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# Effect of Nitrogen Rates and Time of Application on Some Morphological Characters and Yield of Grain Sorghum (*Sorghum bicolor* L. Moench)

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ABSTRACT. A field experiment was conducted for two consecutive years during the crop season of 1980 and 1981 to investigate into the response of some morphological characters and grain yield to five rates of N and three times of application. Splitting relatively high nitrogen rates into two applications widely separated in time had no effect on plant height but had a significant effect on the number of days from sowing to 50% flowering and grain yield. High yields of irrigated sorghum can be obtained if N fertilizer (145-160 kg/ha) was split into two halves and applied 21 days and 45 days from sowing the crop.

Grain sorghum (*Sorghum bicolor* L. Moench) is one of the important food grain crops of arid and semi-arid regions of the world and is widely grown in subsistence farming systems. Among plants that are most economical in their use of water is sorghum (Arnon 1972, Rusell 1980, Farah 1983). In Upper Egypt, grain sorghum is grown in summer (June-October) under irrigation. It is used for human consumption and is also the main cereal forage crop. In arid and semi-arid regions, the soil nitrogen is very low and Upper Egypt is no exception. Many farmers in Egypt add nitrogen fertilizer as a single application at a low rate (usually the dose was 100 kg/ha) after 21 days from sowing. Although this dose has been widely adopted, yet the yield returns of sorghum from nitrogen remained rather low (4.5-5.4 ton/ha). This has posed some questions about several factors, among which are the rate and time of application of fertilizer.

The merits of split application of nitrogen for increasing yields seem to be largely dependent on the growth stage of the crop, growth season and soil conditions (Clapp 1973, Khalifa 1973, Ismail 1984, Wedgwood 1985). Soper and Kalra (1969) pointed out that both the quantity of roots in the fertilizer reaction zone and the efficiency of roots in absorbing the element are important factors in

the ability of plants to absorb any fertilizer. Therefore, in order to provide further information on the effect of rate and time of nitrogen application on the growth and yield of grain sorghum under field conditions, experiments were conducted to investigate the uptake of nitrogen by grain sorghum, when applied as a split dose during 1980 and 1981.

## Material and Methods

The experiments were conducted during the summer seasons (July-October) in 1980 and 1981 at the farm of Shandawel Agricultural Research Station at Sohag Upper Egypt. The soil of the experimental field was clay loam soil which has 4% $CaCO_3$, a pH of 7.3 and 0.2% total nitrogen. The treatments were arranged in a split-plot design which was randomized in four blocks. Treatments of time of application were in main plots and nitrogen rate treatments were allocated to subplots. Each subplot was 6 × 7 m and consisted of 10 rows, of which only the 6 inner rows (surface area 25.2 $m^2$) were used for yield determinations. The crop (*Sorghum bicolor* variety "Giza 114") was sown on 15 June in 1980 and 1981, the seed rate was 30 kg/ha and the crop was harvested during the second week of October 1980 and 1981 respectively. The seeds were sown by hand, 5 seeds being placed in every hole. The holes were 20 cm apart within rows that were 60 cm apart. After 21 days from planting, plant-to-plant spacing was maintained by thinning, so as to leave 2 plants/hill. After initial watering in order to effect seed germination, subsequent irrigation followed usually at 10-day intervals. The frequency of watering under field practice in Upper Egypt is 10 irrigations/season.

The nitrogen fertilizer used was urea (46%N). It was banded on the surface of the soil at 5 rates (100, 115, 130, 145 and 160 kg/ha). Each application was split into two halves: the first half was given 21 days after sowing, whereas the second application was given 35, 45 or 55 days after sowing.

Estimates were made of plant height, grain yield and number of days to 50% flowering (bloom), *i.e.* the number of days from sowing until half the plants had shed their pollen (Eastin 1972, Esechie 1983).

## Results

### *Effect of fertilizer rates on flowering, plant height and grain yield*

The results from the experiment indicate that nitrogen rates had no significant effects on time to 50% flowering and plant height in the 1980 and 1981 seasons, but they gave significantly higher grain yields (Table 1) in both years ($P > 0.001$). Significant grain yield increases were obtained as the dose increased from 100 kg/ha to 145 kg/ha in 1980 and from 100 kg/ha to 160 kg/ha in 1981 (Table 2).

*Effect of time of application*

Time of application had a significant effect on both, the number of days from sowing to 50% flowering and grain yield ($P > 0.05$). There was no response of plant height in both seasons (Table 3). Splitting the nitrogen applications equally, *i.e.* half 21 days and half 45 days from sowing, increased the number of days taken to reach 50% flowering and also resulted in a significant increase in grain yield in both seasons ($P > 0.05$). The average increase ranged from 0.14-0.63 ton/ha in 1980 and from 0.65-0.70 ton/ha in 1981.

*Interactions between the effects of rate and time of application on time to 50% flowering and grain yield*

The interactions between the rate and time of application had significant effects on time to 50% flowering and grain yield in both seasons (Table 3).

The results show that splitting 145 kg/ha of N (half 21 days and half 45 days from sowing) produced significant effects and resulted in a delay of time to 50% flowering (Table 4).

In 1980 and 1981, maximum yields (7.78 and 8.35 ton/ha) were obtained when respectively 145 and 160 kg/ha of N were applied. In both cases, N was given in two equal doses, *i.e.* 21 and 45 days after sowing (Table 5).

## Discussion

The productivity of a crop depends upon its morphophysiological characteristics and the availability of suitable nutrients in its environment. Nitrogen fertilizers should be used in amounts that depend on the responsiveness of the crop to nitrogen and arable crops rarely take up more than between one-third and one-half of that applied. Over a considerable range of nitrogen supply for many crops, the amount of leaf area available for photosynthesis is roughly proportional to the amount of N supplied (Russel 1980).

In both seasons, the rate of N fertilizer and time of application had no effect on plant height. The reason why this occured is not clear, but could possibly be attributed to the fact that the grain sorghum variety 'Giza 114' belongs to the lodging-resistant group of sorghums (Esechie 1983).

The significance of the interaction of N × time of application indicated that the number of days to 50% flowering and the grain yield were related. According to Eastin (1972), the standard practice for measuring maturity in sorghum is the number of days from sowing to 50% flowering. In the present investigation, the rate and time of nitrogen fertilizer application significantly delayed (increased the number of days) 50% flowering (Table 4) and thus delayed maturity of sorghum

but with a substantial increase in the final grain yield. Similar results were reported by Dalton (1967) and Esechie (1983), who also found a strong association between number of days from sowing to 50% flowering and grain yield in sorghum.

The increase in the rate of fertilizer from 100-145 kg/ha significantly increased the grain yield by 1.48 ton/ha (25%) and 2.13 ton/ha (39%) for the years 1980 and 1981 respectively (Table 2). The results also show that the higher levels of N fertilizer (100-160 kg/ha), when applied as a split-dose (half 21 days and half 45 days from sowing) to the crop, resulted in comparatively higher grain yields in both seasons. This could have been induced by several factors. With low rates of N fertilizer, split in two doses, sufficient nitrate may not reach a sufficient number of sorghum roots over a reasonable period of time. There may be advantages in plant growth stages to be gained from a higher rate of N applications during an earlier growth stage and a later one (Wedgwood 1985). In the present investigation, with larger quantities of N (when split in two doses), the chances of a larger amount of nitrate reaching a sufficient area of root are increased (Soper and Kalra 1969), so that dividing the application may be of vital importance, subsequently resulting in higher grain yields. For sorghum, a high level of N fertilizer hastens the time of flowering and maturity and increases the grain yield relative to the straw (Russel 1980).

To conclude, these results suggest that split application of N fertilizer in two equal portions, under Upper Egypt conditions, gave extra benefit from the higher application rates during the relatively short growing season. The results support the findings of other Workers (Mehrotra *et al.* 1967, Cooke 1975, Wedgwood 1985), who emphasized the importance of available N at various stages of plant growth.

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**Table 1.** Analysis of variance of time to 50% flowering, plant height and grain yield of 1980 and 1981 season.

| Source of Variance | d.f. | 1980 Season | | | 1981 Season | | |
|---|---|---|---|---|---|---|---|
| | | 50% flowering M S | plant height M S | grain yield M S | 50% flowering M S | plant height M S | grain yield M S |
| Replication | 3 | 0.47 ** | 123.96 – | 1.38 * | 1.31 * | 197.22 – | 2.45 ** |
| Time of Application | 2 | 9.82 | 42.32 | 13.28 | 7.47 | 87.92 | 19.46 |
| Error 1 | 6 | 0.35 – | 113.14 – | 2.37 ** | 1.11 – | 198.47 – | 1.50 ** |
| Nitrogen rate | 4 | 0.35 ** | 111.27 – | 9.40 ** | 1.40 * | 278.54 – | 48.88 ** |
| N × Time of Application | 8 | 6.28 | 138.13 | 9.53 | 6.11 | 261.35 | 4.86 |
| Error 2 | 36 | 1.00 | 200.12 | 0.52 | 2.22 | 154.31 | 1.60 |
| TOTAL | 59 | | | | | | |
| % C.V. for main plot | | 0.90 | 2.74 | 10.44 | 1.54 | 4.00 | 7.37 |
| % C.V. for sub-plot | | 1.53 | 3.64 | 4.89 | 2.18 | 3.53 | 7.72 |

* $P<0.05$
** $P<0.001$

**Table 2.** Effect of nitrogen fertilizer rates on time to 50% flowering, plant height and grain yield.

| Nitrogen Rate (kg/ha) | 1980 Season | | | 1981 Season | | |
|---|---|---|---|---|---|---|
| | plant height cm | 50% flowering days | grain yield ton/ha | plant height cm | 50% flowering days | grain yield ton/ha |
| 100 | 387 | 65.75 | 5.56 | 345 | 68.25 | 5.70 |
| 115 | 392 | 65.42 | 5.68 | 354 | 68.00 | 5.83 |
| 130 | 387 | 65.42 | 5.67 | 358 | 68.92 | 6.42 |
| 145 | 389 | 65.75 | 6.41 | 350 | 68.25 | 6.90 |
| 160 | 384 | 65.50 | 5.99 | 353 | 68.42 | 7.64 |
| L.S.D. at 5% level | N.S. | N.S. | 0.20 | N.S. | N.S. | 0.16 |

**Table 3.** Effect of time of application on time to 50% flowering, plant height and grain yield.

| Time of Application | Season 1980 | | | Season 1981 | | |
|---|---|---|---|---|---|---|
| | 50% flowering days | plant height cm | grain yield ton/ha | 50% flowering days | plant height cm | grain yield ton/ha |
| half 21 days + half 35 days from sowing | 65.35 | 388 | 5.50 | 68.90 | 350 | 6.30 |
| half 21 days + half 45 days from sowing | 66.35 | 386 | 6.12 | 67.70 | 354 | 6.95 |
| half 21 days + half 55 days from sowing | 65.00 | 389 | 5.98 | 68.50 | 353 | 6.25 |
| L.S.D. at 5% level | 0.46 | N.S. | 0.10 | 0.82 | N.S. | 0.18 |

**Table 4.** Effect of the interaction between nitrogen rate and time of application on time to 50% flowering (days).

| Nitrogen Rates / Time of Application | 1980 | | | | | 1981 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | kg / ha | | | | | | | | | |
| | 100 | 115 | 130 | 145 | 160 | 100 | 115 | 130 | 145 | 160 |
| half 21 days + half 35 days from sowing | 64.75 | 65.00 | 66.75 | 65.00 | 65.25 | 68.00 | 68.50 | 67.75 | 66.75 | 67.50 |
| half 21 days + half 45 days from sowing | 67.25 | 65.50 | 64.25 | 67.25 | 67.50 | 67.50 | 67.75 | 69.75 | 68.75 | 70.75 |
| half 21 days + half 55 days from sowing | 65.25 | 65.75 | 65.25 | 65.00 | 63.73 | 69.25 | 67.75 | 69.25 | 69.25 | 67.00 |
| L.S.D. at 5% level | | | 0.20 | | | | | 0.30 | | |

**Table 5.** Effect of the interaction between nitrogen rate and time of application on grain yield (ton/ha).

| Nitrogen Rates / Time of Application | 1980 Season | | | | | 1981 Season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **100** | **115** | **130** | **145** | **160** | **100** | **115** | **130** | **145** | **160** |
| half 21 days + half 35 days from sowing | 5.06 | 5.56 | 5.88 | 5.13 | 5.82 | 5.92 | 5.35 | 5.94 | 6.52 | 7.74 |
| half 21 days + half 45 days from sowing | 5.96 | 5.24 | 5.61 | 7.78 | 6.33 | 5.48 | 6.30 | 6.99 | 7.61 | 8.35 |
| half 21 days + half 55 days from sowing | 5.65 | 6.26 | 5.50 | 6.65 | 5.84 | 5.68 | 5.84 | 6.30 | 6.58 | 6.82 |
| L.S.D. at 5% level | | | 0.17 | | | | | 0.30 | | |

# أثـــر معـــدلات التسميـــد الأزوتي وميعـــاد الإضافة على كل من التزهير وارتفاع النبات ومحصول الحبوب في الذرة الرفيعة

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اشتملت هـذه التجربـة التي أجـريت في مـوسمي ١٩٨٠م و ١٩٨١م على دراسة تأثير خمسة معدلات من النتروجين وثـلاثة مواعيد إضافة على كل من الـتزهير وارتفـاع النبات ومحصـول الحبوب للصنف جيزة (١١٤).

لم يكن لمعـدل التسميد الأزوتي الـذي أضيف كـدفعـة واحدة أثر معنوي على التزهير وارتفاع النبات بينما كان له تأثير عالي المعنوية على محصول الحبوب في كلا الموسمين.

كان لميعاد إضافة السماد الأزوتي تأثـير معنوي عـلى كل من الـتزهير ومحصـول الحبوب بينـما كان التـأثـير غـير معنـوي لارتفاع النبات في كلا الموسمين.

أدت زيـــادة معـدلات التسميـــد الأزوتي من ١٠٠ إلى ١٤٥ كيلو جرام أزوت للهكتار الواحد على دفعتين متساويتين نصف الكميـة بعد ٢١ يـوماً + نصف الكميـة الأخـرى بعـد ٤٥ يوماً من الزراعة إلى تأخير التزهير وزيادة المحصول زيـادة معنـوية وبمقـدار قدره ١,٤٨ طن للهكتـار في موسم ١٩٨٠م و٢,١٣ طن للهكتـار في موسم ١٩٨١م أي بـزيـادة قـدرهـا ٢٥٪ و٣٩٪ على الترتيب.