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# EFFECT OF HILL SPACING AND NITROGEN LEVEL ON FORAGE YIELD OF TEOSINTE (*Zea mexicana,* L.)

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## ABSTRACT

Two field experiments were conducted during two consecutive summer seasons 1997 and 1998 at Sakha Agricultural Research Station. The study aimed to investigate the effect of three hill spacings 10, 20 and 30 cm and 60 cm between ridges (35000, 23333 and 17500 hills/fad) and three nitrogen levels, 20, 30 and 40 kg N/fad/cut on forage yield of teosinte (*Zea mexicana* L.). The experimental design used was a split-plot with four replications.

The results revealed that plant height (cm), leaf/stem ratio (fresh and dry); and fresh and dry forage yields were significantly affected by hill spacing and nitrogen levels. Twenty centimeters hill spacing gave the highest values for the two characters. It produced 28.525 and 4.172 ton/fad fresh and dry forage yields, respectively (combined total). Concerning nitrogen level, 40 kg/fad/cut led also to high values; and it gave the highest fresh and dry forage yields; 30.363 and 4.358 ton/fad., respectively (combined total). The data of stem diameter revealed no significant differences among the different treatments due to hill spacing or nitrogen levels. Crude protein content was slightly affected by hill spacing, where 10 cm and 20 cm gave the same percentage. Crude protein content was gradually increased by increasing nitrogen level up to 40 kg/fad/cut.

For fresh and dry forage yields, the interaction between hill spacing and nitrogen levels was significant at the three cuts and their total in 1997 as well as at second and third cuts in 1998 season.

In conclusion, 20 cm hill spacing combined with 40 kg N/fad/cut gave the highest fresh and dry yields.

## INTRODUCTION

Teosinte (*Zea mexicana* L.) recently expanded as a summer forage crop in Egypt. It recovers quickly after grazing or clipping and produces highly palatable forage. It is closely related to maize in most allelometric characters. It has also the advantages of tillering and regeneration as a fodder crop under irrigated conditions in addition to its high level of tolerance to excess moisture (Lal *et al.,* 1980) which it makes this crop more adaptable to the humid tropics and sub-tropics (Whyte *et al.,* 1975). For forage crops, nitrogen fertilization could determine both the productivity and quality of the herbage.

The effect of cultural practices on the productivity of teosinte was studied by few investigators. Walli and Relwani (1962) recorded an increase in yield of teosinte by increasing the doses of nitrogen application. Patel *et al.* (1976) showed that increasing nitrogen levels, i.e., 0, 40, 80 and 120 kg/ha, had progressively increased the yield of green forage, dry matter and crude protein from 341 to 463 q/ha, 60.9 to 83.5 q/ha and 5.2 to 7.4 q/ha, respectively. Virendra Singh *et al.* (1988a) mentioned that increasing N levels. In teosinte increased both yields (significant upto 100 kg N $ha^{-1}$), crude protein and dry matter digestibility (significant up to 150 kg $ha^{-1}$). Virendra Singh *et al.* (1988b) showed that both herbage yield and quality of teosinte increased with increasing N levels. The increase in herbage yield was significant with 100 kg N $ha^{-1}$ in single-cut and with 150 kg N $ha^{-1}$ in two-cut systems. Forage yield of pearl millet ultimately depends on seeding rates, which affect the production per unit area of land. Decreasing row spacing and increasing seeding rate of pearl millet produced more leafy forage where stems become more smaller in diameter as the plants become more crowded (Richard and Burton 1965).

Mousa *et al.* (1994) found that plant height of pearl millet decreased with increasing row spacing up to 40 cm and seeding rates also caused significant increase in plant height and the rate of 22 kg/fad seeding gave the tallest plants. Increasing row distance or seeding rate increased fresh and dry yields of pearl millet. Gheit *et al.* (1995) reported that plant height, stem diameter, fresh and dry forage yields and crude protein of sorghum hybrid 402 plants were significantly increased by increasing nitrogen levels upto 90 kg N/fad. Bassal *et al.* (1997) found that increasing nitrogen fertilizer levels in sorghum had marked effects on plant height, fresh and dry forage yields; and crude protein percentage. Each increase in nitrogen levels upto 30 kg N/fad/cut was associated with marked increase in growth, productivity and quality of forage sorghum. This study aimed to investigate the effect of hill spacing and nitrogen levels on forage yield and crude protein content of teosinte (*Zea mexicana* L. or *Euchlaena mexicana* Schrad.).

## MATERIALS AND METHODS

This investigation was carried out during two consecutive summer seasons of 1997 and 1998 at Sakha Agriculture Research Station.

The experimental treatments were laid out in a split-plot design with four replications. The main-plots were assigned to the three hill spacing 10, 20 and 30 cm (35000, 23333 and 17500 hills/fad) and the sub-plots were devoted to the three nitrogen levels, 20, 30 and 40 kg N/fad/cut. The plot area was 3 m x 4 m = 12 $m^2$ consisted of 5 ridges, 4 m long and 60 cm apart. Seeds were sown on June, $20^{th}$ and May $24^{th}$ in the first and the second seasons, respectively. Plants were thinned in two plants per hill one month after germination. All plots received 22.5 kg $P_2O_5$/fad at soil preparation. Nitrogen fertilizer was added at three equal doses. The first dose was added after 21 days from sowing, the second and third doses were added after the first and the second cuts, respectively. The studied characters were: plant height in cm, stem diameter in cm, fresh and dry leaf/stem ratio (%), fresh and dry forage yields (ton/fad.), and crude protein content (%) according to A.O.A.C. (1980).

Data were statistically analyzed using M.STAT. Computer Program (1986).

## RESULTS AND DISCUSSION

**1. Plant height (cm):**

The results in Table (1) show that plant height of teosinte was significantly affected, in most cases, by hill spacing and nitrogen levels at the three cuts in both seasons. The tallest plants were obtained from 20 cm hill spacing, meanwhile, 10 and 30 cm hill spacing led to shorter plants. With respect to nitrogen levels, significant differences among nitrogen levels were

**Table (1):Effect of hill spacing and nitrogen level on plant height, stem diameter, leaf/stem ratio (fresh and dry) and crude protein content of teosinte in 1997 and 1998.**

| Treatments | 1997 | | | 1998 | | |
|---|---|---|---|---|---|---|
| | 1st cut | 2nd cut | 3rd cut | 1st cut | 2nd cut | 3rd cut |
| **Plant height (cm)** | | | | | | |
| Hill spacing (cm) | | | | | | |
| 0 | 73.8 a | 84.0 b | 54.5 ab | 49.4 ab | 114.5 a | 113.5 ab |
| 20 | 78.0 a | 89.7 a | 57.6 a | 54.6 a | 121.6 a | 115.2 a |
| 30 | 72.0 a | 85.1 ab | 52.7 b | 48.8 b | 103.1 a | 111.7 b |
| N levels (kg/fad/cut) | | | | | | |
| 20 | 67.0 b | 82.3 c | 52.0 b | 49.2 b | 104.7 b | 105.5 c |
| 30 | 71.2 b | 85.3 b | 53.3 ab | 49.3 b | 115.8 a | 114.7 b |
| 40 | 82.2 a | 91.2 a | 59.4 a | 54.3 a | 118.8 a | 120.2 a |
| **Stem diameter (cm)** | | | | | | |
| Hill spacing (cm) | | | | | | |
| 0 | 0.88 a | 0.98 a | 0.41 a | 1.00 a | 0.86 a | 0.95 a |
| 20 | 0.90 a | 1.03 a | 0.42 a | 1.03 a | 0.92 a | 0.95 a |
| 30 | 0.89 a | 1.03 a | 0.42 a | 0.99 a | 0.87 a | 0.93 a |
| N levels (kg/fad/cut) | | | | | | |
| 20 | 0.87 a | 0.99 a | 0.41 a | 0.98 a | 0.86 a | 0.90 b |
| 30 | 0.90 a | 1.00 a | 0.41 a | 1.00 a | 0.88 a | 0.92 b |
| 40 | 0.91 a | 1.04 a | 0.43 a | 1.03 a | 0.91 a | 1.01 a |
| **Fresh leaf/stem ratio (%)** | | | | | | |
| Hill spacing (cm) | | | | | | |
| 0 | 92.9 a | 54.5 ab | 60.2 b | 93.7 b | 76.9 b | 47.5 b |
| 20 | 95.0 a | 55.3 a | 69.7 a | 9.5 a | 83.1 a | 52.3 a |
| 30 | 81.0 b | 51.5 b | 51.3 c | 90.7 c | 73.1 b | 47.0 b |
| N levels (kg/fad/cut) | | | | | | |
| 20 | 82.4 c | 51.2 b | 53.4 b | 83.2 c | 72.6 b | 47.0 b |
| 30 | 90.3 b | 53.8 ab | 62.2 a | 96.2 b | 75.2 b | 49.0 ab |
| 40 | 96.3 a | 56.3 a | 65.6 b | 104.5 a | 85.3 a | 50.5 a |
| **Dry leaf/stem ratio (%)** | | | | | | |
| Hill spacing (cm) | | | | | | |
| 0 | 149.2 b | 94.7 b | 65.5 b | 159.5 b | 144.5 ab | 67.4 b |
| 20 | 181.8 a | 104.0 a | 70.9 a | 169.2 a | 151.3 a | 73.4 a |
| 30 | 114.1 c | 94.8 b | 52.3 c | 148.8 c | 141.8 b | 67.5 b |
| N levels (kg/fad/cut) | | | | | | |
| 20 | 146.0 b | 93.2 c | 52.7 b | 146.3 c | 131.0 c | 66.9 b |
| 30 | 148.6 ab | 98.3 b | 66.3 a | 157.7 b | 143.3 b | 69.3 ab |
| 40 | 150.5 a | 102.2 a | 69.8 a | 173.5 a | 163.3 a | 72.2 a |
| **Crude protein content (%)** | | | | | | |
| Hill spacing (cm) | | | | | | |
| 0 | 8.7 | 8.8 | 10.6 | 9.2 | 8.6 | 9.6 |
| 20 | 8.7 | 8.8 | 10.6 | 9.2 | 8.7 | 9.5 |
| 30 | 8.6 | 8.7 | 10.4 | 9.1 | 8.5 | 9.5 |
| N levels (kg/fad/cut) | | | | | | |
| 20 | 8.6 | 8.6 | 10.4 | 9.1 | 8.5 | 9.4 |
| 30 | 8.6 | 8.8 | 10.5 | 9.2 | 8.6 | 9.6 |
| 40 | 8.8 | 8.9 | 10.6 | 9.2 | 8.7 | 9.6 |

**Means designated by the same letter(s) are not significant at the 0.05 level according to Duncan's multiple range test.**

detected at all cuts in the two seasons. Increasing nitrogen levels up to 40 kg/fad/cut gradually increased plant height. These results are in harmony with those obtained by Gheit *et al.* (1995) and Bassal *et al* (1997).

**2. Stem diameter (cm):**

Data presented in Table (1) show that there were no significant differences among stem diameter due to hill spacing at all cuts in both seasons. Nitrogen fertilizer levels did not also induce significant effects on stem diameter, except at the third cut in 1998 where 40 kg N/fad/cut gave the highest value.

**3. Fresh leaf/stem ratio (%):**

Data presented in Table (1) show the effect of hill spacing and nitrogen levels on fresh leaf/stem ratio in both seasons. The results of fresh leaf/stem ratio was clearly affected by hill spacing and nitrogen levels. In all cases, hill spacing of 20 cms and nitrogen level of 40 kg N/fad/cut gave the highest values.

**4. Dry leaf/stem ratio (%):**

Dry leaf/stem ratio had the same trend of fresh leaf/stem ratio (Table 1). The best hill spacing was 20 cm and 40 kg N/fad/cut had the highest dry leaf/stem ratio. Similar results were obtained by Richard and Burton (1965) and Virendra Singh *et al.* (1988).

With regard to the different interactions between hill spacing and nitrogen level, there are no significant effect on the previous four characters.

**5. Fresh forage yield (ton/fad.):**

Significant differences were obtained among hill spacing for fresh forage yield at the second cut and total yield in 1997, at first and third cuts and total yield in 1998 and at the combined total yield. The hill spacing of 20 cm produced the highest total fresh yield (24.414, 32.635 and 28.525 ton/fad. in 1997, 1998 and their combined, respectively) as shown in Table (2). The three nitrogen levels gave significant differences at all cuts, their total and combined over the two seasons. The application of 40 kg N/fad/cut gave the highest total fresh yield (26.599, 34.126 and 30.363 ton/fad. in 1997, 1998 and their combined, respectively) as shown in Table (2). The interaction between hill spacing and nitrogen levels was significant at the three cuts and their total yield in 1997 and at the second and third cuts in 1998. In general, 20 cm hill spacing with 40 kg N/fad./cut combination resulted in the highest fresh yields (Table 3). Similar results were obtained by Virendra Singh *et al.* (1988b), Mousa *et al.* (1994) and Bassal *et al.* (1997).

**6. Dry forage yield (ton/fad.):**

Results in Table 2 represent dry forage yield as affected by hill spacings and nitrogen levels in both seasons. Significant differences were detected among hill spacing at the second cut and total yield in 1997 and at first cut and total in 1998 and total combined. Significant differences were also recorded among nitrogen levels at all cuts and total in both seasons and their combined. Like the same trend of to fresh forage yield, the superior treatment was 20 cm and 40 kg N/fad./cut). The hill spacing of 20 cms gave total dry yields of 3.479, 4.865 and 4.172 (ton/fad) in 1997, 1998 and their combined respectively. The nitrogen level of 40 kg/fad/cut produced total dry yields of 3.704, 5.012 and 4.358 ton/fad in 1997 and 1998 as well as their combined total, respectively. With respect to the interactions between hill spacings and nitrogen levels, they were as the same as those of the fresh yield and the best combination seems also to be 20 cm with 40 kg N/fad/cut (Table 3). These results agree with those of Virendra Singh *et al*. (1988b), Mousa *et al*. (1994) and Bassal *et al*. (1997).

**Table (2):Effect of hill spacing and nitrogen levels on fresh and dry forage yield (ton/fad.) of teosinte in 1997, 1998 and their combined.**

| | 1997 | | | | 1998 | | | | Comb. |
|---|---|---|---|---|---|---|---|---|---|
| | 1st cut | 2nd cut | 3rd cut | Total | 1st cut | 2nd cut | 3rd cut | Total | |
| **Fresh yield (ton/fad)** | | | | | | | | | |
| **Hill spacing (cm): A** | | | | | | | | | |
| 10 | 8.078 a | 13.272 b | 1.983 a | 23.333 b | 8.197 b | 11.070 a | 9.625 b | 28.892 b | 26.113 b |
| 20 | 8.460 a | 14.000 a | 1.954 a | 24.414 a | 10.791a | 10266 a | 11.578 a | 32.635 a | 28.525 a |
| 30 | 8.078 a | 13.475 ab | 1.925 a | 23.478 b | 8.691 b | 11200 a | 10.238 b | 30.129 b | 26.804 b |
| Nitrogen levels (kg/fad.)/cut | | | | | | | | | |
| 20 | 6.475 c | 12.485 c | 1.780 c | 20.740 c | 8.197 c | 9.450 c | 9.128 c | 26.775 c | 23.758 c |
| 30 | 8.225 b | 13.710 b | 1.954 b | 23.889 b | 9.247 b | 10.938 b | 10.500 b | 30.685 b | 27.287 b |
| 40 | 9.917 a | 14.553 | 2.129 a | 26.599 a | 10.238 a | 12.075 a | 11.813 a | 34.126 a | 30.363 a |
| **Dry yield (ton/fad)** | | | | | | | | | |
| **Hill spacing cm: B** | | | | | | | | | |
| 10 | 1.169 a | 1.680 b | 0.412 a | 3.261 b | 1.120 b | 1.502 a | 1.696 a | 4.318 b | 3.790 b |
| 20 | 1.215 a | 1.869 a | 0.395 a | 3.479 a | 1.425 a | 1.409 a | 2.031 a | 4.865 a | 4.172 a |
| 30 | 1.125 a | 1.727 a | 0.410 a | 3.262 b | 1.200 b | 1.489 a | 1.834 a | 4.523 b | 3.893 b |
| **Nitrogen levels (kg/fad.)/cut** | | | | | | | | | |
| 20 | 0.964 c | 1.599 | 0.370 b | 2.933 c | 1.131 b | 1.366 b | 1.655 b | 4.152 b | 3.543 c |
| 30 | 1.174 b | 1.776 b | 0.414 a | 3.364 b | 1.245 ab | 1.452 b | 1.844 b | 4.541 b | 3.953 b |
| 40 | 1.371 a | 1.901 a | 0.432 a | 3.704 a | 1.368 a | 1.582 a | 2.062 a | 5.012 a | 4.358 a |

**Means designated by the same letter(s) are not significant at the 0.05 level according to Duncan's multiple range test.**

## 7. Crude protein content (%):

Data in Table (1) revealed that crude protein content was slightly affected by the different hill spacing and nitrogen levels. Hill spacing of 10 and 20 cm gave higher percentages than that of 30 cm. Adding 40 kg N/fad/cut gave the highest percentages over all levels. Similar results were obtained by Patel *et al.* (1976), Virendra Singh *et al.* (1988a) and Bassal *et al.* (1997).

**Table (3): Effect of interaction between hill spacing and nitrogen level on fresh and dry forage yield at first, second, third cuts and total in 1997; second and third cuts in 1998.**

| Treatments | 1997 | | | | 1998 | |
|---|---|---|---|---|---|---|
| (A + B) | 1st cut | 2nd cut | 3rd cut | Total | 2nd cut | 3rd cut |
| **Fresh forage yield (ton/fad.)** | | | | | | |
| 10 + 20 | 6.300 f | 10.850 d | 1.925 b | 19.075 d | 8.925 e | 8.400 f |
| 10 + 30 | 8.400 d | 14.175 ac | 1.925 b | 24.500 b | 11.638 ac | 9.363 df |
| 10+ 40 | 9.538 bc | 14.788 ab | 2.100 b | 26.425 a | 12.425 a | 11.123 bc |
| 20 + 20 | 6.563 f | 13.388 c | 1.488 c | 21.438 c | 8.663 e | 10.063 ce |
| 20 + 30 | 8.925 cd | 13.563 c | 2.013 b | 24.500 b | 10.325 d | 11.550 b |
| 20 + 40 | 9.888 ab | 15.050 a | 2.363 a | 27.300 a | 11.813 ab | 13.125 a |
| 30+ 20 | 6.563 f | 13.213 c | 1.925 b | 21.700 c | 10.763 cd | 8.925 ef |
| 30 + 30 | 7.350 e | 13.388 c | 1.925 b | 22.663 c | 10.850 bd | 10.588 bd |
| 30+ 40 | 10.325 a | 13.825 bc | 1.925 b | 26.075 a | 11.988 a | 11.200 bc |
| **Dry forage yield (ton/fad.)** | | | | | | |
| 10 + 20 | 0.953 c | 1.360 d | 0.401 b | 2.714 f | 1.315 c | 1.491 c |
| 10 + 30 | 1.198 b | 1.786 bc | 0.411 b | 3.396 c | 1.560 ab | 1.692 bc |
| 10+ 40 | 1.355 a | 1.894 b | 0.423 ab | 3.672 b | 1.631 a | 1.906 b |
| 20 + 20 | 0.941 c | 1.744 bc | 0.304 c | 2.989 a | 1.279 c | 1.860 b |
| 20 + 30 | 1.330 a | 1.758 bc | 0.409 b | 3.497 bc | 1.396 bc | 1.899 b |
| 20 + 40 | 1.372 a | 2.105 a | 0.471 a | 3.948 a | 1.553 ab | 2.335 a |
| 30+ 20 | 0.997 c | 1.693 c | 0.405 b | 3.095 de | 1.504 ab | 1.615 bc |
| 30 + 30 | 0.992 c | 1.783 bc | 0.423 ab | 3.198 d | 1.400 bc | 1.942 b |
| 30+ 40 | 1.387 a | 1.703 c | 0.403 b | 3.493 bc | 1.562 ab | 1.944 b |

**Means designated by the same letter(s) are not significant at the 0.05 level according to Duncan's multiple range test.**

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## تأثير مسافات الزراعة ومستويات التسميد النيتروجينى على محصول علف الذرة الريانة

**جابر سليمان غيط**
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أجري هذا البحث بمحطة البحوث الزراعية بسخا خلال موسمى 1998/1997. ويهدف هذا البحث إلى دراسة تأثير ثلاث مسافات زراعة بين الجور وهى 10 ، 20 ، 30 سم على خطوط عرضها 60 سم (35000 ، 23333 ، 17500 جوره/فدان) وثلاث مستويات من التسميد النتروجينى هى 20 ، 30 ، 40 كجم/فدان/حشه على محصول علف الذرة الريانة. وقد استخدم تصميم القطع المنشقة مرة واحدة فى اربع مكررات.

وقد أوضحت النتائج ان صفات طول النبات ونسبة الورق/السوق (اخضر وجاف) ومحصول العلف الأخضر والجاف تتأثر معنويا بمسافات الزراعة ومستويات التسميد النتروجينى.

وقد أعطت مسافة 20 سم بين الجور أعلى القيم لتلك الصفات وقد أنتجت هذه المعاملة 28.525 ، 4.172 طن/فدان محصول علف اخضر وجاف على التوالى (للمحصول المشترك).

وبالنسبة لمستويات التسميد النتروجيني أعطت المعاملة 40 كجم/فدان/حشة أعلى محصول كلى للعلف الأخضر والجاف (30.363 ، 4.358 طن/فدان على التوالى).

كما أظهرت النتائج عدم وجود فروق معنوية بين المسافات بين الجور وكذلك بين مستويات التسميد النتروجينى على سمك الساق.وقد كانت الفروق فى نسبة البروتين بين المعاملات قليلة حيث تساوت مسافتى 10 ، 20 سم بين الجور بينما ارتفع محتوى البروتين الخام تدريجيا بارتفاع مستوى التسميد النتروجينى حتى 40 كجم/فدان/حشة.

وقد كان التفاعل بين معاملات المسافات بين الجور ومستويات التسميد النيتروجينى معنويا فى الثلاث حشات والمحصول الكلى سنة 1997 وفى الحشة الثانية والثالثة سنة 1998.

ومن ذلك يتضح أن زراعة الذرة الريانة بمسافة 20سم بين الجور على الخطوط مع اضافة 40 كجم نيتروجين/فدان/حشة أعطت أعلى محصول علف أخضر وجاف ذو قيمة غذائية مرتفعة.