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The effect of timely and late sowing on the maize (*Zea mays* L.) yield: feasibility study of delay compensation using nitrogen fertilizer and cow manure

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Abstract. Maize (*Zea mays* L.) belongs to Poaceae family. Due to the enormous diversity in the form, quality and growth habit, maize is cultivated and utilized in large fertile agricultural regions in the world. The present study aimed at examining the effect of sowing dates on maize yield. For this purpose, maize was sowed in a randomized complete block design in split plots with two levels of organic fertilizer and four levels of nitrogen urea fertilizer on the date recommended by the Agricultural Research Center (23 July) and in early August. According to the results, the use of 0% urea fertilizer based on the soil test (180 kg ha^{-1}) and 50% lower than the soil test (90 kg ha^{-1}) had a significant impact on the number of grains per row, 1000-kernel weight and protein content at a significance level of 1%. It also had a significant impact on the number of rows per ear at a significance level of 5%. It had no effect on the grain yield. Comparing the late and timely sowing, the highest protein content was obtained by adding urea fertilizer 50% higher than the soil test (270 kg ha^{-1}) in late sowing. According to the results, the optimal fertilizer treatment was urea fertilizer based on the soil test. The optimal treatment in the late sowing was urea fertilizer 50% higher than the soil test.
Key Words: maize, urea fertilizer, organic fertilizer, late sowing.

Introduction. Maize (*Zea mays* L.) belongs to Poaceae family and it has a high ranking in the diet of humans and animals. Given the high production of maize and high per capita consumption of this product in different countries, agricultural researchers are trying to find ways to increase the quantity and quality of maize. As a result, further research is required for more economical production of maize (Cocks 2003).

Maize can be used in other industries even for energy production. According to FAO (2014), maize is the first-ranked crop in terms of the global production of crops in the world. In 2005, maize was the first-ranked crop in terms of yield with the third place in terms of cultivation area (after wheat and rice) (Elzubeir & Mohamed 2011). Due to population growth and food security, achieving self-sufficiency in agricultural products is one of the most important goals of the Iranian Government. Self-sufficiency in strategic products is of great importance. In this regard, self-sufficiency in maize production is among the government goals in the agricultural sector. Maize constitutes 65 to 70 percent of the poultry feed ration in Iran. Maize is considered as a strategic commodity in poultry industry in Iran.

Najafinia (2002) examined maize sowing date in Orsoiieh tropical region and found no statistically significant difference in maize yield for sowing dates from 3 February to 17 March. However, the cultivars were different in terms of grain yield. The cultivar 720 showed the highest grain yield of 11.5 tons/ha as compared with Hybrid 704 and Three Way Cross 647 cultivars.

Afshar Manesh (2004) compared the summer sowing of delay mature hybrid cultivars and found the highest grain yield for the cultivars 720 and Karaj 700.

According to Gesch & Archer (2005), one of the techniques for early maize sowing in spring is to use polymer-coated seeds. This technique allows 2 to 4 weeks early maize sowing while reducing the risk of yield reduction in late sowing. In addition, the plant will have more flexibility for the inputs. In the early spring sowing, the soil moisture should not be very high causing damage to the soil structure.

The aim of the present study is to find good outcomes for farmers who perform late maize sowing due to various reasons such as the lack of water or delays in the provision of required fertilizers. Through this, the late sowing can be managed using specified amounts of fertilizer treatments.

Material and Method. This research was done in July-August 2013 in Ahvaz Agricultural Research Center with this location: 31°18'09" N, 48°38'18" E. Maize sowing was performed in a randomized complete block design in split plots with two levels of cow manure (control and 20 tons ha^{-1}) and four levels of nitrogen urea fertilizer on the date recommended by the Agricultural Research Center (23 July) and in early August. The urea treatments include 0% based on the soil test (180 kg ha^{-1}), 50% lower than the soil test (90 kg ha^{-1}) and 50% higher than the soil test. The seed used was 15 kg ha^{-1} Single Cross 704 (dent maize). The distance between the plants after thinning operation was 15 cm.

For sampling, 0.5 m from the both ends of each plot was removed as margins. Then, the plants were randomly picked from the two middle rows from each plot with a surface area of 0.25 m^2. The samples were transported to the laboratory and separated into plant components (stem, leaf, ear and wreath) and allowed to dry in the oven at 70^oC to reach a constant weight. Then, the plant components were weighed by a digital balance with an accuracy of 0.01 g. After harvesting, the variables including grain yield, number of grains per row, number of rows per ear and 1000-kernel weight were measured. The data was statistically analyzed with the help of SPSS version 18. The mean values were compared by Tokay's test and the reports were prepared by Microsoft Excel.

Results and Discussion. Table 1 shows the results of variance Analysis of some maize features such as number of grains per row, number of rows per ear, 1000-kernel weight and grain yield. As can be seen, the organic manure and urea fertilizer have a significant impact on 1000-kernel weight at a significant level of 0.01. The interactive effect of organic manure and urea fertilizer on the 1000-kernel weight is significant at a significance level of 0.05. The 1000-kernel weight will be compared at different levels of factors. The main effects of urea fertilizer and cow manure (cow) and interactive effects of urea fertilizer and organic fertilizer on the number of grains per row are significant at a significant level of 0.01. The number of grains per row will be compared at various levels of factors.

Table 1

The results of variance Analysis

Variation source	*Degree of Freedom*	Mean of square			
		Number of grains per row	*Number of rows per ear*	*1000-kernel weight (g)*	*Grain yield (kg ha^{-1})*
Urea fertilizer	1	610.111**	23.111*	10333**	1000640.88ns
Cow manure	3	68.056**	3.55ns	4640.056**	8120269.778ns
Urea fertilizer - cow manure	3	122.111**	1.778ns	2538.778*	68522011.11*
Error	16	67.333	21.33	5148.667	62878712
Total	24	14261	3144	967973	9401483

** Significant at significance level of 1%, * significant at significance level of 5%, ns: insignificant.

According to Figure 1, the highest average number of grains per row was obtained for the second treatment by adding the urea fertilizer based on soil test (180 kg ha^{-1}) and the

control organic manure. The maximum number of grains per row in the first (late July) and second (early August) planting dates was 40.3 and 39.33, respectively (Figure 1). The prolonged growth period increased the number of grains per row. However, the difference between the first and second sowing dates was not significant. The addition of the urea fertilizer compensated planting delays in terms of the number of grains per row. According to Sepehri et al (1994), Ebrahimi (1997) and Oktem et al (2004), the number of grains per row is influenced by sowing date and increases with prolonged growth period.

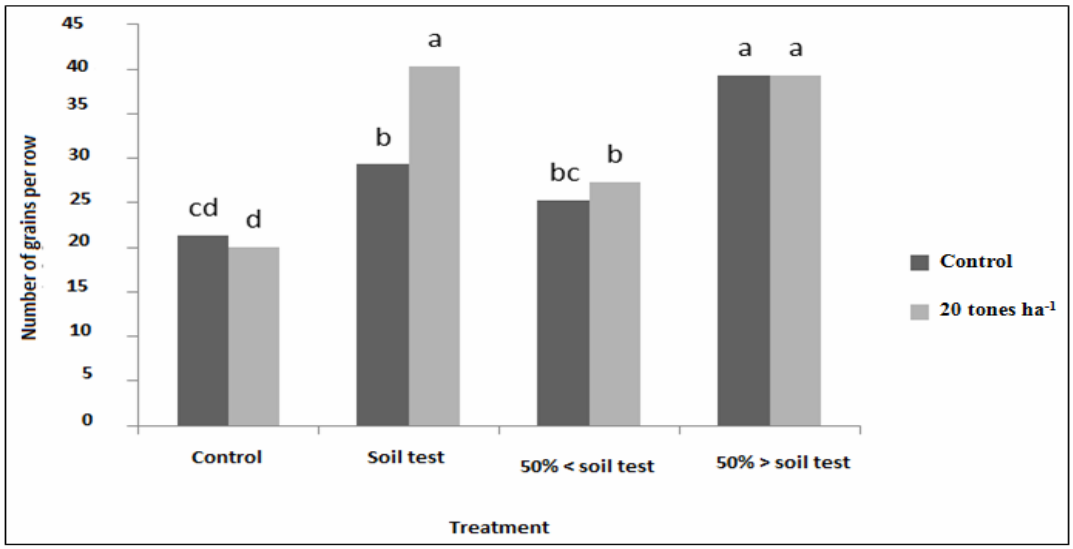

Figure 1. The average number of grains per row, interactive effect of cow manure-urea fertilizer in two sowing dates (the similar letters show that there is not significant difference between treatments).

As shown in Figure 2, the highest average number of rows per ear was obtained for the second treatment by adding the urea fertilizer based on the soil test (180 kg ha^{-1}) and control organic manure. Sowing date has a significant impact on the yield and yield components of many crops including cereals. In general, more vegetative growth and higher yields have been attributed to the early sowing dates. An appropriate combination of agronomical factors and varieties is required to achieve maximum grain yield (Khan et al 2002).

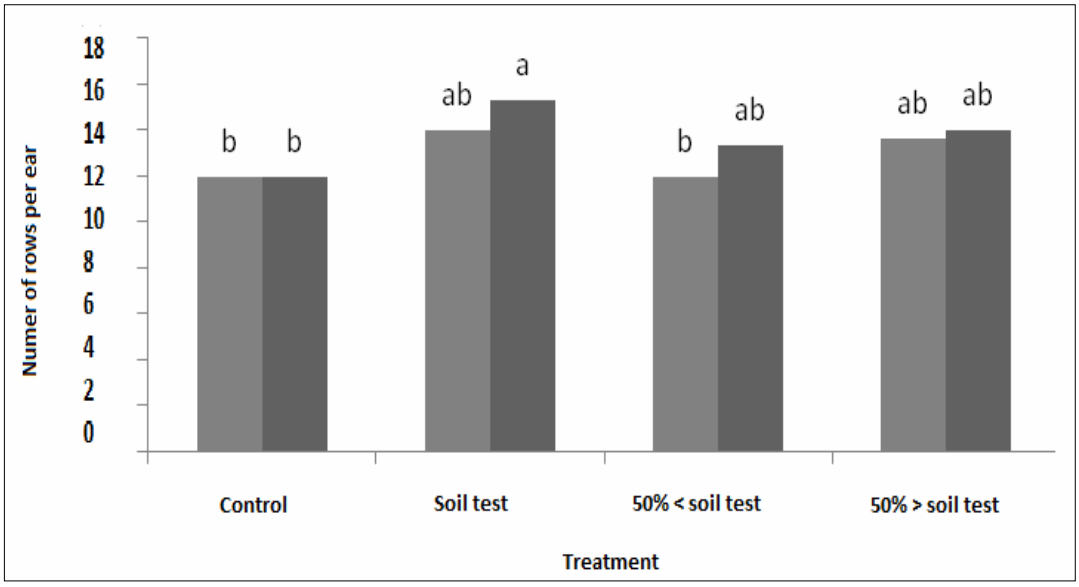

Figure 2. The number of rows per ear and the interactive effect of organic cow manure-urea fertilizer in two sowing dates (the similar letters show that there is not significant difference between treatments).

According to Figure 3, the highest mean 1000-kernel weight was obtained for the fourth treatment by adding urea fertilizer 50% more than the soil test and 20 tones ha^{-1} of organic manure in late sowing.

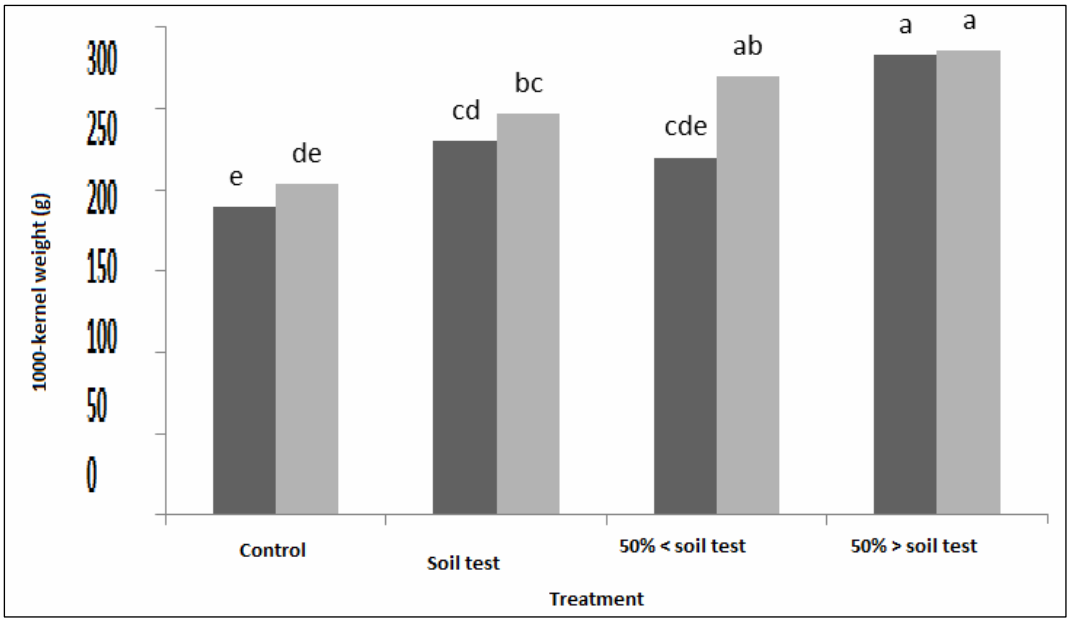

Figure 3. The mean 1000-kernel weight and interactive effect of organic cow manure-urea fertilizer in two sowing dates (the similar letters show that there is not significant difference between treatments).

As shown in Figure 4, the highest average grain yield was obtained for the fourth treatment by adding urea fertilizer 50% higher than the soil test and control organic manure in late sowing. Late sowing in the fourth treatment did not reduce the grain yield because of increased urea level. Mokhtarpour et al (2008), Oktem et al (2004) and Dahmardeh (1999) found yield reduction in late sowing. Chogan & Mosavat (2000) found increased 1000-kernel weight with a delay in sowing.

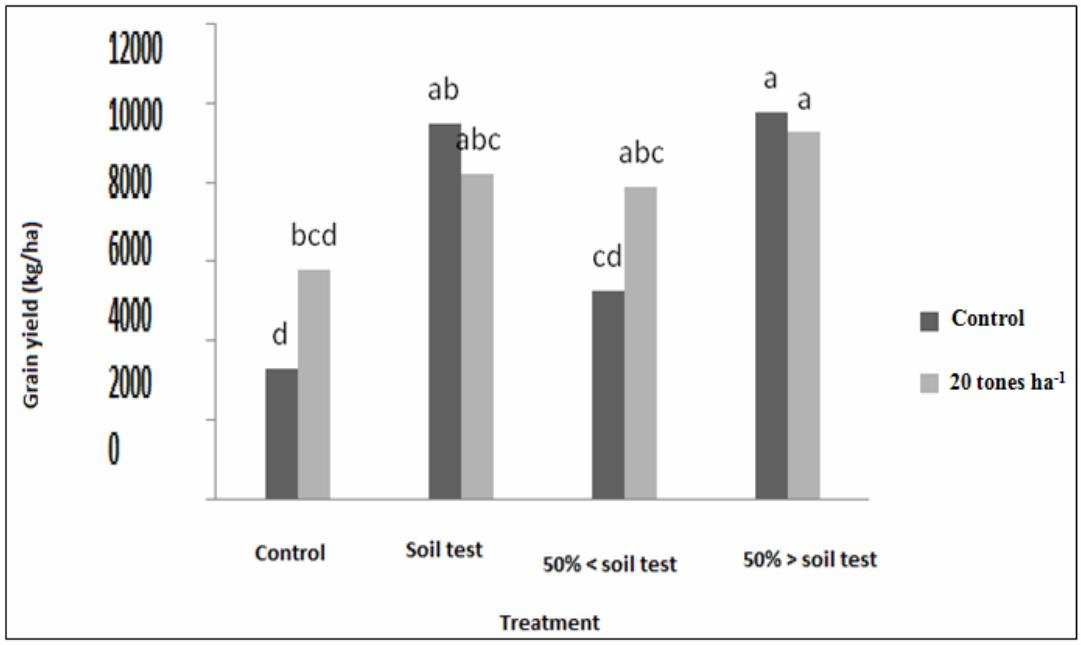

Figure 4. The average grain yield and interactive effects of organic cow manure-urea fertilizer in two sowing dates (the similar letters show that there is not significant difference between treatments).

Conclusions and recommendations. The use of fertilizer (50% higher than the soil test in the late sowing) resulted in the highest average grain yield in the second treatment by adding urea fertilizer based on the soil test (180 kg ha^{-1}) and control organic manure. The use of urea fertilizer did not compensate for planting delays in terms of the number of rows per ear. The highest mean 1000-kernel weight (285.66 g) was obtained in late sowing by adding urea fertilizer 50% higher than the soil test (270 kg ha^{-1}) and 20 tons ha^{-1} of organic manure. The increased levels of urea fertilizer could compensate for the delay in sowing.

Comparing the late and timely sowing, the highest mean 1000-kernel weight was obtained in late sowing by adding urea fertilizer 50% higher than the soil test (270 kg per ha^{-1}) and control organic manure. The delay in sowing in the fourth treatment did not reduce the grain yield because of increased urea level.

Based on the results of this research, the optimal fertilizer treatment is urea fertilizer based on soil test. The urea fertilizer 50% higher than the soil test is the optimal treatment in the late sowing.

Further research is needed to examine the role of contamination. It is recommended to repeat this experiment in other locations in future. Further studies should be carried out on the effect of urea fertilizer on sowing delay compensation on other crops.

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