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The study of planting date and seedling density on ear yield and forage of sweet corn as a second crop

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INTRODUCTION

Corn is widely grown in all the continents of the world. Forage maize can be utilized by animals in many ways. It can provide high quality yields of palatable forage (Karsten *et al.,* 2003). Sweet corn (*Zea mays* L. var. saccharata Korn.) is a crop plant grown for fresh human consumption and for raw or processed material for the canned food industry (Rosa, 2014). Both total production and value of processed sweet corn has increased by 60% over the last 25 years (Williams *et al.* 2006). In Iran corn is increasingly gaining an important position in crop husbandry because of its higher yield potential and short growth duration. It is a rich source of food and fodder. Corn is an important crop in conventional cropping systems of Kermanshah province, west of Iran and area of under corn cultivation is more than 45000 ha at 2014.

Corn silage is popular forage for ruminant animals because it is high in energy and digestibility and is easily adapted to mechanization from the stand-crop to time of feeding. Sweet corn is a variety of corn with high sugar content. Sweet corn is only produced for human consumption as either a fresh or processed product. Beside it is possible to use its green part for feeding Depending on sweet corn's purpose (canned, frozen, fresh market) it is harvested in the milk or late milk stage of maturity ranging from 70 to 78%. Sweet corn was harvested at about the milk stage (Aug. 12-Sept. 3), then the stalks were cut and removed (Guldan and *et al.,* 1999). After its cobs have been harvested the Stover still contains a good source of nutrients suitable for cattle feeding. With 9.6% crude protein concentration we found in an earlier study, it is comparable to that of Stover harvested at 75 days of age (Yacob *et.al.* 1992). In most parts of the world significant amount of sweet corn are grown for human consumption, providing considerable amount of sweet corn residues (Mustafa *et al.,* 2004). Sweet corn residue silage consists of husk leaves, cobs, discarded kernels and amount of stalks. Although, the residue is attractive forage for ruminant animals, the residue is not well utilized due to plenty of green forage when the residue is available. Generally the residue is left over and causes pollution problem (Cheva-Isarakul *et al.,* 2001). Yacob *et al.* (1992) estimated a production of 10 t of dry matter of stover per ha of sweet corn and this figure is close to the average of 12 t achieved in the current work. It is evident that a substantial quantity of forage can be obtained if stover from every crop of sweet corn is ensiled and utilised by dairy smallholders. Sweet corn production produces byproducts that can be fed to livestock. They include sweet corn stalks (stalklage left on the field after harvest), sweet corn silage (from bypassed acres that were not harvested), and corn canning factory waste (Dyk, 2009). Yilmaz *et al.* (2008) reported that yield and yield component of corn were significantly affected by planting patterns, plant densities and maize hybrids. Turgut *et al.* (2005) reported that there were significant effects of corn hybrids and plant densities on corn forage and DM yields.

Sweet corn is grown for processing in many locations. Detailed analysis of the effect of plant population density on processing sweet corn does not exist in the peer-reviewed literature. 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). Plant populations for optimum corn grain yield typically range from 32,000 to 36,000 plants/acre in the central Corn Belt and are higher in the northern Corn Belt. Optimum plant density generally depends on hybrid, maturity, field productivity and growing conditions. Planting to achieve these populations helps maximize utilization of soil nutrients, solar radiation and water during the growing season.

Desired plant populations for corn silage are dependent upon productivity of the hybrid and the soil. Generally, populations for corn silage should have 2,000 to 4,000 more plants per acre than are recommended for grain. In conditions without major nutrient or water limitations, maize grain yield depends most on radiation interception and radiation-driven photosynthetic conversion efficiencies around the critical period bracketing silking. Overall, benefit it's from narrowing rows is expected in situations where the crop is not likely to achieve the critical value of LAI at silking. Increases in plant density generally have a large positive impact on the incident solar radiation intercepted (%) and, as a consequence, on crop growth rate around silking as well as final grain yield (Robles and *et al.,* 20012). Decreasing row spacing at equal plant density promotes more equidistant plant spacing, theoretically reducing plant-to plant competition, while improving plant resource capture and utilization (Andrade *et al.,* 2002) and decreasing weed competition through earlier canopy closure. Nonetheless, sharply contrasting conclusions have been reported regarding grain yield response to narrow rows (Yilmaz *et al.,* 2008). Conceivably, decreased plant-to-plant competition due to narrow or twin rows could also benefit maize production via greater early-season radiation interception (Nielsen, 1988) and via assertions of higher biomass production and improved root growth (Sharratt and McWilliams, 2005) Current recommendations for fresh market sweet corn suggest row spacing of 30 to 40 inches and in-row spacing of 8 to 10 inches for early varieties and 9 to 12 inches for late varieties.

Planting date and variety selection are the major factors affecting maize production in addition to soil fertility, temperature regimes and irrigation (Ramankutty *et al.,* 2002). The amount of time required to reach sweet corn maturity is influenced by planting date primarily due to variation in temperature environment during growth. Yield can be increased to a greater extent provided high yielding varieties are identified and planted at proper time (Khan *et al.,* 2009). Selecting varieties adapted to local growing conditions and with suitable market value is critical to successful sweet corn production. Corn hybrid selection is one of the most important management decisions in silage production. Selecting the correct hybrid can often mean the difference between profit and loss. Even selecting the "best" hybrid might not be enough if some aspect in agronomic management is lacking such as delaying harvest. Selecting hybrids for silage production depends somewhat on whether a field is planted specifically for silage or whether the field may be harvested for grain.

Corn silage is primarily an energy supplying forage, and its nutritive value is related to digestibility and factors that affect digestibility. Any good forage crop should have high dry matter yield, high protein content, high-energy content (high digestibility), high intake potential (low fiber), the proximate and mineral compositions of maize depend on the stage of harvest of the silage material. Roth (2001) stated the ranges of 7.2-10.0, 23.6-33.2 and 41.0-54.1% for crude protein (CP), acid detergent fibre (ADF) and neutral detergent fibre (NDF) contents, respectively in maize silage. The concentrations of crude protein (CP), fat, non-fiber carbohydrate (NFC), and neutral detergent fiber (NDF), and the digestibility of these nutrient components influence the energy value of feedstuffs (Schwab *et al,* 2003).

MATERIALS AND METHODS

The fields studies was conducted at Islamabad-e Gharb agricultural research station in the Kermanshah province, west of Iran during 2012 and 2013 cropping cycles. The geographical position of station was 46,50E, 24, 16N and 1346 m from sea level and is located in cold moderate region. The average annual rainfall is 538 mm, its average annual temperature is + 10.5. Maximum absolute temperature is +41, minimum absolute temperature is -28.8 and its soil texture is silty- clay. The experimental design was a split-plot arrangement with completely randomized subplots replicated three times.

The treatments including planting date factor were assigned to 4 levels as main factor and density and variety as factorial in sub- plots. Four sweet corn hybrids including Basin and Chase (from early-maturity group) and Merit and Signet (from moderate maturity group) and 3 plant populations levels including 70000, 78000, 86000 and 94000 plant per hectare were used. The seeds of varieties under study were prepared by Asgrow vegetable seeds company. The seeds were produced in 2012. The percent of purity of seeds was 99% and their germination percent was 93%. According to soil test, 150 kg/ha phosphorus fertilizer as triple super phosphate, 100 kg/ha potash fertilizer as potassium sulphate along with 1/3 required Nitrogen (100 keg/ha urea) were added to soil before planting. The planting in 10 June, 20 June, 1 and 10 July was done manually in 5cm depth as hill. On any hill, 4 seeds were used and in order to obtain desired density in 4 leaf stage additional bushes were thinned. The size of plots was $12m^2$ (4 × 3) and row spacing was 75 cm and distance on row was regulated with respect to density. Any plot included 4 cultivation lines that 2 marginal lines and 2 middle lines were used to measure.

The bushes of two middle lines were harvested in pulp stage and after counting, their fresh weight was measured. After transfer to laboratory within 72 hours in oven with temperature 75, samples were put and then were scaled.

RESULT AND DISCUSSION

A. Fresh ear yield (green cob)

The results of variance analysis of data (Table 1) showed that the effect of year on fresh ear yield was not significant, but effect of different planting dates showed very significant difference (Table 1). The most fresh ear yield belonged to planting date of 10 June with yield 15.7 tons per hectare and least yield belonged to last planting date 10 July with 11.8 tons per hectare fresh ear yield (Fig. 1). There was meaningful difference among different hybrids and hybrid chase with production 16.9 tone/ha fresh ear had highest corn production and then hybrids Merit, Basin and signet had 15.9, 12.9 and 10.4 tone/ha production respectively (Fig. 2).

The results showed that density has very meaningful effect on fresh ear yield (Table 3) and density 86000 plants per heater with 15.8 tones/ha had most fresh ear yield that with density 94000 plants per heater in ha with yield 15.6 tones/ha had not meaningful difference. Then density 78000 and 70000 plants per heater produced 13.6 and 11.9 tones/ ha corn respectively (Fig. 3).

Also, interaction of density on hybrid is also meaningful. The results showed that hybrid chase in all planting dates, had most yield. This hybrid because of early- maturity had acceptable yield until 1th July and even in last planting date (10th July) produced 12.6 tons/ha fresh ear (Fig. 4). Hybrid Merit had most ear yield after chase, but because of late maturity relative to chase with delay in planting date, its yield was decreased considerably. Hybrid Basin with production of 11.7 tone/ ha fresh corn in 10th July in late maturity planting dates is advisable hybrid Merit in planting dates 10th June until 1th July, in 10th July had better yield (Fig. 4).

Table 1: Variance analysis of yield of fresh corn, dry corn, wet forage.

Mean squares MS			
Source of changes SV	**Freedom degree DF**	**Fresh corn yield**	**Dry corn yield**
Heration	2	2	0.09
Year	1	0.9 ns	0.9 ns
Year error	2	1.3	0.1
Planting date	3	251.3**	6.09**
Spilt error	12	1.1	0.05
Density	3	323**	10.4**
Density × planting date	9	6.32*	5.2*
Hybrids	3	835.1**	76.8**
Planting date × hybrid	9	23.9**	0.36**
Hybrid × density	9	15.1**	069**
Planting index × density × hybrid	27	136.4**	0.05 ns
Year × planting date × density × hybrid	36	0.08 ns	010 ns
Total error	240	415.6	0.07
CV	9.3	8.9	

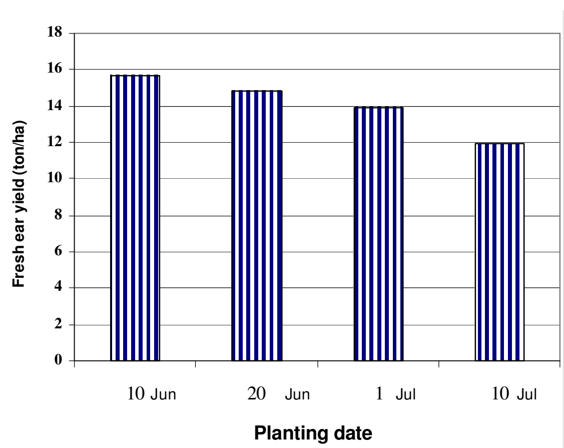

Fig. 1. Effect of planting date on fresh ear yield.

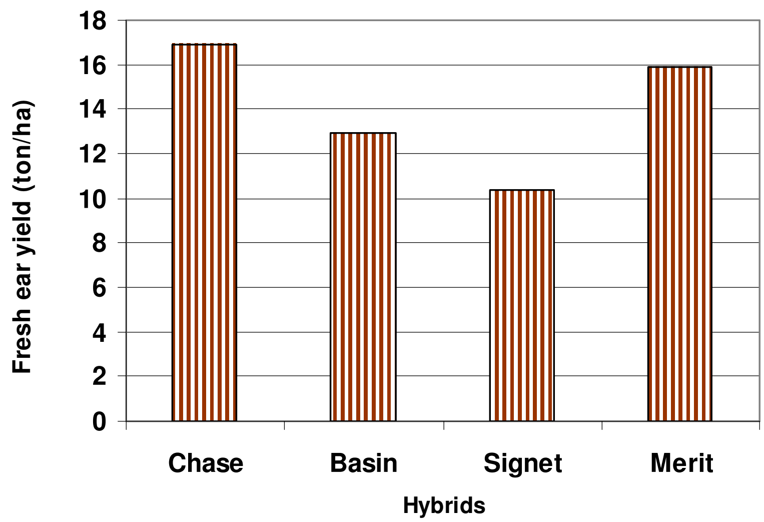

Fig. 2. Fresh ear yield in different hybrids.

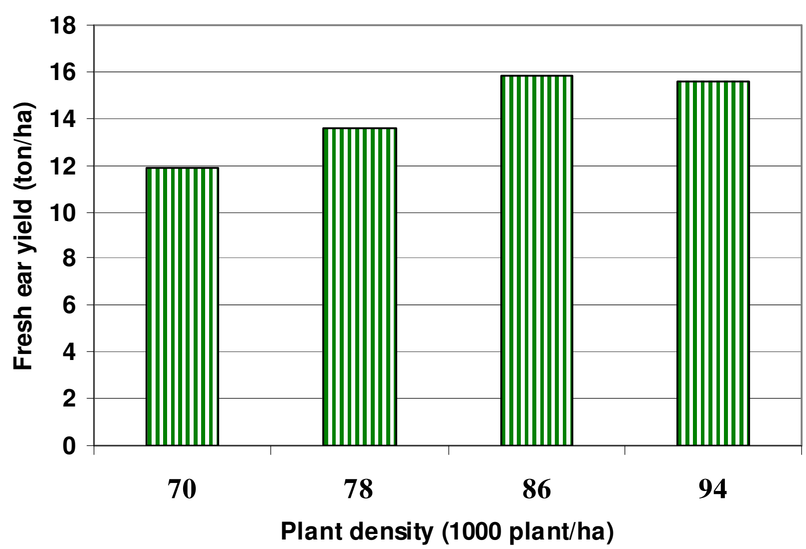

Fig. 3. Effect of density on Fresh ear yield.

The interaction of density and hybrid is meaningful and the results showed that in hybrid chase, by increasing density up to 94000 bushes in hectare, ear yield was increased. But between 86000 and 94000 bushes in ha, there was not meaningful difference. In all hybrids, increase in density from 70000 to 86000 plants per hectare increased yield, but in density 94000 plants per hectare, yield decreased (Fig. 5). Olsen *et al* (1993) reported that in regions with early planting of sweet corn, duration of planting until maturity increases and late planting decreases duration of growth and mentioned temperature as the most important determination of sweet corn growth. Reduction of yield and forage quality due to delay in planting date reported by other researcher also (Shaheenuzzamn *et al,* 2015). With delay in planting date, since duration of growth is shorter, to make enough substance to store in grain also decreases. The highest grain yield usually is obtained by planting of corn in first opportunity and with delay in planting date, yield decreases (Panahi *et al* 2010). Williams and Lindquist (2007) reported that delay in planting date of sweet decreases competitive ability of crops and as a result its yield decreases. In this experiment, varieties that had smaller bush height were less affected by density. Reduction of yield due to using of high plant density reported by Cox and Cherney (2001).

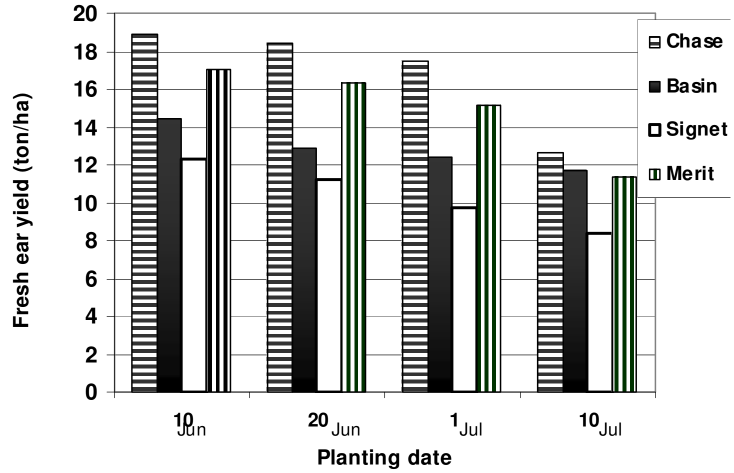

Fig. 4. Effect of planting date on Fresh ear yield.

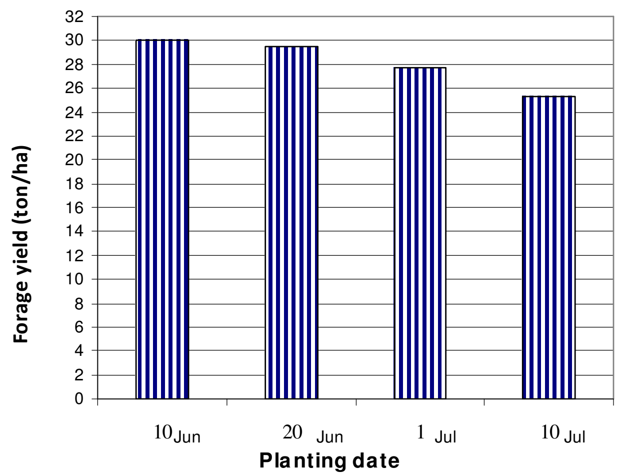

Fig. 5. Effect of planting date on foliage yield.

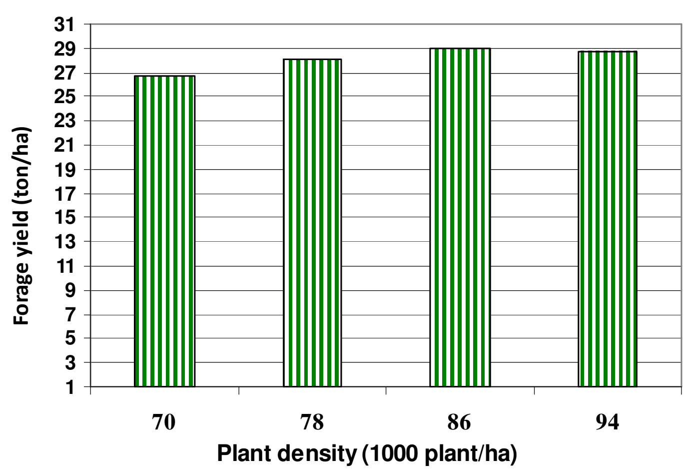

Fig. 6. Effect of density on Fresh ear yield.

The experiment by Major *et al* (1991) showed that by increasing corn density, efficiency of solar energy use increased. Perhaps its cause is increase in leaf area index. The late- maturity varieties relative to early maturity varieties in late planting dates receive more effects. Waligora (1997) studied reaction of 4 sweet corn hybrids in densities 3, 5, 7, 9 bushes in m^2 and mentioned 7 bushes in m^2 as most suitable density.

Planting date and landraces showed significant effects on final grain yield of sweet corn (Khan *et al.,* 2009). Zaki *et al.* (1994) reported decrease in grain yield when sowing delayed from April to May and then increased in June sowing. Khan *et al.* (2004 reported that genetically different varieties significantly differed in their grain yield performance in corn.

B. Forage yield

After ear harvesting, Sweet corn residue without ear harvested as forage. Data analysis showed a significant different between planting date. Delay in sowing decreased forage yield. Highest yield produced by earliest sowing date (10th June) and lowest forage production belonged to the late planting dates (Fig. 6). Reduction of yield and forage quality due to delay in planting date reported by other researcher also (Lauer, 2003).

Densities affects fresh yield; by increasing of density from 80000 plant/ha to 90000 plant/ha fresh weight increased so highest yield produced by second density (Fig. 6). Densities more than 90000 plant /ha reduced fresh weight because of extra intra specific competition. Armestrang and Albert (2008) found that 80000 plants/ha is desirable density for forage production.

Similarly, Asadi (2004) found 90000 plants/ha as optimum density for silage production. Garcia *et al.* (2009) observed decrease in above ground biomass when planting date was delayed from early March to mid-May in three different maturity group sweet corn hybrids.

There are also some interesting results reported for increased plant populations for silage production. Roth (2001) in Pennsylvania found a 3 to 4 percent increase in corn silage yields with a plant population of 34,000 plants/A compared to 27,000 plants/A. Cox (1997) in New York determined plant densities for silage production should average about 7.5 percent greater than for grain production.

Merit hybrid produced highest earless forage yield (34 ton/ha) followed by Chase (29.9 t/ha) and Signet (21.8 t/ha). The 86000 plant/ha density showed highest forage yield (29 t/ha) also (Fig. 7).

C. ADF and NDF

The total fiber content of forage is contained in the neutral detergent fiber (NDF). Chemically, this fraction includes cellulose, hemicellulose, and lignin. Because of these chemical components and their association with the bulkiness of feeds, NDF is closely related to feed intake and rumen fill in cows.

The proportion of NDF to body weight is an important fundamental relationship.

If we know the percent of NDF in the forage and the cow's body weight, we can estimate maximum forage dry matter intake (DMI). Highest NDF and ADF observed in Chase hybrid and the lowest observed in Signet hybrid (Fig. 8).

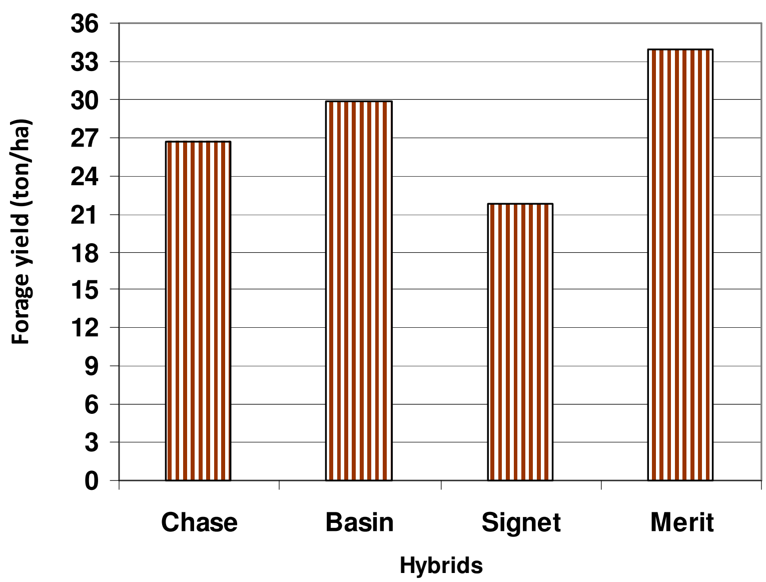

Fig. 7. Foliage yield in different hybrids.

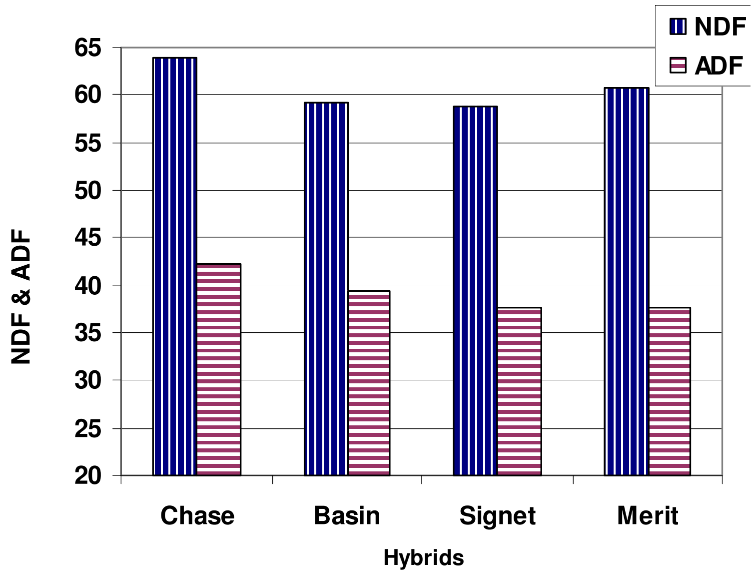

Fig. 8. ADF and NDF in different hybrids.

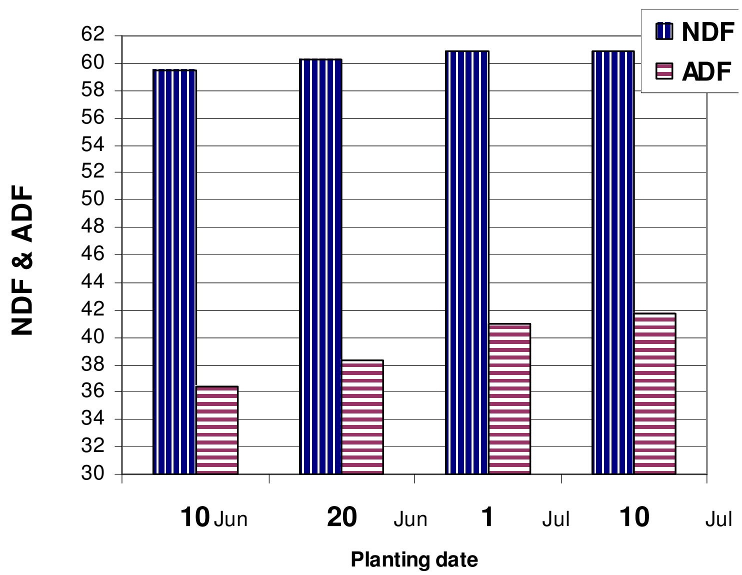

Fig. 9. Effect of planting date on ADF and NDF.

Confirms those of Iptas and Acar (2003), indicated that increasing of NDF *i.e* reduction of forage quality. Increasing of NDF and ADF was observed due to delay in planting date (Fig. 9). Increasing populations from 70,000 to 94,000 plants ha?1 increased NDF from 57.5 to 62.7 and ADF from 37.2 to 41.8 (Fig. 10). Lauer (2003) found that increasing plant density negatively affects corn nutritive value, In vitro digestibility decreased 2.0% as plant density increased, which could be due to increasing fiber concentration. In addition, neutral detergent fiber (NDF) and acid detergent fiber (ADF) concentrations increased an average of 2.6% as plant density increased; potentially reducing feed value (Francisco *et al,* 2010). Cox and Cherney (2001) evaluating two corn plant densities, 32,400 and 47,000 plants/ac, at different N rates. In this study, in vitro digestibility decreased 0.7% and NDF increased 1.3% with the increase in plant density.

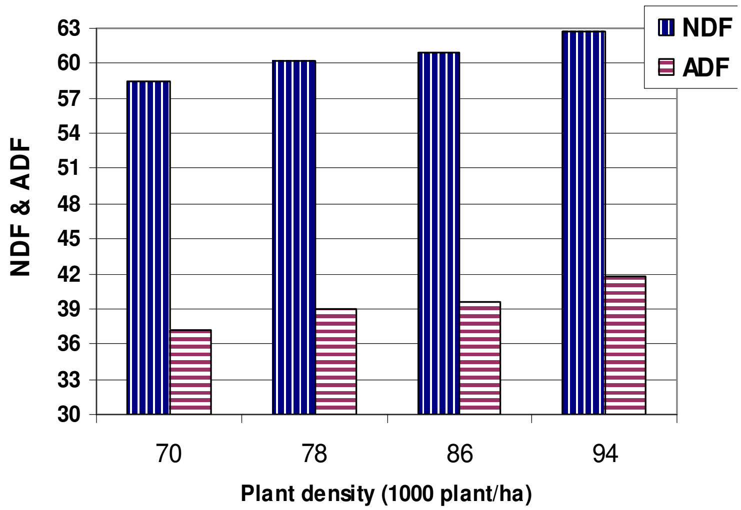

Fig. 10. Effect of density on ADF and NDF**.**

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