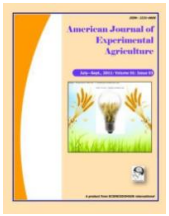

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# Standard Ear Yield and Some Agronomic Characteristics of Baby Corn var. ksc 403 su under Influence of Planting Date and Plant Density

**Atena Rahmani[1*], Majid Nasrolah Alhossini[1] and Seyed Mohsen Nabavi Kalat[2]**

*[1]Department of Agronomy and Plant Breeding, Young Researchers and Elite Club, Mashhad Branch, Islamic Azad University, Mashhad, Iran.*
*[2]Department of Agronomy and Plant Breeding, Mashhad Branch, Islamic Azad University, Mashhad, Iran.*

***Authors' contributions***

*This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

In order to investigate of standard ear yield and some agronomic characteristics of baby corn under influence of planting date and plant density an experiment was conducted at Khorasan Razavi Agricultural and Natural Resources Research center, Mashhad, Iran in 2010. In this research planting date (14 June, 3 July and 24 July) and plant densities (65000, 85000 and 105000 plant $ha^{-1}$) were arranged in main and sub plots, respectively. This experiment was laid out using a split plot design with four replications. The results indicated that different planting dates had significant effects on agronomic traits such as plant height, ear height, number of leaves above ear, stem diameter, ear length, and ear diameter, dehusked and husked baby corn yield, standard and sub-standard dehusked ear yield, standard and sub-standard ear percentage. The highest husked ear yield with 13240 kg $ha^{-1}$ was belonged to 24 July planting date. Although, delay in planting date, led to increase of growth period prevail suitable weather (low temperatures) at anthesis, therefore, ear yield increased but caused to the reduction of ear length and increased ear diameter. Also, ear

**Corresponding author: E-mail: atenarahmani@mshdiau.ac.ir;*

marketing obviously decreased, not only for fresh consumption but also for industry. The highest dehusked standard ear yield (722 kg ha$^{-1}$) was obtained from the highest plant density. Interaction effect of planting date × plant density had significant on standard ear percentage at a 5% level of probability. Finally, planting date of 14 June and the highest planting density of 105000 plant ha$^{-1}$, is recommended in order to maximize and produce high quality standard ear that can be presentable in market.

*Keywords: Baby corn; planting date; plant density; standard ear yield.*

## 1. INTRODUCTION

Baby corn has had a special place among fresh and conserved vegetables as a product with high nutritional value in recent years. This product is the very green ear, which is harvested and consumed in pollination stage. From decades ago, baby corn has been consumed freshly in the east west of Asian countries. In fact, it is a long-term that Chinese, Thai, and Taiwanese farmers have used dehusked ears. It is also used as a new nutritional substance in some foods such as salads, soups and pickles [1]. Baby corn contains vitamin B and C, fiber, carotenoids with high nutritional value [2].

Production and processing of baby Corn as an exportable vegetable in countries such as Taiwan, Sri Lanka, Indonesia, India, Zambia, Zimbabwe, South Africa, Guatemala and Nicaragua become increasingly popular and has been adapted [3]. The most effective factor in producing baby corn is Suitable variety. Accordingly, the most important criteria for the selection of suitable varieties are: early maturity, prolificacy (more number of cobs/plant), and synchronized ear emergence [1].

Investigations indicate that there are no researches related to the baby corn in Iran and most of the researches have focused on sweet corn. Fundamentally, planting date is one of the important components of cropping systems. Selecting appropriate planting date leads to produce high yield of corns. In a research being done in Arlington Mexico, the effect of planting date in improving the products and ear yield has been studied and indicates that late planting date is the cause of yield reduction [4]. The results of experiment on a variety of sweet corn (*Zea mays L.* Saccharata sturt) in eight sowing dates (26 April, 11 May, 26 May, 11 June, 26 June, 11 July, 26 July and 11 August) conducted at Agricultural Research Center, Haran University of Turkey determined that plantings dated there was no such planting dates as mentioned earlier were significant in terms of grain yield, grain size and single grain weight [5]. Noldin and Mundstock reported that different planting dates (11 October, 2 November ) had significant effect on three varieties of sweet corn and it was determined that late planting date was the cause of yield reduction which was about 9% and the number of ear per plant were not affected by planting date [6]. The investigation associated with effect of planting date and plant density on corn yield (cultivar SC 403) indicated that maximum yield being about 2250 plant ha$^{-1}$ was obtained on 29 April [7]. In this research, corn production rate, ear height and the harvest index were affected by plant density. However, with increasing density, ear length decreased. Accordingly, spring sowing sweet corn with density of 65000-55000 plant ha$^{-1}$ for market was recommended.

Also, result of the other researcher on four different planting dates (25 April, 10 May, 25 May, 9 June) of sweet corn (SC404 variety) revealed that different planting dates had significant differences with each other in terms of ear height and ear diameter. Planting date had significant effect on yield in a way that maximum yield (11.2 ton ha$^{-1}$) was obtained with 65000 density plant ha$^{-1}$ on 10 May [8]. Determination of an appropriate plant density may lead to optimum higher yield [9,10]. Genter et al. found that with increase in plant density, the number of plants having no ear increases [11]. In the investigation associated with yield and yield components of 35 corn genotypes with two plant densities of 55000 and 110000 plant ha-$^{1}$ have reported that levels of plant density have significant effect on all investigated traits except ear height and weight of husked ear [12]. Hybrids 27A x 29B with plant density of 110000 plant ha$^{-1}$ had priority over the other studied genotypes in terms of plant height, ear height, number of ear plot-1, height and diameter of husked ear and dehusked ear. In an experiment associated with 35 genotypes of single gross yield of baby corn with two levels of density (55000, 110000 plant ha-$^{1}$) it was revealed that hybrid (27A x 31B) had

the highest yield of husked and dehusked ear with plant density of 55000 plant ha-$^{1}$. Hybrid (27A x 29B) had the better yield with plant density of 110000 plant ha$^{-1}$ [12]. Considering the nutritional value, baby corn needs to be added to the individuals' daily consumption. So far, there has not been any arable investigation associated with baby corn at Khorasan Razavi province. Determining planting date and plant density is a necessary requirement for planting baby corn. The objectives of this study were to investigate the effect of plant density and planting date and their interaction effects on baby corn in order to achieve the highest yield of standard baby corn. The purpose of this study was to investigate the effects of plant density, planting date, and Their Interaction of Baby corn in order to produce high-performance standard Baby corn.

## 2. MATERIALS AND METHODS

The present study was conducted at field experiment of the Khorasan Razavi Agricultural and Natural Resources Research Center (Latitude: 36º 13́ N., Longitude: 59º 40́E. and 985 meters above sea level), Mashhad, Iran in 2010. Soil texture at the experimental area was silt loam (having pH 8 and EC =1.67 mmhos cm$^{-1}$). In order to investigation summer planting and short growing season of Baby Corn, This experiment was carried out on split plot Based on a Randomize Completely Block design. The experiment, was consisted, three planting dates (14 June, 3 July, 24 July, the main factor) and three planting density (65, 85 and 105 thousand plants ha$^{-1}$, as subplots) with four replications. Each plot was considered with dimensions of 12 m² Consists of four rows with a pacing of 75 cm. Three seeds were planted into a hile in the 4 to 6 leaf stage seedlings were reduced to the one. To ensure germination of seeds, Irrigation was conducted with of 4 days interval. After emergence and seedling establishment irrigation was performed by based on plant demined. Fertilizer was used based on soil test. At sowing add 200 kg ha$^{-1}$ Ammonium phosphate ($NH_4H_2PO_4$), 200 kg ha$^{-1}$ potassium sulfate ($K_2SO_4$) and 300 kg ha$^{-1}$ urea ($CH_4N_2O$) were used for the experiment and this was followed by 200 kg ha$^{-1}$ N as urea at the six leaf stage. Morphological characteristics were measured and recorded at during the crop growing season such as plant height, ear height (distance from the ear to the ground); number of ears per plant, stem diameter (between the second and third nodes), the total number of leaves and number of leaves above the ear from 10 competitive randomly plants from each plot. At the harvesting time (1 to 2 cm silking length or 2 to 3 days after silking) in each plot two lateral rows Considered and removed as margin and the rest of plants were counted first, then harvested by hand. Also traits such as ear height, ear diameter, and husked and dehusked ear yield and harvest index of 10 ears in each plot were observed and recorded, on random basis. Also 10 to 12 length (cm) and 1 to 2 diameters (cm) are scale of diagnosis for standard and non-standard ear. Therefore, ears with this size, are standard and ears out of this, in order to processing are nonstandard. It should be noted that the reason for choosing ksc 403 su as sweet corn varieties in this investigation are as follows: Prolificacy, early maturity and ear emergence is simultaneously, whereas many of the other improved varieties are lacking this feature. Excel and SAS (Ver9.2) statistical software's recorded and analyzed Data related to measured characteristics, respectively. Mean comparisons were conducted by Duncan's multiple range test at a 1% level of probability.

## 3. RESULTS AND DISCUSSION

### 3.1 Plant and Ear Height

Results of variance analysis indicated that planting date had significant effect on plant height and ear height at a 1% level of probability. However, plant density was only significant in plant height ($p<.01$) (Table 1). Evaluating the effect of planting date indicated that the tallest plant and maximum ear height were obtained on 24 July with mean of 162.6 and 67.46 cm, respectively. Also, the shortest plant minimum ear height was obtained on 14 June with mean of 106 and 45.82 cm, respectively (Table 3). In addition, the highest plant height was from the plant densities of 85000 ha$^{-1}$ with mean of 140.9 cm (Table 5). The main reason for increasing these traits in 3 July were suitability of climatic conditions and also coincide being time of pollination with desired temperature. Finally, with decreasing intensity of radiation entered into the canopy, internodes length will be increased and consequently plant height will be increased with increasing density and it could be due to plant competition, for light and nutrients. If the plant density excessively, plant in addition to light would be compete on other environmental sources and the plant height will be decreased [13,14].

### 3.2 Number of Leaves per Plant and above Ear

Planting date and plant density have no significant effect on number of leaves per plant. However, planting date had significant effect on number of leaves above ear at 1% level of probability (Table 1). The highest number of leaves above ear was obtained with average of 6.3 leaves on planting date of 24 July (Table 3). Number of leaves per plant is a genetic trait and environmental factors such as the plant density do not have significant effect on it. In this regard, Charles and Arnold indicated that although the number of leaves per plant is a genetic trait, it can be affected by temperature, planting date, soil conditions and agronomical cultivation [15].

### 3.3 Stem Diameter

Stem diameter was affected by plant density and planting date (Table 1). Accordingly, the highest and the lowest stem diameter were observed on planting date of 3 July and 14 June with amount of 23.9 and 19.8 mm, respectively (Table 3). Also, The highest and lowest stem diameter were belong to 65 and 105 thousand plants ha-$^{1}$ with 22.19 and 21.27 mm, respectively (Table 5) These results were in agreement with those obtained by Tamadon Rastagari [8].

### 3.4 Ear Length and Ear Diameter

Analysis of variance of ear length and ear diameter data revealed that planting date had significant effect on these traits; while plant density did not have affect (Table 1). The highest and lowest ear length were obtained on 14 June and 24 July planting dates which were about 9.3 and 7.5 cm, respectively. Regarding the ear diameter the highest and the lowest value was obtained on 24 July and on 3 July planting date being about 15.75 and 14.05 mm, respectively (Table 3). Ear diameter and ear length are important traits being considered in selecting the high quality products in convert industry factories. Despite the fact that the ear length decreased on 24 July planting date, its popularity in markets decreased because of the increase in ear diameter and poor quality. Therefore, the best value of ear diameter and ear length concerning to marketability were obtained on 3 July planting date being about 7.9 (cm) and 14.05 (mm), respectively. Along with late planting of sweet corn, the ear length and the corn production were decreased [16].

### 3.5 Number of Ears per Plant

Planting date did not have a significant effect on number of ears per plant. However, plant density had significant effect on number of ears per plant at 1% level of probability (Table 1). Mean comparison number of ears per plant decreased up to 1.6 (Table 5).

### 3.6 Standard and Sub-Standard Ear Percentage

Standard ear percentage is one of the most important traits in producing ear in such a way that standard ear percentage is the proportion of the number of ear to the total number of harvested ear. Planting date had significant effect on standard and sub-standard ear percentage However; trait did not affect by plant density (Table 2). Investigations demonstrated that interaction planting date × plant density had significant effect on standard ear percentage at 5% level of probability (Fig 1). Mean comparison of planting dates effect on standard ear percentage indicated that the highest percentage of standard and sub-standard ear were obtained on 14 June and 24 July planting dates which were estimated about 53.68 and 66.98 percentage (Table 4). Accordingly, the highest percentage standard ear was obtained on 14 June planting date with plant density of 65000 plants ha-$^{1}$ being about 49.31 percentage (Fig. 1).

### 3.7 Husked Ear Yield

Planting date had significant effect on husked ear yield at 1% level of probability. However, plant density did not have significant effect on husked ear yield (Table 2). The highest yield obtained on 24 July (13240 kg ha$^{-1}$) and 14 June (12250 kg ha$^{-1}$). However didn't have any significant different between 24 July and 14 June, but they have significant different with 3 July (7396 kg ha$^{-1}$) (Table 4). The main reason for increasing crop yield on 24 July it could be depends on optimal temperature on during the pollination and suitability of climatic conditions compare the previous two planting date. Researchers reported that in an investigation of different planting date of sweet corn in the southeast of Antalya the highest and lowest production, was belonged to 25 July and 25 April with 17751 and 1824 kg ha$^{-1}$ respectively. Such result is in harmony with those obtained by Oktem et al. [5].

**Table 1. Analysis of variance for standard ear yield and agronomic characteristics of baby corn on different planting date and plant density**

| S.O.V | df | Mean of squares | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Replication (R) | 3 | 0.841n.s | 15.906n.s | 0.656n.s | 0.182n.s | 2.532n.s | 0.127* | 0.051n.s | 0.246n.s |
| P da | 2 | 11137.88** | 1591.18** | 2.093n.s | 10.304** | 53.438** | 11.114** | 9.147** | 1.903n.s |
| Error (a) | 6 | 113.63 | 87.19 | 0.685 | 0.140 | 2.054 | 0.029 | 0.150 | 2.230 |
| P de | 2 | 0.551** | 29.92n.s | 0.242n.s | 0.134n.s | 4.001* | 0.132n.s | 0.440n.s | 0.826** |
| P da × P de | 4 | 37.920n.s | 35.55n.s | 0.345n.s | 0.090n.s | 1.356n.s | 0.111n.s | 0.455n.s | 0.110n.s |
| Error (b) | 18 | 49.794 | 22.127 | 0.294 | 0.085 | 1.171 | 0.057 | 0.266 | 0.110 |
| CV % | | 5.01 | 7.98 | 4.99 | 5.11 | 5.03 | 2.89 | 3.49 | 15.46 |

*(1): Plant height, (2): Ear height, (3): Number of leaves plant$^{-1}$, (4): Number of leaves above ear, (5): Stem diameter, (6): Ear length, (7): Ear diameter, (8): Number of ear plant$^{-1}$. P da: Planting date, P de: Plant density also P da × P de: Interaction between planting date and plant density. CV: Coefficient of variance; Ns,* and **: Non-significant and significant at 5% and 1% levels of probability, respectively*

**Table 2. Analysis of variance for standard ear yield and agronomic characteristics of baby corn on different planting date and plant density**

| S.O.V | Mean of squares | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | df | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Replication (R) | 3 | 5.512n.s | 25.194n.s | 4709791.72n.s | 233256.30n.s | 0.005n.s | 344394.77n.s | 7.141n.s |
| S d | 2 | 531.29* | 677.73** | 117354024.18 ** | 12340853.8** | 0.536** | 14733650.53** | 88.11n.s |
| Error (a) | 6 | 104.78 | 79.80 | 2443858.32 | 323312.24 | 0.027 | 288057.87 | 21.61 |
| P d | 2 | 66.006n.s | 36.228n.s | 11578263.62n.s | 1813610.75** | 0.094** | 1303281.83** | 23.68* |
| S d×P d | 4 | 86.429* | 69.215n.s | 1133890.85n.s | 173060.93n.s | 0.013n.s | 487190.58n.s | 4.149n.s |
| Error (b) | 18 | 29.566 | 32.870 | 3865299.40 | 241659.74 | 0.012 | 214909.28 | 5.919 |
| CV % | | 13.68 | 9.57 | 17.94 | 21.29 | 17.49 | 29.10 | 11.58 |

*(1): Standard ear %, (2): Sub-Standard ear %, (3): Husked ear yield, (4): Dehusked ear yield, (5): Dehusked standard ear yield, (6): Dehusked sub-standard ear yield, (7): Ear harvest index. S d: Planting date, P d: Plant density also Sd × Pd: Interaction between planting date and plant density. Also CV: Coefficient of variance. Ns,* and **: Non – significant and significant at 5% and 1% levels of probability, respectively*

**Table 3. Means comparison for standard ear yield and some agronomic characteristics of baby corn on different planting date**

| Planting date | Treatment | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 14 June | 106b | 45.82b | 10.57a | 4.642b | 19.81b | 9.335a | 14.57b |
| 3 July | 153.7a | 63.46a | 10.69a | 6.217a | 23.89a | 7.904b | 14.05c |
| 24 July | 162.6a | 67.46a | 11.35a | 6.275a | 20.90b | 7.505c | 15.75a |

*(1): Plant height (cm), (2): Ear height (cm), (3): Number of leaves plant$^{-1}$, (4): Number of leaves above ear, (5): Stem diameter (mm), (6): Ear length (cm), (7): Ear diameter (mm). Mean followed by similar letters are not significantly different at 5% probability level*

**Table 4. Means comparison for standard ear yield and some agronomic characteristics of baby corn on different planting date**

| Planting date | Treatment | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 14 June | 53.68a | 53.68b | 12250a | 2810b | 833a | 1977b |
| 3 July | 39.13ab | 60.13ab | 7396b | 755c | 411c | 344c |
| 24 July | 33.98b | 66.98a | 13240a | 3082a | 623b | 2459a |

*(1): Standard ear %, (2): Sub-standard ear %, (3): Husked ear yield (kg ha$^{-1}$), (4): Dehusked ear yield (kg ha$^{-1}$), (5): Dehusked standard ear yield (kg ha$^{-1}$ ), (6): Dehusked sub-standard ear yield (kg ha$^{-1}$ ). Mean followed by similar letters are not significantly different at 5% probability level*

**Table 5. Means comparison for standard ear yield and some agronomic characteristics of baby corn on different plant density**

| Plant density (plant ha$^{-1}$) | Treatment | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 65000 | 140.5a | 22.19a | 2.50a | 20.42b | 1879c | 554b | 1325b |
| 85000 | 140.9a | 21.13b | 2. 11b | 20.01b | 2084b | 591b | 1493b |
| 105000 | 140.8a | 21.27c | 1.65c | 22.62a | 2683a | 722a | 1961a |

*(1): Plant height (cm), (2): Stem diameter (mm), (3): Number of ear plant$^{-1}$, (4): Ear harvest index(%), (5): Dehusked ear yield (kg ha$^{-1}$ ), (6): Dehusked standard ear yield(kg ha$^{-1}$ ), (7): Dehusked sub-standard ear yield(kg ha$^{-1}$ ). Mean followed by similar letters are not significantly different at 5% probability level*

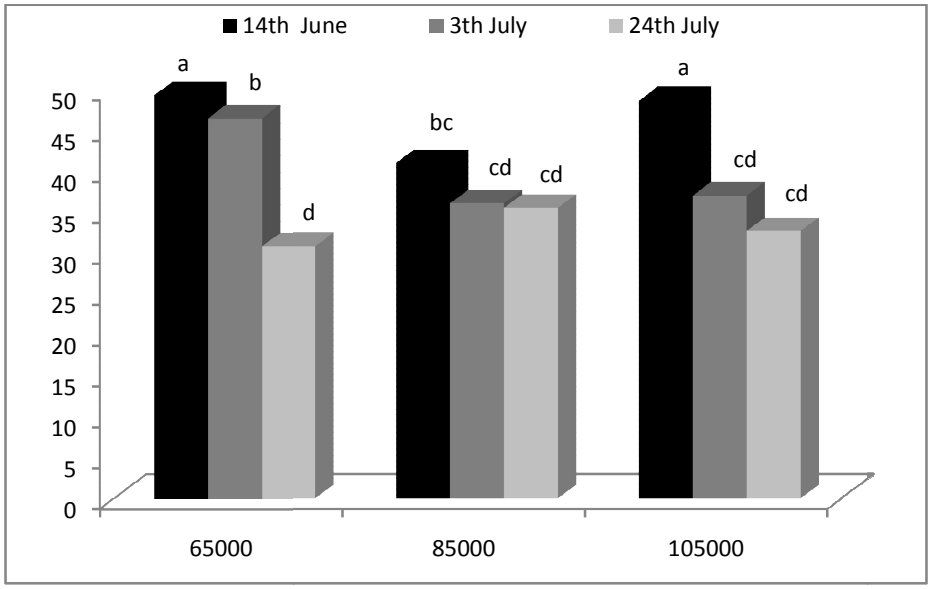


**Fig. 1. The interaction effects of planting date and plant density on standard ear percentage**
*Mean followed by similar letters are not significantly different at 5% probability level*

### 3.8 Dehusked Ear Yield, Dehusked Standard Ear Yield and Dehusked Sub- Standard Ear Yield

Variance analysis of dehusked ear yield, dehusked standard and sub standard ear yield indicated that planting date and plant density had significant effects on these traits (Table 2). The results revealed that the crop sown on 24 July gave the highest dehusked ear yield (3082 kg ha-$^{1}$) and dehusked sub-stadard ear yield (2459 kg ha-$^{1}$) while the crop sown on 14 June gave the highest dehusked standard ear yield (833 kg ha-$^{1}$) (Table 4). Also, Mean comparison of plant density indicated that the highest dehusked ear yield, dehusked standard ear yield and dehusked sub-standard ear yield were belong to plant density of 105000 plant ha-$^{1}$ with 2683, 722 and 1961 kg ha-$^{1}$ respectively (Table 5). It should be noted that crop sown on 3 July performed poor due to being coincide daily high temperatures with germination was. Researches indicated that prolongation of seedling emergence could lead to growth retardation and components involved in the yield [17].

### 3.9 Ear Harvest Index

Ear harvest index was influenced by plant densities while not by sowing dates (Table 2). Statistical mean comparison indicated the highest ear harvest index of 22.62% was observed with 105000 plants ha-$^{1}$ (Table 5). Harvest index is the proportion of economic yield to the biological yield and it is affected by plant density, the available amount of nutrient and water and environmental temperature during the growth season [18]. This parameter is the index of grain production or transfer coefficient and distribution of photosynthetic nutrient between economic and herbal sections [19].

## 4. CONCLUSION

The results showed that dehusked ear yield increased on 3 August. However baby corn planting on 24 July due to early cold autumn and reduced marketability is not recommended. In this research according to the international codex to produce and supply products with high quality planting date of 14 June and density of 105,000 plants ha-$^{1}$ recommended for producing the highest and the best standard ear. The results showed that planting date of 14 June and planting density of 105,000 plants ha-$^{1}$ with the highest standard ear Percentage (31/49) has produced. In these circumstances, processing factories, a longer period of time worked the benefits of cultivating this plant weather in Mashhad.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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