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Effects of Cropping Architect and Sowing Date on Forage Quantity and Quality of Corn (*Zea maize* L.) as a Second Crop in Western Iran

Ali Shirkhani[1], Gholam Hossein Ahmadi[1*],Ghadir Mohammadi[2] and Majid Ghitouli[3]

[1]Agricultural and Natural Resource Research Center of Kermanshah, Iran.
[2]University of Thessaly, School of Agricultural Sciences, Department of Agriculture, Crop Production and Agricultural Environment, Volos, Greece.
[3]Department of Biotechnology for Drought Resistance, P. Code 6715685438, Razi University, Kermanshah, Iran.

ABSTRACT

Determination of best sowing date and cropping architect of corn for forage production as a second crop is important for livestock growers in the western Iran. Therefore this study was conducted by using corn hybrid (KSC 704) at Kermanshah province in two years of 2008-09. The experiment was laid out in split–split plot with three replications. Treatments contain three planting dates of 20th, 30th June and 10th July, three plant density of 80000, 90000 and 100000 plant/ha and three inter row space 55, 65 and 75 cm that arranged as main and subplots respectively. Result showed that there was no significant difference between two sowing years. The highest fresh yield with 82.8 and dry yield with 39.2 ton/ha produced by earliest sowing date (20 June) respectively. Also the highest fresh (77.9 ton/ha) and dry (36.6 ton/ha) yield produced by 65 cm inter row space, while the lowest fresh (74 ton/ha) and dry (34.6 ton/ha) yield achieved by 75 cm inter row space. By increasing plant density from 80000 plant/ha to 90000 plant/ha fresh and dry yield increased but by raising more plant density to 100000 plant/ha fresh and dry yield decreased. Highest amount of NDF (55.4 %) and ADF (34 %) was achieved in planting dates of 20 June and 10 of July, respectively. Also highest NDF (55.5 %) and ADF (35.8 %) was produced in inter row spacing of 75 cm. Plant density of 100000 plant/ha produced highest amount of NDF (56.3 %) and ADF (34.8 %). Delay in planting date reduced forage quantity and quality. Using of higher sowing density resulted in forage quality reduction because of increasing of acid detergent fiber (ADF) and non detergent fiber (NDF) indices.

Nomenclature: *Zea maize*
Key Word: Forage quality, forage quantity, cropping date, ADF, NDF.

INTRODUCTION

High quality seed is important to ensure maximum seedling vigor, which is turn is instrumental in achieving maximum yield [22]. Most agricultural regions of Iran are located on a dry climate. And drought is one of the factors limiting photosynthesis and yield [12]. Corn is an important crop in conventional cropping systems of Kermanshah province, west of Iran; Area of corn cultivation was more than 45000 ha at 2008. On the other hand, area of winter crops (including bread and durum wheat, barley and rape seed) is more than 130000 ha annually and silage corn production after harvesting of winter plants, as a second crop is important for livestock growers. Growth

period of corn for forage production is shorter than grain corn production [11], so its cultivation is possible in large part of country after harvest of cereal till next cropping season. Corn silage is used extensively for lactating dairy cows that require high energy feed for maximum milk production. However, corn requires large amounts of water (up to 770 mm year^{-1}; [2-14-15-16] in order to be high yielding and of adequate nutritional value. Silage corn production as a second crop after cereal harvest in Turkey is possible [17]. Shorter growth period of forage corn that allowing delay in its planting date, is in contrast with grain corn [11]. Silage corn shows high yield potential among forage crops [21] and assumed as a one of the best forage crop because of easy, cheap production, storage, higher yield and energy per hectare [25]. Quantity and quality of forage corn can affect by cultivation management [9-11], sowing density, date, soil fertility and harvest management. Different hybrids have optimum planting dates [11-1]. A density of 80000-100000 plant/ha showed highest forage yield [13] and inter row spaces less than 76 cm was suitable for silage corn [27]. Although Cox and Cherney [8] reported that corn populations of 116,000 plants ha^{-1} resulted in higher DM yields than 80,000 plants ha^{-1}, Cox et al. [9] indicated maximum DM yield was obtained between 85,000 and 95,000 plants ha^{-1}. In Canada under rainfed (non-limiting soil moisture) conditions, increasing corn plant populations from 60,000 to 90,000 plants ha^{-1} increased DM yield [25].

Quality of product forage is important also. Forage fiber is routinely measured as acid detergent fiber (ADF) by most commercial labs [19]. The acid detergent fiber, ADF i. e. amount of cellules and lignin in cell wall composition and non detergent fiber ,NDF i.e. amount of cell wall in silage [24-23] are two important quality indices for livestock growers. It means that NDF is ADF + hemicelluloses [24]. There is a reverse relation between nutrient soluble fiber and forage quality; by increasing soluble fiber quality will decrease, because livestock cannot digest this kind of fiber that contains lignin and cellules [13]. The NDF assay measures total plant cell wall material, and contains mainly hemicellulose, cellulose and lignin [19].

Present study was conducted in order to determine the best planting date, sowing density and inter row spaces (crop architecture) of forage corn production as a second crop after harvesting of winter plants.

MATERIALS AND METHODS

The experiment was conducted in Islamabad-e Gharb agricultural research station in Kermanshah, Iran with the geographic longitude of 46^{o} and 55' and latitude of 24^{o} and 16' and elevation of 1346 meters above the sea level, in two years of 2008 and 2009. Climate characteristics of experimental location were shown in Table 1. Experimental design was a split–split plot with planting dates as main plot, plant density as subplot, and inter row space as sub-subplot. The corn hybrid (KSC 704) planted in three planting dates of 20, 30 June and 10 July, three cropping architects of 80000, 90000 and 100000 plant/ha densities plus three inter row spaces of 55, 65 and 75 cm, arranged as main and subplots respectively. Land preparation operations including plowing, disk and trowel to the desired way, before planting was done in the first half of May in both years. After taking track, map test was implemented on the ground. Each experimental unit of four rows with 3 m length was established. The experiment was irrigated with a center pivot system. Spray heads on drops were fitted with 69-kPa pressure regulators and were located 1.5 m apart and 0.45 m above the ground. In-season irrigation set to 33 mm week^{-1} (16.5 mm every 3.5 days) began immediately after planting and simulated a well capacity of 96.5 m3 h^{-1} on 48.6 ha which is considered to be limiting for optimal corn production [21]. All plots were fertilized in the spring prior to planting as dictated by soil tests with a base application of 120 kg N ha^{-1}, 75 kg P2O5 ha^{-1}, 60 kg K2O ha^{-1}. Two central rows by forage harvester was used to chop plants within each treatment to a particle size of 12.7 mm. Plant material was collected in a basket and weighed to estimate wet yield per ha. A 400-g subsample was taken from each plot and oven dried at 55 ^{o}C for 48 hr until a constant weight was achieved to estimate DM concentration and DM yield. Dry samples were ground to 1 mm using a Wiley Mill and stored at room temperature for further nutritive value analysis. Ground forage was analyzed by near-infrared (NIRSystems) absorption techniques to predict levels of neutral detergent fiber (NDF).

Data were analyzed by using SAS statistical program and Duncan test was employed to classify mean values of different treatments when F-values were significant ($p<0.05$).

Table 1. Climate characteristics of experimental location 2008-9

Month	Minimum temperature (°C)	Maximum temperature (oC)	Minimum Humidity (%)	Maximum humidity (%)	Minimum temperature (°C)	Maximum temperature (oC)	Minimum Humidity (%)	Maximum humidity (%)
	2008				2009			
May.	8.6	24.3	27	76	9.1	26.2	32	86
Jun.	11	31.9	12	55	13.5	33.4	11	50
July.	25.6	37.7	7	34	16.5	37.6	7	34
Aug.	25.3	37.9	8	30	19.7	37.5	8	30
Sep.	14.6	34.1	13	40	15.4	33.9	9	37
Oct.	10.7	28	12	44	10.4	29.3	13	46
Average	15.9	32.3	13.1	46.5	14.1	32.9	13.3	47.1

RESULT AND DISCUSSION

Fresh and Dry Yield:

Result of analysis showed that there was no significant difference between two planting years (Table 2); but significant difference between planting dates was observed (P<0.01) and highest fresh yield with 82.8 and dry yield with 39.2 ton/ha produced by earliest sowing date (20 June) respectively (Table 3). It seems cold weather that delayed harvesting caused yield and forage quality reduced (Table 3). Reduction of yield and forage quality due to delay in planting date reported by Asadi [4].

Table 2. AOVA table of fresh and dry yield of two years experiment

S. o V.	Df	MS	
		Fresh Yield	Dry Yield
Replication	2	614.9ns	124 ns
Year	1	63.78ns	1388 ns
Year* replication	2	93.48ns	32 ns
Dates	2	2096.2**	613**
Year* dates	2	108.7ns	54.8 ns
Error	8	47.04	9.8
Row spaces	2	215.3**	63.2**
Year*row spaces	2	5.25 ns	0.64 ns
Dates*row spaces	4	97.2*	23.88*
Density	2	4976.2**	1052.2**
Year* density	4	46.5 ns	14.5 ns
Dates*density	4	105.4*	38.7**
row spaces*density	4	110.9**	30.5*
Dates*row spaces*density	8	117.8**	24.3*
Error	48	34	9.7
C.V.	7.77		8.85

** significant at 5 percent (P<0.05), ** significant at 1 percent (P<0.01), ns not significant.*

Effects of inter row spaces on dry and fresh yield was significant (P<0.01) (Table 2). The highest fresh (77.9 ton/ha) and dry (36.6 ton/ha) yield produced by 65 cm inter row space (Table 4), while the lowest fresh (74 ton/ha) and dry (34.6 ton/ha) yield achieved by 75 cm inter row space (Table 4). It may increasing inter row space raised competition between plants and caused the yield of fresh and dry yield decreased. Shapiro and Wortman [23] and Asadi [4] found that changing of inter row space at fixed density per ha showed no effect on forage and grain yield but Cox et al. [9] showed that narrower row spaces will increase fresh yield without any change in quality.

Table 3. The effect of planting dates on fresh yield and dry yield, NDF and ADF

Planting dates	Fresh Yield (ton/ha)	Dry Yield (ton/ha)	NDF (%)	ADF (%)
20th June	82.8	39.2	55.5	32.4
30th June	72.3	33.7	55.4	33
10th July	71.6	33.1	53.5	34
LSD	5.48	2.92	2.35	1.53

Table 4. The effect of inter row spaces on fresh yield, dry yield, NDF and ADF

Inter row spaces	Fresh Yield (ton/ha)	Dry Yield (ton/ha)	NDF (%)	ADF (%)
55 cm	74.5	34.9	52	29.2
65 cm	77.9	36.6	54	35
75 cm	74	34.6	55.5	35.8
LSD	5.4	2.9	2.45	1.6

Result showed that different densities had a significant effect on fresh and dry yield ($P<0.01$) (Table 2). By increasing of plant density from 80000 plant/ha to 90000 plant/ha fresh and dry yield increased but by raising more plant density to 100000 plant/ha fresh and dry yield decreased (Table 5). It seems raising density to more than 90000 plant/ha due to increasing competition between plants reduced fresh and dry yield. Highest fresh and dry yield with 85.9 and 40.1 ton/ha produced by density of 90000 plant/ha respectively (Table 5). Armestrang and Albert [3] found that density of 80000 plants/ha is desirable density for forage production. Similarly, Asadi [4] found 90000 plants/ha is optimum density for silage production.

Table 5. The effect of sowing density spaces on fresh yield, dry yield, NDF and ADF

Densities (Plants/ha)	Fresh Yield (ton/ha)	Dry Yield (ton/ha)	NDF (%)	ADF (%)
80000	66.8	31.4	52.2	31.9
90000	85.9	40.1	54	33.2
100000	74.1	34.5	56.3	34.8
LSD	5.1	3.2	2.4	1.65

Interaction effect of Planting date × inter row space × density ($P<0.01$) was significant (Table 2). The highest fresh and dry yield with 105.5 and 50.3 ton/ha produced by earliest planting date (20 June), 65 cm inter row spaces and density of 90000 plant/ha, respectively (Table 6). The lowest fresh and dry yield with 56.2 and 26.2 ton/ha created in panting date of 30 June, inter row space 55 cm and plant density of 80000 plant/ha, respectively (Table 6). In contrast, interaction effects of year × planting date, year × inter row space and year × plant density was not significant (Table 2).

ADF and NDF:

Studying the effect of planting dates, inter row spacing and plant density separately on NDF and ADF, showed that highest amount of NDF (55.4 %) and ADF (34 %) was achieved in planting dates of 20 June and 10 of July, respectively (Table 3). Highest NDF (55.5 %) and ADF (35.8 %) was produced in inter row spacing of 75 cm (Table 4). Also plant density of 100000 plant/ha produced highest amount of NDF (56.3 %) and ADF (34.8 %) (Table 5). Study the effect of planting dates, inter row spacing and plant density together on NDF and ADF showed that the highest NDF (58.7 %) and ADF (39.6 %) produced in planting date of 10 June, 75 cm inter row space and 100000 plant density (Table 6). This result confirms those of Iptas and Acar [17]; Bal et al, [5] that indicated increasing of NDF caused the forage quality reduced. Increasing of NDF and ADF and decreasing foliage quality as a result of sowing date was reported by Cusicanqui and Lauer [10]. Similar result was reported by Valdez et al, [26] and Champion [7]. In contrast, an opposite result reported by Marsalis et al, [20], William and Kurt [27] which investigated hybrids from different maturing groups and observed increasing o f NDF by delay in planting date. They showed that the NDF values were higher in late maturing hybrids. Also reduction of forage quality due to the using high plant density was reported by Cox and Cherney [8]. Baron et al, [6] found that as sowing density raised from 75000 to 125000 plant /ha, NDF and ADF increased. They concluded there was no effect of inter row space on forage quality indices. Similarly, Stanton and et al, [24] observed that increasing plant density caused the forage quality raised.

Table 6. The effects of Interaction of sowing date, inter row space and density on fresh yield, dry yield, NDF and ADF

Planting date	Inter row spaces	Density	Fresh Yield (ton/ha)	Dry Yield (ton/ha)	NDF (%)	ADF (%)
20th June	55	80000	75.2	36.1	47.2	27
		90000	94.98	45.5	50.1	28
		100000	79.18	37.3	52	28
	65	80000	71.7	33.7	49.2	31.9
		90000	105.5	50.3	53.8	32.6
		100000	79.2	37.1	53.1	36.8
	75	80000	736	35.1	50.9	34.1
		90000	85.7	40.7	51.2	33.9
		100000	80.2	34.3	56.6	35.6
30th June	55	80000	56.2	26.2	54.2	29
		90000	78.8	38.4	55.6	29.3
		100000	70.6	32.7	57	30.3
	65	80000	68.1	31.8	54.8	32.7
		90000	88.7	41.7	53.3	35.6
		100000	71.7	33.4	56.2	35.9
	75	80000	61.1	29.1	56	35.4
		90000	80.7	37.5	54.8	36.4
		100000	74.8	34.8	54.8	37.1
10th July	55	80000	65.8	30.3	51.9	26.7
		90000	79.7	36.6	53.9	30.5
		100000	70.6	32.6	56.2	32.2
	65	80000	62.8	30	54.1	36.1
		90000	79.9	36.8	54.5	35.7
		100000	73.7	34.5	57.1	37.5
	75	80000	66.6	30.3	55	34.1
		90000	79.4	35.6	57	36.5
		100000	67.3	30.9	58.7	39.6
LSD			9.4	5.1	4.6	3.5

CONCLUSION

Delay in planting date will reduce fresh and dry yield and resulted in quality reduction of forage. Best planting density is 90000 plants /ha and using of higher density will reduce quality and quantity of silage. Better inter row space is 65 cm also. In addition, the 20th June planting date and using of 90000 plants/ha at 65 cm inter row spaces is recommendable for silage corn producer and livestock growers as second crop after harvesting of winter cereals and rape seed in Kermanshah province.

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