	Average of temperature (°C)	Average of Moisture (%)	Suny duration (day)	Precipitation (mm)	Evaporation (mm)
July	26.9	74	217.9	70.3	189.4
August	28.1	71	298.4	8.4	199.1
September	27.3	79	184.1	88.6	110.0

Table 1. Weather condition in experiment site during corn growth period in 2014

Note. The soil type was classified as clay loam at location. Soil PH at Qaemshahr was 7.6.

In order to determine the best plant densities of new corn cultivars and check (SC704) for silage yield, SC703 and SC705 cultivars were planted at July 7, 2014. Plant densities were 75,000, 85,000, 95,000 and 105,000 plants per hectar. A factorial on the basis of randomized completely block design with four replications was used. Cultivars and plant densities were located to plots. Experiment was done at agricultural research station in Qarakheil (Qaemshahr, 31°28'N, 52°35'E) in 2014 in Iran. Eeach treatment was planted in four rows. The previous crop at the site was wheat. NPK fertilizers were applied according to yield potentials and soil test level to the site. Fertilizer used as NPK (300-100-100 kg/ha) were made from urea, amonium phosphate and potassium sulfate. Hand weeding was practiced to control weeds. The site was irrigated with water using a sprinkler irrigation system. Plants from each plot harvested separatly. Plants were cut at the surface from the two middle rows in the plots (area of 9 m<sup>2</sup>). In harvest time, plants in each treatment were weighted and then were dried. Dry and wet silage yield were measured. Number of kernel row, number of row per ear, ear height (cm) and plant height (cm) also were measured. Data were analyzed using the by MSTAT-C procedure to develop the ANOVA for a factorial on the basis of randomized completely block design. The DMRT procedure was used to make tests of simple and interaction effects by MSTAT-C, all differences reported are significant at P < 0.05 unless otherwise stated.

### 3. Results and Discussion

### 3.1 Silage Yield

Analyses of variance and means comparision of traites was shown in Tables 1 and 2.

Plant density had a significant effect on silage yield (Table 2). The highest silage yield was produced with 75,000 and 105,000 plant/ha with 66.54 and 65.70 t/ha respectively. The lowest silage yield (64.04 and 64.54 t/ha) was produced in 95,000 and 85,000 plant/ha. Plant density had not significant difference in 75,000 p/ha in compare of 105000 p/ha on silage yield (Table 2).

SC704 produced the highest silage yield with 70.96 t/ha. The lowest silage yield (60.22 and 64.67 t/ha) were in related to SC705 and SC703 respectively. Yield and yield component of corn varieties in two densities of 55,000 and 110,000 plants/ha of 21 Hybrid single cross and 13 Inbreed line with a commercial witness were significantly affected by plant density (Rodrigues et al., 2003). Shakarami and partners (Shakarami & Rafiee, 2009), in investigating three plant density (7, 10 and 13 plant m<sup>2</sup>) of corn recognized that the highest grain yield, harvest index, number of grain row and number of grain ear was produced in 10 plant m<sup>2</sup> and the highest biological yield obtained from 13 plant m<sup>2</sup>. Kisic et al. (2010) in the study of crop yield and plant density found that the plant density and yields of maize, soybean, oilseed rape, winter wheat and spring barley point to the conclusion that high density crop (winter wheat, spring barley and oilseed rape) are suitable for growing under reduced tillage systems. Tetio-Kagho and Gardner (1988) reported that plant density is affected on kernel yield.

# 3.2 Dray Silage Yield

SC704 (43.19 t/ha) and SC703 (36.75 t/ha) were best cultivars for dry silage yield and had not significant difference (Table 2). The highest dry silage yield were produced in 75,000 (40.23 t/ha) and 105,000 (39.75 t/ha) plant/ha and the lowest dry silage yield (39.07 and 39.10 t/ha) were produced in 95,000 and 85,000 plant/ha. Plant density had not significant difference at 75000 in compare of 105,000 and 95,000 in compare of 85,000 density on dry silage yield (Table 2).

# 3.3 Plant Height

The highest plant height was in related to SC704 with 193.8 cm. There was 175 cm and 162.8 cm plant height for SC703 and SC705 respectively.

Lowest plant height was in related to density of 75,000 p/ha (171 cm). With increasing of density, plant height increased. Density of 105,000 (180.2 plant/ha) and 95,000 (179.6 plant/ha) have highest plant height (Table 2).

# 3.4 Ear Height

SC704 had highest ear height (83.14 cm). SC703 (175 cm) and SC705 (162.8 cm) had less ear hight than SC704. Density of 105,000 p/ha and 95,000p/ha had higher ear height with 180.2 cm and 179.6 cm respectively. With increasing of density, from 75,000 to 95,000 p/ha, ear height also increased. The lowest ear height was in related to 75,000 p/ha with 171 cm (Table 2).

# 3.5 Kernel Row Number

Cultivars were nearly similar in point of kernel row number and had not significant difference. SC703, SC704 and SC704 had 13.94, 13.81 and 13.31 kernel row number respectively. Densities had not significant difference at this trait. Density of 75,000 p/ha had the highest kernel row number with 14 n (Table 2).

### 3.6 Kernel Row in Ear

SC704 had the highest kernel row in ear row with 29.5 n. SC705 (27.5 n) and SC703 (27.06 n) had less kernel row in ear, in compare of SC704. The highest kernel row in ear with 30.33n was optained from 75000 p/ha. Densities of 85,000, 95,000 and 105,000 p/ha had 27.42, 27.33 and 27 n kernel row respectively (Table 2).

# 3.7 Crude Kernel Protein (%)

Cultivars were nearly same in point of crude kernel protein, SC703 had the highest crude kernel protein with 9.44%, the lowest crude kernel protein was in relatet to SC704 with 8.61%. SC705 had 9.14% crude kernel protein. With increasing of density from 75,000 p/ha to 105000 p/ha crude kernel protein decreased. The highest and lowest crude kernel protein was obtained from 75000 p/ha (9.83%) and 105000 p/ha (8.58%) respectively.

## 3.8 Crude Stem and Leaves Protein

SC703 had the highest crude stem and leaves protein with 14.9% and had significant difference with other cultivars. Crude stem and leaves prote in SC704 cultivar was same as SC705 (13.5%). With increasing of density from 75,000 p/ha to 105,000 p/ha crude stem and leaves protein also decreased. The highest and lowest crude stem and leaves protein was obtained from 75,000 p/ha (14.8%) and 105,000 p/ha (12.9%) respectively.

SOV	DF	Silage yield (t/ha)	Dry silage yield (t/ha)	Plant height (cm)	Ear height (cm)	Kernel row number	Kernel number in ear row	Crude kernel protein (%)	Crude stem and leaves protein (%)
Replication	3	227.17*	85.06 <sup>ns</sup>	452.63 <sup>ns</sup>	290.94 <sup>ns</sup>	0.014 <sup>ns</sup>	6.57 <sup>ns</sup>	2.91 <sup>ns</sup>	7.47 <sup>ns</sup>
Factor A (Cultivar)	2	466.57**	174.58*	3065.03**	956.44*	0.034 <sup>ns</sup>	9.58 <sup>ns</sup>	2.84 <sup>ns</sup>	11.3 <sup>ns</sup>
Factor B (Density)	3	36.61 <sup>ns</sup>	28.10 <sup>ns</sup>	27.63 <sup>ns</sup>	26.92 <sup>ns</sup>	0.153 <sup>ns</sup>	2.25 <sup>ns</sup>	2.54 <sup>ns</sup>	7.85 <sup>ns</sup>
$\mathbf{A} \times \mathbf{B}$	6	55.87 <sup>ns</sup>	17.25 <sup>ns</sup>	222.24 <sup>ns</sup>	129.29 <sup>ns</sup>	0.168 <sup>ns</sup>	5.48 <sup>ns</sup>	1.3 <sup>ns</sup>	5.54 <sup>ns</sup>
Error	33	73.19	43.25	177.45	70.44	0.119	2.82	1.48	5.86
CV%	3	13.1	16.6	7.83	11.95	20	11.1	13.4	17

#### Table 2. Analysis of variance of the traits

*Note.*<sup>\*</sup>, <sup>\*\*</sup> and ns significant at the 5%, 1% and non significant respectively.

Table 3. Comparison of the means of the traits

Treatment	Silage yield (t/ha)	Dry silage yield (t/ha)	Plant height (cm)	Ear height (cm)	Kernel row number	Kernel number in ear row	Crude kernel protein (%)	Crude stem and leaves protein (%)
Cultivar								
SC703	64.67b	38.69ab	175.0b	70.26b	13.94a	27.06b	9.44a	14.9a
SC704	70.96a	43.19a	192.8a	83.14a	13.81a	29.50a	8.61a	13.5b
SC705	60.22b	36.75b	162.8c	59.99c	13.31a	27.50b	9.14a	13.5b
Density (plant/ha)								
75000	66.54a	40.23a	171.0c	68.98b	14.00a	30.33a	9.83a	14.8a
85000	64.54b	39.10b	176.6b	69.27b	13.67a	27.42b	9.63a	14.4a
95000	64.04b	39.07b	179.6a	72.87a	13.05a	27.33b	9.22b	13.8b
105000	65.70 a	39.75a	180.2a	73.77a	13.58a	27.00b	8.58c	12.9c

Note. Different letters in each column shows significant difference at 5% probability (DMRT).

#### 3.9 Investigation of the Results of the Correlation Coefficients

Results of individual correlation coefficients of the traits studied suggest that silage yield has the strongest positive and significant correlation with the trait of the kernel number in ear row (0.601), with the ear height (0.919), with plant height (0.865) with the kernel row number (0.541) and with the dry silage yield (0.991). It was also found that the the crude kernel protein had the strongest positive and significant correlation with the crude stem and leaves protein (0.883). Furthermore, the plant height had the strongest positive and significant correlation with the ear height with 0.985 (Table 4).

Table 4. The correlation coefficients of the features studied

	Silage yield (t/ha)	Dry silage yield (t/ha)	Plant height (cm)	Ear height (cm)	Kernel row number	Kernel number in ear row	Crude kernel protein (%)
Crude stem and leaves protein %	-0.026ns	-0.110ns	-0.280ns	-0.220ns	0.539*	0.256ns	0.883**
Crude kernel protein %	-0.325ns	-0.370ns	-0.560*	-0.520*	0.261ns	0.195ns	1
Kernel number in ear row	0.601*	0.620*	0.190ns	0.302ns	0.517*	1	
Kernel row number	0.541*	0.445ns	0.151ns	0.242ns	1		
Ear height (cm)	0.919**	0.924**	0.985**	1			
Plant height (cm)	0.865**	0.878**	1				
Dry silage yield (t/ha)	0.991**	1					

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