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Response of Effective Traits on Sugarcane Crop Production to Different Level of Tillage System and Urea Fertilizer under Warm and Dry Climate Condition

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ABSTRACT

BACKGROUND: By using low-tillage methods in combination with management of urea fertilizer consumption, beneficial results such as improving sugarcane yield, reducing soil physical degradation and reducing the cost of inputs will be achieved.

OBJECTIVES: This research was carried out to produce economic yield and investigating the possibility of reducing the consumption of urea fertilizer, frequency of tillage operations and movement of machinery in the field.

METHODS: Current study was done according split plot experiment based on randomized complete blocks design with three replications. The main plot included tillage system (T_1: moldboard plow one time, Subsoiler two time as conventional tillage, T_2: moldboard plow one time, Subsoiler one time, T_3: moldboard plow two time, without Subsoiler) and Urea fertilizer (U_1: 250 kg.ha^{-1}, U_2: 300 kg.ha^{-1}, U_3: 350 kg.ha^{-1}) belonged to subplots.

RESULT: Result of analysis of variance revealed effect of tillage system only on leaf sheath moisture was significant at 5% probability level also effect of urea fertilizer on cane yield was significant. Interaction effect of treatments on all measured traits was not significant. Mean comparison result of different level of tillage system indicated that maximum leaf sheath moisture (83.2%) was noted for T_1 (moldboard plow one time, Subsoiler two time as conventional tillage) and minimum of that (82.1%) belonged to T_2 treatment. Assessment mean comparison result indicated in different level of urea fertilizer the maximum cane yield (118 t.ha^{-1}) was noted for 300 kg.ha^{-1} urea fertilizer and minimum of that (103 t.ha^{-1}) belonged to 250 kg.ha^{-1} although it does not have significant difference with 350 kg.ha^{-1} treatment.

CONCLUSION: Considering the maximum yield of the product with the consumption of 300 kg per hectare of urea fertilizer, reducing the consumption of 50 kg per hectare of urea fertilizer compared to the current consumption amount will not have an effect on reducing the yield. Due to the fact that reducing one round of plowing operation (compared to the conventional plowing method) did not affect the yield of the crop, it is possible to skip this operation in the field.

KEYWORDS: *Leaf sheath moisture, Nitrogen, Plow, Sugar, Yield.*

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1. BACKGROUND

Sugarcane is a semi-perennial crop, which can be harvested annually up to five years without replanting; the first harvested crop is termed plant cane and stubble cane for each successive harvest. Worldwide N recommendations for sugarcane production are dependent on climate, crop age, and length of growth cycle, plant characteristics, and soil characteristics (Lofton *et al*., 2012). Sugarcane is an important agro-industrial sugar crop, contributing about 70% of the world sugar production. In Iran, sugarcane is grown under irrigated systems and is seriously prone to soil salinization (Wahid *et al*., 2009). Among the benefits of reducing tillage operations, we can mention the reduction of wind and water erosion and improvement of physical and chemical properties of soil, more storage and easier movement of water, improvement of pH and better distribution and availability of nutrition elements. Also, with less use of tools and machines, energy consumption will be reduced and as a result production costs will be reduced (Kumar *et al*., 2020). Lorzadeh *et al*. (2002) in order to investigate the effects of different levels of soil compaction on yield and sucrose in sugarcane, cv. CP 48-103 reported compacting the soil to a penetrometer resistance of 650 kpa had no significant effect on cane yield. However, the yield of cane decreased as compaction of the soil was increased to a penetrometer resistance of 3250 kpa. A similar trend to that of cane yield was observed for plant height, number of tillers and total dry matter yield as soil compaction increased. Soil compaction to the rate of PR of 3250 kpa had no significant effect on purity and sucrose percentage, consequently, on sucrose yield. However, there was a decreasing trend in these qualitative characteristics. Koochekzadeh *et al*. (2013) by evaluate the influence of different rates and split application of Nitrogen on qualitative and quantitative characteristics of first sugarcane ratoon reported however, the maximum stems and sugar yields were obtained by using 138 kg N ha^{-1} which was split to 20-40-40% with values of 91.7 and 10.6 t ha^{-1}, respectively. The highest nitrogen use efficiency was for the N_1 treatments (92 $kg.ha^{-1}$) with 281.7 and 43.2 kg kg^{-1}N in stems and sugar yields, respectively. Results also indicated no significant effect of nitrogen application rates on sugarcane final yields; thus, the excessive application of N is not recommended in sugarcane farms. Singh *et al*. (2012) applied two treatments of disc and subsoiling reported that the treatment of lump breaking disc did not have a significant effect on the number of cane stem per unit area, but the under breaking treatments had a positive effect on the yield and quality of sugarcane. Sugarcane also shows high response to N application. It can utilize 4 to 7 kg N ha-1 per day during its rapid growth period (Gascho *et al*., 1986). Substantial amounts of N fertilizer is necessary for commercial sugarcane production due to large biomass produced by the crop. However, as harvest time approaches it is desirable to have much of the soil N depleted (Hauck, 1984). In addition, juice quality may be reduced by excess N application

(Robertson *et al*., 1996). The total amounts of N fertilizer which are used for plant cane production in Khuzestan are 400 $kg.ha^{-1}$ of urea and 400 kg of the diammonium phosphate annually (Koochekizadeh *et al*., 2009). Jafarnejadi and Malkoti (1999) announced that the consumption of 135 kg of nitrogen per hectare is the most economical amount of this element to produce high yield of sugarcane and better extraction of sugar. They also stated that increasing nitrogen consumption up to 225 kg per hectare will increase the sugarcane yield, and using more than this amount will decrease the cane yield and sugar yield. Salamati *et al*. (2015) by investigate the effects of split application of different rates of urea on sugarcane yield revealed that the two split treatment of with 60% fertilizer level was the mast preferred treatment in terms of all the quantitative and qualitative attributes and while two split treatment was the most acceptable treatment in terms of water use efficiency of sugarcane, extraction as white sugar of well as fertilizer use efficiency, with the figures of 7.474 and 0.710 $kg.m^{-3}$ and 437.7 $kg.kg^{-1}$ of urea, respectively. Moreover, the treatment of 60% fertilizer level performed better in terms of water use efficiency of sugarcane, white sugar and fertilizer use efficiency, amounting to 6.533 and 0.628 $kg.m^{-3}$ and 454.9 $kg.kg^{-1}$ of urea, respectively.

2. OBJECTIVES

This research was carried out to produce economic yield and investigating the possibility of reducing the consumption of urea fertilizer, frequency of tillage operations and movement of machinery in the field.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

This research was carried out in Farabi Agroindustry Company along 2011-2012 agronomic year. Place of research was located in southwest of Ahvaz city at longitude 48°34'E and latitude 30°57'N in Khuzestan province (Southwest of Iran). According to the climate classification according to the Emberger method, the climate of research field was hot desert region. The average temperature of the coldest month of the year is between 5-8 degrees Centigrade. This area does not have summer rainfall and the highest amount of rainfall occurs in winter and cold season. Current study was done according split plot experiment based on randomized complete blocks design with three replications. The main plot included tillage system (T_1: moldboard plow one time, Subsoiler two time as conventional tillage, T_2: moldboard plow one time, Subsoiler one time, T_3: moldboard plow two time, without Subsoiler) and Urea fertilizer (U_1: 250 $kg.ha^{-1}$, U_2: 300 $kg.ha^{-1}$, U_3: 350 $kg.ha^{-1}$) belonged to subplots. Among the sub-plots, two rows of uncultivated lines and four rows of uncultivated lines were considered among the main plots. The used variety CP69-1062 was one of the introduced and adapted varieties for Khuzestan region. The width of each plot was 21.96 meters and its length was 241.25 meters. Physical and chemical properties of the soil are mentioned in table 1.

Table 1. Physical properties of studied soil (0-60 cm)

Soil moisture (%)	11
EC (ds.m^{-1})	2.89
pH	8.11
Nitrogen (%)	0.74
O.C (%)	0.18
ρb (gr.cm^{-3})	2.44
Soil Texture	Silty clay loam

3.2. Farm Management

In order to apply tillage treatments, disc operations before leveling, trowel before leveling and final leveling with a laser scraper were done in order. According to the design map and specifying the position of each treatment, tillage treatments were applied in the main plots. After that, the operation of creating the furrow, fertilizing with phosphate base fertilizer, planting, machine covering with Discoverer and manual covering were done in August. Irrigation and stages continued until the end of September of the following year. During the months of April to July 1992, based on the calculations and considering the area of each sub-plot, the required amount of urea fertilizer was calculated. Then, in the place of the irrigation divider, by installing 1000 liter tanks on the main irrigation valve, it was distributed in the form of fertilizer-irrigation through hydroflume irrigation pipes in three times on the surface of the sub-plots.

3.3. Measured Traits

In order to determine the percentage of sheath moisture and leaf blade nitrogen, samples were taken weekly from leaves number 3, 4, 5 and 6 from different plots (Celements, 1980). One of the standard methods for determining nitrogen percentage in water, soil and plant samples is the Kjeldahl method. In order to measure the percentage of nitrogen in the leaves, the leaves of numbers 3, 4, 5, 6 were separated and after washing, drying (at 85 degrees Celsius) and grinding these samples, some of it (about 50-100 mg) was weighted and the percentage of nitrogen in the sample was determined using the Kjeldahl method (Anonymous, 2016).

Equ. 1. $\%N = \frac{(A-B)\times C\times 1/4}{D}$

A: The volume of acid used for sample titration

B: The volume of acid used for the titration of the control sample

C: Acid normality

D: The weight of the tested leaf sample

N (%): Nitrogen percentage of the tested leaf sample.

In order to measure the moisture content of the leaf sheath, the plant was first sampled, and then the samples were taken to the laboratory. Leaves No. 3, 4, 5, 6 were separated from each plant sample and the sheaths of these leaves were separated from the leaf, then these sheaths were weighed (wet weight) and stored for 24 hours at a temperature of 80 degrees Celsius, finally they were dried in oven. After that, the dried samples were weighed again and their dry weight was determined (Celements, 1980).

Equ. 2. Moisture (%)== $\frac{(A-B)\times 100}{A}$

A: Wet weight of leaf sheath

B: Dry weight of leaf sheath
At the beginning of December, samples were taken from the product of each plot and the yield (tonnage) as well as parameters such as the weight of sugarcane extract, the percentage of sugar in the cane and the yield of sugar was calculated. Pol refers to the percentage of sugar in the extract. To measure the Pol, 100 ml of the extract was taken and 2 g of lead acetate was added to it and the solution was filtered through filter paper. The filtered extract was transferred to the tube of the Polari meter device and the tube was placed in the device. After the digital screen of the device was fixed, the displayed number was recorded. The read Pol value is multiplied by the Pol factor obtained from the table to calculate the Pol percentage, which indicates the percentage of sucrose in the solution. To calculate the Recoverable sugar, multiply the number of yellow sugar by 0.83 (the coefficient of extraction from yellow sugar to white sugar) to get the percentage of Recoverable sugar (Celements, 1980).

Equ. 3. Recoverable sugar (RS, %)= Cane Yield × 0.83

Equ. 4. Sugar yield (SY, $t.ha^{-1}$)= Cane Yield × RS

3.4. Statistical Analysis

Analysis of variance and mean comparisons were done via SAS (Ver.8) software and Duncan test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. Leaf sheath moisture

According result of analysis of variance effect of tillage system on leaf sheath moisture was significant at 5% probability level but effect of urea fertilizer and interaction effect of treatments was not significant (Table 2).

Table 2. Analysis of variance of measured traits

S.O.V	df	Leaf sheath moisture	Nitrogen percentage	Recoverable sugar	Cane yield	Sugar yield
Replication	2	0.930	0.009	0.039	7.873	0.522
Tillage (T)	2	1.351^{*}	0.0016^{ns}	0.159^{ns}	23.342^{ns}	0.049^{ns}
Error I	4	0.300	0.010	0.088	7.457	0.042
Urea Fertilizer (U)	2	0.333^{ns}	0.0016^{ns}	0.418^{ns}	203.414^{*}	0.272^{ns}
U × T	4	0.230^{ns}	0.014^{ns}	0.060^{ns}	39.003^{ns}	0.154^{ns}
Error II	12	0.930	0.009	0.283	26.137	0.211
CV (%)	-	0.99	3.70	3.01	4.65	4.23

$^{ns, *\ and\ **}$: non-significant, significant at 5% and 1% of probability level, respectively.

Mean comparison result of different level of tillage system indicated that maximum leaf sheath moisture (83.2%) was noted for T_1 (moldboard plow one time, Subsoiler two time as conventional tillage) and minimum of that (82.1%) belonged to T_2 treatment (Fig.1).

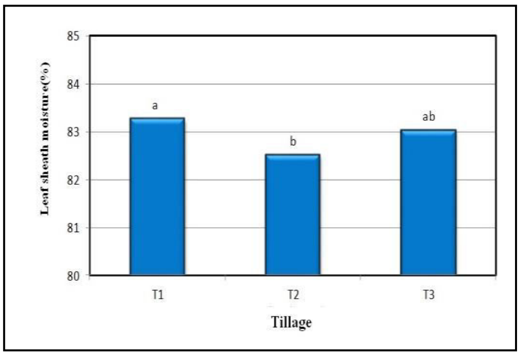

Fig.1. Mean comparison effect of different level of tillage on leaf sheath moisture.
T_1: moldboard plow one time, Subsoiler two time as conventional tillage, **T_2**: moldboard plow one time, Subsoiler one time, **T_3**: moldboard plow two time, without Subsoiler.
Similar letters in each column show non-significant difference at 5% probability level in Duncan's multiple rang test.

It seems that the advantage of reduced plowing systems in maintaining soil moisture and increasing leaf sheath moisture is more significant in the years of low rain and reduced irrigation system, so in sugarcane cultivation, due to the large amount of water consumed and the heavy irrigation system, the conventional plowing system is more effective than the reduced plowing system in supplying the water needed by the plant. Lopez-Bellido *et al* (1996) reported same result. Bahrani *et al.* (2010) by evaluate response of sugarcane crop production to different level of nitrogen and irrigation regime reported the highest sugar yield was obtained under IW/CPE = 1.2 (29 irrigations) and with 172 kg N ha^{-1} with no significant difference with IW/CPE = 1.0 (25 irrigations) and 86 kg N ha^{-1}, respectively. Higher irrigation and N levels showed a small but not significant reduction in both juice sucrose and purity percentages. Higher N levels significantly increased the N use efficiency (NUE) for cane yield, but NUE for sugar yield was highest at 86 kg N ha^{-1}. Water use efficiency (WUE) increased with higher water application. Thus pan evaporation data and N management can effectively meet both irrigation (IW/CPE = 1.0) and N requirements (86.0 kg ha^{-1}) of sugarcane without any adverse effect on yields and environment and reduces production costs as well.

4.2. Nitrogen percentage

Result of analysis of variance revealed effect of tillage system, urea fertilizer and interaction effect of treatments on nitrogen percentage was not significant (Table 2). The small changes in the amount of nitrogen in the leaves were mostly related to the use of nitrogen fertilizer (increasing the percentage of nitrogen in the leaves) and accelerating the growth of the plant (decrease in the percentage of nitrogen in the leaves). Celements (1980) believed that in the range of 1.5-2.7% nitrogen in the leaves, the sugarcane plant will not show deficiency symptoms. In this experiment, the percentage of nitrogen in the leaves was in the range of 1.55-2.43%, which indicated no nitrogen deficiency. Haghnazari *et al.* (2020) by evaluate effect of different level of irrigation regime and nitrogen fertilizer on sugarcane crop production reported that F_2I_1 (100% water requirement and 80% manure requirement of sugarcane plant to nitrogen fertilizer) has higher yield and biomass than other treatments and with the 20% reduction in fertilizer application, the desired yield could be achieved. This will reduce agricultural costs and, in the long run, will also eliminate the negative effects of excessive fertilizer use and, while increasing production, will be a strategic plan for achieving sustainable agricultural objectives.

4.3. Recoverable sugar

According result of analysis of variance effect of tillage system, urea fertilizer and interaction effect of treatments on recoverable sugar was not significant (Table 2). The results of Lorzadeh (2003) and Ramezani (1989) studies showed that qualitative traits such as sugar percentage and syrup purity are under the control of genetic traits and the aptitude of the variety and are less affected by treatments such as plowing, fertilizer, etc. On the other hand, Rhoades (1996) showed that excessive consumption of nitrogen leads to the reduction of sucrose in sugarcane syrup.

4.4. Cane yield

Result of analysis of variance revealed effect of tillage system and interaction effect of treatments on cane yield was not significant but effect of urea fertilizer was significant at 5% probability level (Table 2). Assessment mean comparison result indicated in different level of urea fertilizer the maximum cane yield (118 $t.ha^{-1}$) was noted for 300 $kg.ha^{-1}$ urea fertilizer and minimum of that (103 $t.ha^{-1}$) belonged to 250 $kg.ha^{-1}$ although it does not have significant difference with 350 $kg.ha^{-1}$ treatment (Fig.2).

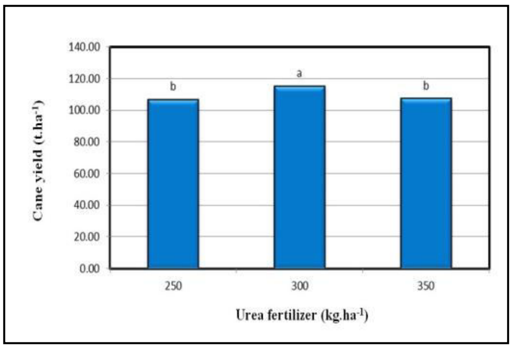

Fig.2. Mean comparison effect of different level of urea fertilizer on cane yield.
Similar letters in each column show non-significant difference at 5% probability level in Duncan's multiple rang test.

The results of this research were consistent with the findings of Bahadori (2005) that there was no significant difference between the amount of sugarcane produced in different tillage treatments. Naseri *et al*. (2020) also reported that different tillage treatments had no significant effect on quantitative traits of sugarcane except stem height. Improper tillage operation is one of the effective factors of yield loss in fields, which causes two important factors of soil compaction and thinness (less tiller) of the field. So, in subsoiler operations, one should try to minimize effects of soil compaction and thinness of high fields. Subsoiling in a field where the surface of land is wet causes the compacted soil to disintegrate (the purpose of Subsoiling is not realized) and if the soil is too dry, it causes the creation of large and integrated lumps and causes the lumps to be pushed out the surface of the earth. This causes roots of plant to be unwittingly uprooted, as well as the whole sugarcane plant being uprooted from its bed and drying up.

On the other hand, due to the formation of clods during the irrigation operation, fine soil particles along with the irrigation water quickly migrate to the depth of the soil and create a layer with low permeability and soil ventilation decreased (Ghasemipour, 2010). In the research of Kochakzadeh (2009), the maximum production of cane yield and sugar was achieved with the consumption of 138 kg of nitrogen per hectare (300 kg of urea). Based on the results of this experiment, to achieve high yields it was recommended to use 92 kg of nitrogen per hectare and 138 kg of nitrogen per hectare in ratoon field of southern Khuzestan. The increase in the yield of sugarcane stalks due to the use of nitrogen will be the result of the increase in the length and diameter of the stalks and the number of stalks in the harvest stage (Abaymi, 1987). This researcher reported that with the increase of nitrogen consumption up to 160 kg per hectare, the length of the stem and as a result the yield of the stem increased. However, with the consumption of 200 kg of nitrogen per hectare, the length of the stem and the yield of the stem decreased. Malkoti (1996) stated that the consumption of 135 kg of nitrogen per hectare is the most economical amount of this element to produce high yield and better extraction of sugar. With the increase of nitrogen consumption up to 225 kg per hectare, the process of increasing the yield continues, but the consumption of more than this amount causes a decrease in the yield and yield of sugarcane.

4.5. Sugar yield

According result of analysis of variance effect of tillage system, urea fertilizer and interaction effect of treatments on sugar yield was not significant (Table 2).

5. CONCLUSION

Among the examined traits, only leaf sheath moisture percentage was significantly affected by tillage treatment. Also, tillage treatments had no significant effect on quality indicators of sugarcane, such as the amount of recoverable sugar. This problem indicates that quality factors are more related to genetics and variety characteristics, and environmental factors such as different tillage methods are less effective on product quality. Due to the lack of effect of different amounts of urea on most of the examined traits, it is suggested to use more amounts of this fertilizer in similar researches. Due to the fact that reducing one round of plowing operation (compared to the conventional plowing method) did not affect the yield of the crop, it is possible to skip this operation in the field. Considering the maximum yield of the product with the consumption of 300 kg per hectare of urea fertilizer, reducing the consumption of 50 kg per hectare of urea fertilizer compared to the current consumption amount will not have an effect on reducing the yield.

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FOOTNOTES

AUTHORS' CONTRIBUTION: All authors are equally involved.

CONFLICT OF INTEREST: Authors declared no conflict of interest.

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