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Preliminary evaluations of the yield components and productivity of sole cropped and mix-intercropped sweet corn with berseem clover as influenced by various spatial arrangements

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Abstract. The study was designated to assess whether, and to what extent, yield-related characteristics in sweet corn and/or forage attribute in berseem clover are influenced by mono- or mixed cultivation systems, when combined with various corn planting arrangements. Effect of different culture methods (sole cropping/mixed intercropping) and spatial arrangements of 20×65 cm, 20×75 cm, 25×65 cm, 20×85 cm, 25×75 cm, and 25×85 cm on yield attributes of sweet corn and berseem clover was investigated at Gavdasht Research area, Babol region, Mazandaran Province, Iran, during 2009 cropping season. Significant differences in corn plant height, total number of leaves per plant, ear length, number of grains per row, plant dry weight, and can grain weight were observed with culture method. Spatial arrangement caused significant variations in all studied parameters. The maximum ear length and plant dry weight were obtained in sole cropped sweet corn. The highest values for the number of grains per ear, number of grain rows per ear, husked green ear yield, grain yield and forage yield in sweet corn/berseem clover mixed intercropping were recorded in spatial arrangement of 20×75 cm. However, crop arrangement of 25×85 cm resulted in producing maximum rate of fresh and dry forage yield in berseem clover in the first cut, and highest stem and ear diameter in sweet corn. The interaction between sole cropped sweet corn and 20×75 cm spatial arrangement led to the greatest number of grains per ear row. Whilst, mixed intercropping along with the said spatial arrangement produced maximum can grain weight. Findings suggested that growers for producing highest can grain weight, as a qualitative agronomic factor, should apply 20×75 cm spatial arrangement in sweet corn/berseem clover intercrops.

key words: can grain weight, planting arrangement, culture method, *Zea mays* L., *Trifolium alexandrinum* L.

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INTRODUCTION

Sweet corn (*Zea mays* L. *saccharata* Sturt.) is a high yielding and early maturing crop suitable for producing superior amount of dry matter per unit area; so that, early harvested plants can be considered for green forage production (Bazrafshan et al., 2005). Due to having large amounts of sugar in the endosperm layer, fresh (unripe) sweet corn has a sweeter taste as compared to other corn varieties (Mokhtarpour et al., 2008a). The purposeful production of sweet corn is mainly based upon the market demands (*i.e*. cream-style, frozen-style, whole grain canning and fresh consumption) of consumers. Cultivation of sweet corn cv. SC 403 (Iranian cultivar) as an agricultural crop was never common in Iran and it is only considered as a luxury product. Therefore, there are very few and scattered researches have been conducted on this crop (Mokhtarpour et al., 2001).

Berseem clover (*Trifolium alexandrinum* L.), also known as Egyptian clover, is a fast growing annual legume crop having both the summer and winter types in Mediterranean zone with moderate climate (Khoshgoftar, 2010). As a forage crop, it is widely cultivated throughout the southern basin of the Caspian sea and plays a major role in a) feeding the livestock (it yields 40–80 t ha^{-1} high quality fresh forage in three cuttings), b) covering the rangelands, c) fertilizing the soil via nitrogen fixation, and d) biocontrolling(or suppressing) the weed growth in the field on which the crop is grown (Khoshgoftar, 2010). The production rate in berseem is dependent on sowing date, soil fertility, environmental conditions (relative humidity and temperature), shoot height, the number of harvests, and variety (Mokhtarpour et al., 2008b). High water percentage and fewer dry matter content (higher water to dry-matter ratio) at the time of harvesting, usually make difficulties in the cutting, dryness and transportation processes. To overcome such issues, serious attention has now been shifted toward the mixed intercropping of clover with other nitrogen-demanding forage crops, particularly from cereals.

Intercropping, as one of the components in sustainable agriculture, is formed through simultaneous producing of two or more crops on the same field in a year (Mazaheri, 1998). Cereals in legume/cereal intercrop system have faster growth rate; however their nutrient values due to lesser protein percentage assumes to be little profitable compared to legumes. Regarding the total digestible nutrients, the legume/cereal intercrop is similar to sole cropped cereals; yet, their mixture forage shows a better balance of nutrients (Posler et al., 1993). The appropriate seeding schemes can help balance rivalry between species in intercropping systems (Yolcu et al., 2010). These findings support the fact that it is possible to increment the exploitation of crop-required resources by planting two or more crop in the same field for annual growing season and this will be more complicated in case of simultaneous several plantings which causes an interaction (competition) that calls integrative efficiency of cropping system (Mokhtarpour et al., 2008b). It is also concluded that two crops intercropping produces a plant community that takes advantage of required restricted resources and continuously it resulted in advanced crop quality and quantity (Mokhtarpour et al., 2008b).

According to the results by Jamshidi et al. (2008), cereal/legume intercropping gained from natural pastures through locating the aerial parts of plants in opposite photosynthetic systems at different stratum help the system to receive maximum light and energy efficiently. An experiment on intercropping of some sorghum cultivars with pigeonpea (*Cajanus cajan* [L.] Millsp.) revealed that the highest yield of sorghum cultivars was observed in intercrop compared to the sole cropped system (Holkar and Jagtap, 1992). A significant increase in grain and forage yield was reported in maize/ricebean (*Vigna umbellata* [Thumb.] Ohwi and Ohashi) intercrop in comparison with sole cropped maize (Rerkasem and Rerkasem, 1988). Ross et al. (2001) reported that the most important factors for producing forage in legumes are soil texture, pH, rainfall, temperature and varieties. Ghorbani and Kochaki (1994) reported that an increase in the ratio of clover grain in the seed-mixture led to decrease in dry matter content of the first cut, the shared yield of barley dry matter and the yield of digestible dry matter. In addition, increasing the amount of clover grain in the mixture increased the total forage yield, yield of clover dry matter, and clover yield ratio of the total yield. Vaezzadeh (1992) declared that berseem clover/cereals intercropping in the four regions of Iran (Karaj, Sari, Ahvaz, Dezfoul) tend to 21% increase in yield compared to sole cropped system and there was 4% increase in dry matter content of the intercrops in relation to sole cropped system. Rahnama and Poori (1995) studied the effect of various spatial arrangements of intercropping in barley with berseem clover (*Trifolium alexandrinum* L.) and common vetch (*Vicia sativa* L.) on fresh and dry forage yield. Their results showed that barley/berseem clover intercrops had more fresh and dry forage yield as compared to barley/common vetch intercrops. In addition, Kashani and Bahrani (1993) in a three years study on legumes/cereals intercropping demonstrated that the highest forage yield was obtained when legumes intercropped with cereals.

Plant distribution is a momentous factor in competition between species in the root zone (subsoil) and aerial space (topsoil) within a mixture (Yolcu et al., 2010). The optimum planting density has a serious effect on the components of crop yield in the way that choosing optimum plant density contributed to an appropriate yield production (Norwood, 2001; Widdicombe and Thelen, 2002). Bazrafshan et al. (2005) found that the maximum product of corn dry matter and green ear yield can be obtained in density of nine plants per square meter, but the maximum grain yield was obtained in 7.5 plants m^{-2} density which was in accordance with the findings of Hassan (2000). Rodrigues et al. (2003) reported that in the different planting densities of Baby corn, the plant height, the number of ear per plant, the stem diameter, and ear yield had a significant differences and the maximum ear yield (722 kg ha^{-1}) was obtained in the plant density of 105,000 plants ha^{-1}. Rangarajan et al. (2002) reported that the distances among rows had a significant effect on ear yield. Peet (2004) recommended 76.2 to 106.6 cm row-spacing and in-row spacing of 15.2 to 30.4 cm for southern region of America. Bean and Gerik (2000) found that in 50 cm row spacing the ear yield increased up to 11.1% compared to 75 cm row spacing. Yankov et al. (1996) showed that alfalfa under irrigation could be sown along with silage maize at a row distance of minimum 70 cm and sowing rate for silage maize of about 120000 plants per ha. Haş (2002) remarked that weight and length of ear decreased with increasing plant density. Sadeghi and Choukan (2008) remarked that planting distances of 65 cm was superior to two other planting distances of 55 and 75 cm. Farnham (2001) showed that the grain yield increased 6.9% with increasing plant density from 59 to 89 thousand plants ha^{-1}. In an experiment, Norwood (2001) reported a reduction in kernel weight and kernel number per ear by increasing density. Andrade et al. (2002) indicated that the grain yield increased with reducing width of planting rows and increasing density per unit area. Furthermore, the grain yield increased 4% with decreasing the distances of planting rows from 76 to 56 cm (Shapiro and Wortmann, 2006).

Keeping in view the importance of these two factors, the present study was designed to investigate the effect of different culture methods with varying spatial arrangements individually and in combination on yield performance of sweet corn and berseem clover.

MATERIALS AND METHODS

This study was carried out from July to mid September 2009 at Gavdasht, Agricultural Research Field in Babol, which is located at latitude 36°33′ N, longitude 53°75′ E, with the altitude 14 m above mean sea level. This site has a moderate climate with an average annual rainfall of about 526.5 mm and mean annual temperature of 15.5°C. During the experimental period, the recorded meteorological data related to total amount of rainfall, monthly evaporation and mean monthly minimum and maximum air temperatures were 0.1 mm, 204 mm, 21.8°C and 28.5°C (in July), 45.5 mm, 125 mm, 24.6°C and 27.3°C (in August), and 44.2 mm, 113 mm, 22.6°C and 25.2°C (in September), respectively.

The soil texture of experimental site (0–30 cm depth) was clay loam, with nitrogen content of 0.22%, low in organic matter (2.8%), alkaline in reaction, phosphorus and potassium content of 17.5 and 195 mg kg^{-1}, respectively, with a pH of 7.2 and EC = 0.21 mmhos cm^{-1}.

The experimental field was split plot based on randomized complete block design (RCBD) in three replicates. Two planting methods comprising of sole cropping of sweet corn (*Zea mays* L. *saccharata* Sturt.) cv. SC 403 (a hybrid single-cross sweet corn with 80-day growth cycle) and mixed intercropping of sweet corn and berseem clover were applied in main plots (as major factor). The subplots consisted of split application of six planting arrangements (20 cm×65 cm, 20 cm×75 cm, 25 cm×65 cm, 20 cm×85 cm, 25 cm×75 cm, and 25 cm×85 cm). Each subplot consisted of six 5 m long plant rows with specific row spacing pattern proportional to each treatment. The experimental field was done on a fallow farm. The soil was plowed in the winter by Mollboard Plough. Next, in the spring, to fragment clods and to uniform soil condition, perpendicular disk was operated and land leveling was done afterwards. At the time of pre-sowing, 200 kg ha^{-1} potassium sulfate (50% K_2O), and 200 kg ha^{-1} ammonium phosphate (20% P_2O_5) were incorporated and added to the soil. Nitrogen fertilizer was used as urea (46% N) in two splits. The first application (83 kg ha^{-1} urea ~ 38 kg N ha^{-1}) was applied alongside and beneath the seed row as the starter fertilizer and the second application (116 kg ha^{-1} urea ~ 53 kg N ha^{-1}) was made as topdressing when the corn crop had between six and eight leaves fully expanded. The additional application of N was set mainly due to probable leaching caused by the cumulative impact of irrigation and usual rainfall during August and September.

Planting rows in the experimental units were sowed 3 to 5 cm deep by corn grains on 1st July 2009. Then, in the plots with mixed intercropping pattern the clover grains were equally hand-sprinkled on the rows and by means of Garden fourche soil-covered in which the grains were placed at 1 cm depth. A thinning operation was performed at 3–4 leaves phase, leaving the more vigorous plants in each plot (one seedling per hole in the planting rows). Weed control at pre-sowing was achieved by means of EPTC (a pre-emergence and early post-emergence thiocarbamate herbicide) at 5 L ha^{-1}. After sowing, weeds were eradicated by hand hoeing and also application of Atrazine (1 kg ha^{-1}) and Lasso (4 L ha^{-1}) herbicides. Crop was furrow-irrigated. In order to facilitate the emergence of seedlings, all plots were irrigated equally once in every five days. Subsequent irrigations were set at 7-day intervals after seedling establishment according to plant water requirements and it continued until the crop physiological maturity. Pest control was performed by Lindane 1% (benzene hexachloride/BHC) against turnip moth (*Agrotis segetum* Schiff.) when the seedlings had four leaves. Metasystox R (1.5 ml L^{-1}, systemic insecticide) was employed to eradicate sucking insects before occurrence of male ones. Crop management was similar to those commonly applied to crops in the area. Total management practices were done uniformly and simultaneously in all plots. Final harvests were carried out on 10th Sept. 2009.

When the grains moisture reached 72%, ears from two rows in each sub-plot (2 m^2, middle parts of rows 2 and 5) were harvested manually. The outer rows and 0.5 m from both sides of the inner rows in each sub-plot were not subjected to any data collection (sampling activity) to avoid any border effect. The green ear yield was evaluated via total weight of green husked ears; it is done through the weight of both marketable unhusked and husked ears using a 0.001 g digital precise scale and it expressed as g m^{-2}. Then, the harvested fresh ears were de-husked (husk off) and their grains detached using kitchen knife. The total weight of fresh grains from harvested area regarded as can grain weight (g m^{-2}).

At pre-maturity stage, 10 random samples were hand harvested from rows 2 and 5 and the following parameters were assessed: plant height (cm), total leaf number per plant, stem diameter (mm), ear diameter without kernel (mm), ear length (cm), number of grain rows in ear, number of grains per ear, number of grains per ear row and plant dry weight (g m^{-2}). The distance from ground level to the insertion point of the highest leaf blade was considered as plant height. Stem diameter was measured with a caliper ruler below the ear insertion node. All marketable husked ears in the same ten plants were considered for diameter and length evaluation. Yield components in the ears including number of grain rows in ear, number of grains per ear and number of grains per ear row were detected from the ten randomly selected plants in the trial plots. Samples (10 fresh shoots per sub-plot) were then oven-dried at 70°C for 72 h in a stove with air circulation and the dry weight of the shoots was determined (plant dry weight).

At final harvest stage, the aerial parts correspond to sweet corn and berseem clover were cut from the ground level and the marketable ears were hand-picked. The separated grains from marketable ears were considered for grain yield evaluation. The fresh weight of the shoots was measured for berseem clover as fresh forage yield (g m^{-2}). The harvested shoots from two central rows (2 m^2, middle parts of rows 3 and 4) in every sub-plot were left in the field for final drying until constant weight was achieved for evaluating the dry matter weight of the above-ground parts (dry forage yield of berseem clover as well as sweet corn separately and in mixed status).

Analysis of variance for the data was carried out using MSTAT-C statistical software package. Difference among the treatment means were compared using Duncan's multiple range test (DMRT) at 0.05 probability level.

RESULTS AND DISCUSSION

The plant height (PH) was statistically affected by culture method and interaction effect of culture method × planting arrangement at 5% probability level; however, planting arrangement could significantly influence this trait to a highly level (Table 1 and 2). Plant height of sweet corn in sole culture (123.5 cm) was found to be more than intercrop result (120.44 cm). Taller PH (133 cm) was achieved in planting arrangement of 20×65 cm. With increasing the distances between planting rows, a descending procedure in PH was obtained. The lowest values of PH (111.5 cm) gained under planting arrangement of 25×85 cm.

Planting arrangement of 20×65 cm caused the plant density to be increased in the unit of area and as consequence it resulted in more inter/intra plant competition for light (*Photosynthetic Active Radiation*) and nutrient absorption (Table 1).

Results showed that the highest plant height (134 cm) was related to plots with spatial arrangement of 20×65 cm under sole cropping of sweet corn which was followed by the same spatial arrangement and corn/clover intercropping. In contrast, a combination of intercropping (sweet corn with berseem clover) and planting arrangement of 25×85 cm produced the lowest PH (111 cm) (Table 2). Findings of this study conform findings of Turgat (2000), Haş (2002), Mokhtarpour et al. (2008a), and Rahmani et al. (2010).

Result for total number of leaves per plant was similar to PH (from the culture method perspective), according to analysis of variance outcome (Table 1). As it is clear in Table 2, the maximum number of leaves per plant (15 leaves) was produced under sole culture and planting arrangement of 25×85 cm; however the least number of which (eight leaves per plant) belonged to intercropping method under planting arrangement of 20×65 cm. This interaction was statistically at par with combinations of 20×65 cm for sole cropping, 20×75 cm for intercropping, and planting arrangement of 25×65 cm for intercropping. Indeed, the more planting density (lesser row spacing), the lower enough space for leaf planophile (horizontal) growth and leaf generating which cause erectophille growth (vertical leaves) and increasing leaf height in the crop. Charles and Arnold (1969) showed that although the number of leaves per plant is a genetically controlled parameter, it is under influence of environmental factors such as temperature degree, planting density, soil condition and farming operations. In this regard, Rahmani et al. (2010) found that there was no distinctive link between planting density and the number of leaves in plants. He noted that there are some factors which can affect this genetic trait among which plant population could be effective. During our investigation, stem and ear diameter were highly significantly influenced by the spatial arrangement ($p < 0.01$) (Table 1). Maximum stem diameter (22 mm)

Table 1. Individual effects of culture methods and spatial arrangement on plant height, total number of leaves per plant, stem diameter, ear diameter, ear length, and number of grain rows per ear in sweet corn in estimated means (*ANOVA* results included).

Treatments	Plant height [cm]	Total number of leaves per plant	Stem diameter [mm]	Ear diameter [mm]	Ear length [cm]	Number of grain rows per ear
Culture method						
C_1	123.50 a	12.44 a	17.33 a	18.17 a	15.50 a	15.28 a
C_2	120.44 b	8.78 b	17.06 a	18.22 a	14.33 b	14.72 a
F-test	*	*	ns	ns	*	ns
Spatial arrangement						
20 cm×65 cm	133.00 a	8.50 d	14.50 d	16.50 c	16.33 b	15.00 bc
20 cm×75 cm	127.00 b	10.00 c	16.50 c	17.50 bc	19.00 a	16.50 a
25 cm×65 cm	124.50 c	10.00 c	16.50 c	18.50 b	18.67 a	16.50 a
20 cm×85 cm	119.00 d	12.00 b	17.50 c	18.50 b	18.67 a	15.50 b
25 cm×75 cm	115.00 e	12.50 b	20.00 b	20.00 a	18.50 a	14.50 cd
25 cm×85 cm	111.50 f	14.00 a	22.00 a	21.00 a	19.00 a	14.00 d
F-test	**	**	**	**	**	**

Means not sharing a common letter in a column differ significantly at 0.05% level of probability according to Duncan's multiple range test; C_1 – sole cropping of sweet corn; C_2 – mixed intercropping of sweet corn with berseem clover; * – $p < 0.05$; ** – $p < 0.01$; ns – $p > 0.05$

was obtained from spatial arrangement of 25×85 cm, and spatial arrangement of 20×65 cm resulted in minimum diameter for sweet corn's stem (14.5 mm). The highest stem diameter in the higher row-to-row spacing might come from providing enough space for diametric growth. Rahmani et al. (2010), in their study on sweet corn, asserted that stem diameter decreased with the increasing planting density. It seems that with planting density increment, the plant required geometric space is gradually reduced and as a result it decreased its absorbed nutrients and proportionally mitigated stem diameter as well. Similar results concerning the direct effect of plant population on stem diameter have been reported earlier (Farivar, 1997; Hassan, 2000). Statistically higher value of ear diameter (21 mm) was recorded in spatial arrangement of 25×85 cm than spatial arrangement of 20×65 cm with the least ear diameter (16.5 mm) (Table 1). The reason in variation of ear diameter was probably due to competition between the plants for absorbing light, active photosynthetic radiations, and necessity nutrients (Hassan, 2000; Turgat, 2000; Haş, 2002; Oktem et al., 2004). The results are contradictory to those of Rahmani et al. (2010) who reported that ear diameter was not correlated with plant population. The results in Table 1 indicated that ear length at maturity was significantly ($p < 0.05$) and highly drastically ($p < 0.01$) influenced by culture methods and different spatial arrangements, respectively. Length of ear in sole cropped sweet corn (15.5 cm) was more than corn/clover intercrops (14.3 cm). The minimum ear length (16.3 cm) under planting arrangement of 20×65 cm and the maximum ear length (19 cm) under applied arrangement of 25×85 cm was obtained (Table 1). The results confirmed the findings of earlier researchers (Turgat, 2000; Haş, 2002; Oktem et al., 2004; Mokhtarpour et al., 2008a). Among inputted treatments, planting arrangement dramatically could impress number of grain rows in ear ($p < 0.01$) (Table 1). As it is observed in Table 1, number of grain rows per ear was minimum (14 rows) for spatial arrangement of 25×85 cm and maximum (16.5 rows) for both spatial arrangements of 20×75 cm and 25×65 cm. Contradictory results were found by Bazrafshan et al. (2005) who stated that the number of grain rows per ear did not affect by planting densities and it was considered a less-affected parameter by environmental conditions. This finding coincided with most of the researchers' findings (Hashemi-Dezfouli and Herbert, 1992; Farivar, 1997; Jabari, 2000). Nevertheless, Siadat and Shaigan (1994) have reported non-similar results; they mentioned that an increased planting density decreases this trait partially.

There were effects of culture method (C; $p < 0.05$), planting arrangement (A; $p < 0.01$), and of the C × A interaction ($p < 0.05$) on number of grains in ear row (G/ER) (Tables 2 and 3).

Although the response of culture methods were linear and positive as planting density increased, G/ER increases was higher in sole culture (C_1) as planting density boosted which explains the interaction. The maximum number of grains in ear row (32 grains) recorded for C_1 with planting arrangement of 20×75 cm and the minimum number of which (23.67 grains) for intercropping (C_2) × planting arrangement of 25×85 cm (Table 2). Considering that, the Duncan test was done with 5% probability level; it can be deducted that C_1 became superior to C_2 starting at a spatial arrangement of 25×85 cm. Hosseinpanahi et al. (2009), in studying the yield and yield components in intercropping of maize and potato, noted that the number of grains per

Table 2. All significant interaction effect of spatial arrangement and culture methods (C_1 – sole cropping of sweet corn; C_2 – mixed intercropping of sweet corn with berseem clover) on plant height, total number of leaves per plant, number of grains per ear row, and can grain weight of sweet corn in 2009 (*ANOVA* results included).

(Spatial arrangement) × Culture method	Plant height [cm]	Total number of leaves per plant	Number of grains per ear row	Can grain weight [g m^{-2}]
(20 cm×65 cm) × C_1	134.00 a	9.00 d	27.00 cde	420.00 e
(20 cm×75 cm) × C_1	128.00 b	11.00 c	32.00 a	500.00 b
(25 cm×65 cm) × C_1	125.00 c	11.00 c	30.00 b	450.00 d
(20 cm×85 cm) × C_1	120.00 d	13.00 b	29.00 bc	420.00 e
(25 cm×75 cm) × C_1	116.00 ef	14.00 ab	26.00 de	370.00 g
(25 cm×85 cm) × C_1	112.00 gh	15.00 a	25.00 ef	330.00 h
(20 cm×65 cm) × C_2	132.00 a	8.00 d	27.00 cde	450.00 d
(20 cm×75 cm) × C_2	126.00 bc	9.00 d	30.30 b	520.00 a
(25 cm×65 cm) × C_2	124.00 c	9.00 d	28.70 bc	480.00 c
(20 cm×85 cm) × C_2	118.00 de	11.00 c	27.70 cd	450.00 d
(25 cm×75 cm) × C_2	114.00 fg	11.00 c	25.70 def	400.00 f
(25 cm×85 cm) × C_2	111.00 h	13.00 b	23.67 f	360.00 g
F-test	*	*	*	*

Means in each column followed by the different letters are significantly different ($p < 0.05$) according to Duncan test (a–h letters mean homogenous groups); * – $p < 0.05$

Table 3. Individual effects of culture methods and spatial arrangement on number of grains per ear row, number of grains per ear, plant dry weight, can grain weight, husked green ear yield, and grain yield of sweet corn in estimated means (*ANOVA* results included).

Treatments	Number of grains per ear row	Number of grains per ear	Plant dry weight [g m^{-2}]	Can grain weight [g m^{-2}]	Husked green ear yield [g m^{-2}]	Grain yield [g m^{-2}]
Culture method						
C_1	28.00 a	429.06 a	944.44 a	418.89 b	1944.44 a	403.89 a
C_2	26.67 b	395.28 a	846.33 b	450.56 a	2008.33 a	391.67 a
F-test	*	ns	**	**	ns	ns
Spatial arrangement						
20 cm×65 cm	27.00 cd	409.00 d	1150.00 a	435.00 c	1950.00 d	370.00 c
20 cm×75 cm	31.67 a	527.80 a	950.00 b	510.00 a	2250.00 a	450.00 a
25 cm×65 cm	29.33 b	488.70 b	850.00 c	465.00 b	2150.00 b	420.00 b
20 cm×85 cm	28.33 bc	443.80 c	800.00 cd	435.00 c	2050.00 c	400.00 b
25 cm×75 cm	25.83 d	379.00 e	750.00 d	385.00 d	1850.00 d	356.70 c
25 cm×85 cm	24.33 e	345.50 f	650.00 e	345.00 e	1650.00 f	330.00 d
F-test	**	**	**	**	**	**

Means not sharing a common letter in a column differ significantly at 0.05% level of probability according to Duncan's multiple range test ; C_1 – sole cropping of sweet corn; C_2 – mixed intercropping of sweet corn with berseem clover; * – $p < 0.05$; ** – $p < 0.01$; ns – $p > 0.05$

ear row impressively differed as by intercropping. Jabari (2000) found that G/ER has the highest sensitivity to planting density. The competition impact for nutrients and carbohydrates between ear and tassel would be more severe under the detrimental condition of environment (Magalhges et al., 1993), and this includes higher planting densities. It seems that amongst applied densities, spatial arrangement of 20×75 cm could provide an efficient condition for tassel emergence and caused a harmonic action between the amounts of produced pollens and tassel's occurrence that lead to the increased G/ER (Hashemi-Dezfouli and Herbert, 1992). According to data analysis of variance it was an effect of spatial arrangement at the probability level of 1%, not the culture method (C) solely and spatial arrangement × C interaction on the number of grains in ear (Table 3). Maximum (527.8 grains) and minimum (345.5 grains) number of grains in ear would be obtained at spatial arrangements of 20×75 cm and 25×85 cm respectively (Table 3).

Bazrafshan et al. (2005) contradictorily showed that with increasing planting density, the number of grains in ear decreased as well. Generally, the negative effect of increasing plant density on the grain number in ear could be due to decrease in fertilization and fertility as a result of excess inter/intra plant competition (Siadat and Shaigan, 1994; Jabari, 2000). The effect of culture method (C) and spatial arrangements was verified ($p < 0.01$) on the plant dry weight; although, no interaction effect was observed (Table 3). Sole culture, which produced 944.44 g m^{-2} plant dry weight on average, was superior to intercropping (846.33 g m^{-2}). It must be pointed out that the plant dry weight increased as planting density in the unit of surface enhanced from planting arrangement of 25×85 cm to 20×65 cm. (Table 3). This tendency of reduction in above ground part dry weigh with planting density decrease is in well agreement with findings by other researchers (Farivar, 1997; Jabari, 2000; Bazrafshan et al., 2005). In this regard, Maddoni and Otegui (2004) indicated that corn biomass would be greater as a result of increased planting population. Accordingly, in the current study, there were an effect of culture method ($p < 0.01$), spatial arrangements ($p < 0.01$), and of the C × spatial arrangement ($p < 0.05$) interaction on the can grain weight (Table 2 and 3). The maximum (520 g m^{-2}) and minimum (330 g m^{-2}) can grain weight attained under the mutual effect of C_2 × planting arrangement of 20×75 cm and the C_1 × planting arrangement of 25×85 cm respectively (Table 2). The reason can be found in better utilization of light, nutrients, water and finally higher assimilation rate in the intercropping. The superiority characteristic of intercropping, with regard to can grain weight, is contributed to its fresh and dry biomass superiority in the above-ground part (data not shown). Jamshidi et al. (2008) emphasized that at lower row spacing with declined light quality in the canopy, crop would cope with a reduced photosynthetic rate and as a consequence its growth rate faces a considerable decrease. Mokhtarpour et al. (2008a) reported that increasing the population arrangement lead to a significant variation in can grain weight. Regarding the can grain weight, a planting arrangement of 25×65 cm coupled with sole cropped sweet corn was statistically at par with (20×65 cm) ×C_2 and (20×85 cm) ×C_2 interactions (Table 2). Husked green ear yield was only affected by different spatial arrangements ($p < 0.01$); whereas, culture method and interaction between spatial arrangement and culture methods represented no significant effects (Table 3). Statistically, at the range of studied planting arrangements, except for planting arrangement of 20×65 cm (Table 3), husked green ear yield increased as planting density increased (up to spatial arrangement of 20×75 cm). Yet, the negative impacts of increase in plant density from the optimal density are chiefly as a result of reduced availability of nutrients and light; notwithstanding, other elements might be contributed. It goes without saying that, in planting density researches, the negative impact of increased densities may not be only due to water availability, it can be resulted from reduced capacity of root system in absorbing water. It also recommended that, even in irrigated crops, increased planting densities could decrease the yields by reducing the capacity of root system for absorbing water. Similar conclusion can be applied (as suggested for water competition) to competition for nutrients and light. Concerning the light, the greater husked green ear yield (2250 g m^{-2} for spatial arrangement of 20×75 cm) which was noticed at higher densities, regardless of 20×65 cm planting arrangement, could be because of greater photosynthetic rates caused by ideal shading and also by a vast leaf area produced by delayed (non-accelerated) leaf senescence (Borrás et al., 2003; Silva et al., 2007). As it is noted earlier, the corn yield-related traits improved linearly through increasing the planting density (Tables 1 and 3). Clearly, this indicates that the sweet corn crop could adjust its physiology under greater competition as a result of increased plant population up to spatial arrangement of 20×75 cm. Therefore, it increased the proportion of assimilate products partitioned to photosynthesizing tissues rather than respiring ones (Whiley, 1979), under restricted assimilate production with increasing competition from mix-intercropped clover and ultimately enhanced the corn yield related traits. The results in Table 3 indicated that grain yield of sweet corn was drastically ($p < 0.01$) influenced by different spatial arrangements. Mokhtarpour et al. (2001) revealed a significant variation in grain yield of corn with respect to plant density. It should be noted that other treatments remained unaffected. The spatial arrangement of 20×75 cm, by providing maximum grain yield of 450 g m^{-2} was superior to other treatments. The reason could be taller ear length (19 cm), higher number of grain rows per ear (16.5 rows), higher number of grains per ear row (31.67 grains), higher number of grains per ear (527.80 grains), greater can grain weigh (510 g m^{-2}), and greater husked green ear yield (2250 g m^{-2}) in the aforementioned arrangement (Tables 1 and 3). It must be mentioned that an increased planting density over than optimal condition causes the crop to experience several competitive factors including water, nutrients, and light (Silva et al., 2007). Although the quality of receivable light by the leaf area index decreases, it accelerates the leaf senescence and enhances the light attenuation in the canopy (Borrás et al., 2003). In addition, Biaziegr and Glover (1980), in their study on maize, showed that planting arrangement must be taken into account in a way that the maximum solar radiation could be achieved; it is only possible through equal distribution of canopy leaf area in the field. In this study, disregard to increasing trend in plant population, it seems the planting arrangement of 20×75 cm could provide an optimal competition in terms of three mentioned important factors and finally led to higher dry matter allocation for reproductive parts (male and female inflorescences).

It is evident from the data that fresh/dry forage (hay) weight of berseem clover in the first cut showed a highly significant difference ($p < 00.1$) (Table 4). The lightest and heaviest fresh/dry forage weight attained in plots with spatial arrangements of 20×65 cm and 25×85 cm respectively.

Since the highest fresh (5733 g m^{-2}) and dry matter (656.7 g m^{-2}) content in clover forage was obtained upon using spatial arrangement of 25×85 cm, it seems that as the sweet corn's plant density decreased, the competition for growth requirement factors (which includes adequate space for growth and development of shoots and roots , adequate light, nutrients and water requirements) ameliorated in the Egyptian clover and as a result of lesser shading and enough growth space, it could exploited the provided condition to produce more dry matter content. By contrast, with increasing plant density (from 25×85 cm to 20×65 cm spatial arrangement) in sweet corn, a descending trend was found in both fresh (5733 to 4200 g m^{-2}) and dry (656.7 to

Table 4. Effect of spatial arrangement on fresh and dry forage yield of clover in the first cut, and on forage yield in intercropping of sweet corn with berseem clover in estimated means (*ANOVA* results included).

Spatial arrangement	Fresh forage yield of berseem clover in first cut [g m^{-2}]	Dry forage yield of berseem clover in first cut [g m^{-2}]	Forage yield in mixed intercropping [g m^{-2}]
20 cm×65 cm	4200 f	526.7 c	953.3 c
20 cm×75 cm	4500 e	580.0 b	1087.0 a
25 cm×65 cm	4767 d	620.0 ab	1077.0 a
20 cm×85 cm	5033 c	630.0 a	1063.0 ab
25 cm×75 cm	5333 b	647.7 a	1030.0 b
25 cm×85 cm	5733 a	656.7 a	963.3 c
F-test	**	**	**

Means not sharing a common letter in a column differ significantly at 0.05% level of probability according to Duncan's multiple range test (DMRT); ** – $p < 0.01$

526.7 g m^{-2}) forage yield of berseem clover (Table 4). Forage yield especially in legumes depends on several parameters comprising region climate, type of cultivar, thermal condition, planting season and soil textural class (Ross et al., 2001). In the present research, the said factors might be indirectly involved in forage yield variation. Forage yield of sweet corn/berseem clover intercropped followed an opposite trend of fresh and dry forage yield of berseem clover; however, it remained affected by different spatial arrangements according to DMRT test at $p < 0.01$ (Table 4). Highest forage yield of mixed intercropping per unit of area (1087 g m^{-2}) was achieved when the sweet corn was planted by spatial arrangement of 20×75 cm which was at par with 25×65 cm and 20×85 cm planting patterns. This parameter decreased significantly with decline in planting density arising from spatial arrangement of 20×75 cm to 25×85 cm (Table 4). The least value of which (953.3 g m^{-2}) was referred to 20×65 cm planting pattern that was statistically located in similar group with spatial arrangement of 25×85 cm. It is also found that the forage yield advantage of corn/clover mix-intercropped was more superior to sole cropped sweet corn. This finding confirms reports (Kashani and Bahrani, 1993; Posler et al., 1993; Ennin et al., 2005; Mokhtarpour et al., 2008b) that intercropping results in higher productivity compared to sole crops. This implies that simultaneous planting in intercrop system caused the least interspecific and intraspecific competition (Ennin et al., 2005) and improved the light quality in the canopy due to higher light penetration (Mokhtarpour et al., 2008b). The preferential partitioning of assimilate to photosynthesizing tissue rather than respiring tissue appeared to be an important factor that led to greater biological efficiency and productivity of the corn/clover intercrop system (Whiley, 1979).

CONCLUSION

It can be inferred that in both culture methods, increased planting density from spatial arrangement of 25× 85 cm to 20×75 cm positively affected the can grain weigh that is considered to be as an important marketable characteristic of corn. Sweet corn/berseem clover mix-intercropped alongside spatial arrangement of 20×75 cm resulted in highest value for can grain weight (520 g m^{-2}) and forage yield (1087 g m^{-2}). Corn/clover mix intercropping could probably be considered as a stable alternative to growing corn and clover as monocrops in temperate locations. It is also suggested that growers must lead their planting pattern with respect to planting arrangement of 20×75 cm to be able to compete and abide among producers by producing marketable husked ears. However, further confirmation of the observations seen in this experiment needs to be obtained before any more specific suggestions can be made.

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