# Effects of mother bulb size and nitrogen nutrition on production of red onion Seeds at Rahad Scheme

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## Abstract

A field trial was conducted at the Rahad Agricultural Research Station for four consecutive seasons 1999–2003 to study the effects of mother bulb size and level of nitrogen nutrition on seed yield of the red onion cv. "Saggai Red". Results indicated that medium-sized bulbs with diameters in the range of 45 to <55 mm and nitrogen at the level of 36 kg nitrogen per feddan were most suitable for optimum seed production at Rahad when mother bulbs were planted in double rows per 80-cm ridges at 15 cm in-row spacing. Nitrogen was applied in two equal doses. The first dose applied three weeks after planting and the second dose applied four weeks later. The seed yield obtained at Rahad was comparable to the yield reported for northern Sudan and better than the yield obtained at Kassala and New Halfa in eastern Sudan. This gives the Rahad Scheme a comparative advantage in onion seed production for the growing onion export business in the Sudan, mainly because of the availability of land and water.

## Introduction

Onion in Sudan is classified as the most important and popular vegetable crop. The annually cultivated area was estimated in 1999 as 147 thousands feddans and the total production around one million tons of fresh bulbs (Mohamed *et al*., 2003). These estimates may be below the actual figures as Ahmed and George (1984), reported several factors contributing to lack of accuracy in statistics regarding onion acreages and production. The most important among these factors are the cultivation of the crop by small farmers scattering in most part of the country, in areas difficult to access and the annual fluctuation in the cultivated area following price and supply changes caused by disease problems and/or shortage in fuel for irrigation.

In recent years, there is an increasing interest in the production of onion bulbs in larger areas for both the traditional home markets and for the developing horticultural export business. National irrigated schemes, Regional States governments and private companies started to take active steps in formulating their onion export projects. Steady supply of good quality seeds is a pre-requisite for the successful accomplishment of such activities. At present-days the country annual requirement of onion seeds can be estimated as three hundreds tons.

The current status of onion seeds production in Sudan can be described as very poor. Production of certified onion seeds by specialized farmers is lacking and seeds sources, apart from few imports, are limited to traditional production methods described by Ahmed and George (1984). The two authors elaborated on the problem that, most onion seeds are produced as side activity to the main bulb crops. Furthermore, they reported that, for various reasons, some farmers planted the mother bulbs scattered among seedlings of the commercial bulb crops. These practices expose the progeny seeds to all chances of cross fertilization with the pre-mature bolters of the same cultivar or crops of neighboring fields that often have

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different cultivars. As a result of that onion seeds in the market are typically of poor genetic quality.

Ahmed and George (1984) stated that the weather conditions of central and northern Sudan are quite favorable for seed production of many vegetables including onion. Even though, research on agronomic factors related to onion seed production was conducted mainly at northern and eastern Sudan.

In the Rahad Scheme, about seven thousands feddans were allotted for horticultural production. Less than 60% of this area is under cultivation of which about 35% were under vegetable production (Abu-Sarra, *et al*., 2003). The objectives of this study therefore, are to examine the possibility of onion seed production at Rahad Scheme in attempt to formulate profitable alternative production choices to the vegetable farmers and to maximize the utilization of the vegetable areas. Moreover, to evaluate the effects of mother bulb size and level of nitrogen fertilization on seed yield, with the intention of advising farmers on the best management practices that suit the Rahad conditions. Other objectives include the foundation of reliable onion seed source for the developing onion production and export business.

## Materials and methods

Onion variety "Saggai Red" was selected to study the effects of mother bulb size and nitrogen nutrition on onion seed production at Rahad. The experiment was conducted for four successive seasons (1999-2003) in the Horticultural Research Farm at Elfau. The soil is classified as typic haplusterts, a member of very fine, smectitic, isohyperthermic family, shuheit soil series (SMSS-USDA/SSA., 1982). The chemical and physical properties of the soil of the farm were described by Hamid and Saeed (2001) and summarized in Table 1.

Treatments structure comprised a factorial combination of three mother bulbs sizes, viz: small (35 to <45), medium (45 to <55) and large (55 to <65 mm) and four nitrogen levels, viz: 0, 18, 36 and 54 kg nitrogen per feddan. A randomized complete block design with three replications was used in the first two seasons and with four replications in the last two seasons.

For the four seasons, planting of mature sound healthy mother bulbs was carried out in the first or second week of November and harvesting of mature umbels was on the third or forth week of March. Planting was performed on double rows in ridges 80 cm apart at 15 cm in-row spacing in plots of 5 ridges x 6 m long. Nitrogen was applied in the form of urea (46% nitrogen) in two equal doses, the first dose three weeks after planting and the second one four weeks later. The fertilizer application method used was broadcasting on the shoulders of the ridge below the level of the irrigation water. Weeds were controlled by pre-planting spray with "Goal" supported by one hand weeding and plots were sprayed twice for thrips control. Irrigation was at 8–12 days intervals.

Mature umbels were cut with 7-10 cm of stalk and collected into bundles and left to dry under shade. Threshing was affected after complete drying of the umbels and weighing of samples was conducted thereafter.

Data were analyzed using GenStat statistical package. Homogeneity of variance was assessed using Bartlett's test as described by Petersen (1994) and combined analyses were carried out utilizing the accumulated analysis of variance technique of the regression analysis for unbalance design models.

## Results

Tables 2 and 3, show the accumulated analysis of variance for onion seed yield at Rahad over the four seasons (1999-2003) of the experiment. Highly significant interactions at P = 0.003 and hence <0.001 were detected for Nitrogen Level x Bulb Size x Season, Nitrogen Level x Bulb Size, Season x Nitrogen Level and Season x Bulb Size. Differences for the main effects of Bulb size and nitrogen level were also highly significant (P< 0.001).

At the low nitrogen levels (0 and 18 kg N/fed), the medium and large mother bulbs produced similar seed yield, while the small bulbs produced significantly lower yields. At the higher nitrogen levels (36 or 54 kg N/fed) the medium-sized bulbs produced significantly higher seed yield followed by the large bulbs then the small ones (Table 3). Therefore, the optimum seed yield was obtained by medium-sized bulbs with 36 kg nitrogen per feddan.

Irrespective of bulb size the seed yield increased significantly with the increase in nitrogen level up to 36 kg nitrogen per feddan and the increase in seed yield was not significant thereafter. On the other hand, for the main effect of bulb size, medium bulbs produced significantly higher seed yield than large or small bulbs.

Seasonal effects of the treatments on seed yield are depicted in Table 4. The seed yield varied from season to another and the difference between the best and poor season was 52%. Nevertheless, the trend of the treatments effect was consistent throughout the four seasons. Significant nitrogen X bulb size interaction was common for the four seasons and the highest seed yield was obtained with medium-sized bulbs and 36 or 54 kg nitrogen per feddan.

The effect of the treatments on seed weight per umbel is shown in Table 5. Pattern similar to that of seed yield was observed. Significant nitrogen x bulb size interaction was detected and the highest seed yield per umbel was obtained with medium-sized bulbs and 36 kg nitrogen per feddan.

The interaction between the studied factors for the number of seed stalks per plant or the stalk height were non significant at P=0.05. Hence, the main effects are presented in Table 6. The large and medium-sized bulbs produced similar number of seed stalks per plant, which was significantly greater than that of the small bulbs, whereas 18 and 36 kg nitrogen per feddan produced the highest numbers of seed stalks with no significant difference between them compared to none and 54 kg nitrogen per feddan. The increase in bulb size resulted in consistent increase in stalk height, while the increase in nitrogen level resulted in increase in stalk height up to the level of 36 kg nitrogen per feddan.

## Discussion

Accumulated analysis of variance revealed highly significant season x treatments, season x nitrogen and season x bulb size interactions (P= 0.003, <.001 and <.001 respectively). These interactions are of least practical importance, at the present time, as seasonal environmental changes are mostly unpredictable. Consequently, the results of the experiment will be discussed in terms of Nitrogen x Bulb Size interaction. Nevertheless, the main effects of nitrogen and bulb size should not be ignored as they contributed to the observed trial variance. The two effects accounted for about 50% and 17% of the observed sum of squares for the two factors respectively (Table 2).

The trial results indicated that mother bulbs with diameters in the range of 45 to <55 mm, consistently and irrespective of nitrogen nutrition or seasons, resulted in significantly higher seed yield. Nourai *et al*. (2003), in northern Sudan, found that seed yield produced from large red onion mother bulbs (61 mm diameter) were significantly higher than those obtained from smaller bulbs (37 mm diameter). They attributed that to the relative large

amount of food reserves stored in large bulbs which enhanced the production of healthy and vigorously growing plants with large number of umbels. This can be equally applied to the Rahad conditions. However, the closer plant spacing used in the Rahad trial (15 cm, twin rows, 80 cm ridges) in comparison to that of northern Sudan (25 cm, twin rows, 70 cm ridges) limited the optimum seed yields at Rahad to those produced by medium-sized bulbs. El-Hilo and Nourai (1988) recommended sound medium-sized mother bulbs for high seed yield of onion. Similar results were also reported by Singh *et al.* (1990) and Perez, *et al*. (1996).

The beneficial effect of nitrogen in increasing seed yield of onion is well documented (Nourai *et al*. 2003, El-Hilo and Nourai 1988, Singh *et al*. 1990, Ahmed and Abdalla 1984, and Nourai 1984). The results of the Rahad trial confirmed those reports; however, an interaction relationship between mother bulb size and nitrogen level was detected. At low nitrogen level medium and large bulbs produced similar yields, whereas at higher nitrogen levels medium-sized bulbs significantly out-yielded the large bulbs. Small bulbs consistently produced significantly lower yields than medium or large bulbs. Superiority of medium bulbs over large bulbs could most probably be due to the high seed weight produced by the individual umbels of the medium-sized mother bulbs taking into consideration the relatively low number of seed stalks produced per plant under conditions of high plant population and heavy clay soils (Tables 1, 5, 6). Nourai *et al*. (2003) attributed the increase in seed yield, in response to the increase in nitrogen level, to the increase of seed yield of individual plants. El-Hilo and Abu-Goukh (1973) at New Halfa noticed that plants raised on low nitrogen level produced small umbels and hence lower seed yield than well nourished plants.

Rahad offers special opportunity for onion seed production in Sudan due to availability of land, water and specialized farmers. The mean seed yield obtained in the current trial ranged between 296 – 451 kg per feddan. This yield range is equivalent to that reported for northern Sudan and better than the yield obtained in Kassala and New Halfa of eastern Sudan. Nourai *et al*. (2003) reported mean seed yield range of 351–452 and 323– 441 kg per feddan for Hudeiba and Shendi areas, respectively in northern Sudan, while El-Hilo and Nourai (1988) reported less than 200 kg per feddan for New Halfa and Kassala areas in eastern Sudan.

Seed stalks produced per plant (number of umbels) were reported to range between 8 and 10 at northern Sudan (Nourai *et al.* 2003). At Rahad they were about four (Table 5). This low number might be due to the effect of the heavy clay soils of the trial site (Table 1). Abu-Sarra (1999), in a previous study, attributed the low seed yield of onion obtained at Rahad to the low seed stalks produced per plant under the heavy clay soil conditions. To compensate for that, plant population density was increased in this study by reducing the in-row spacing to 15 cm and this was proved effective in increasing seed yield. This confirmed the reports of Abdalla, (1969) and Singh, *et al.* (1990).

## Recommendations

Based on the results of this trial, the following recommendations can be suggested:

***1. Mother Bulbs*:** Sound whole medium size bulbs with diameters in the range of 45 to <55 mm should be used as planting material grown as two rows per 80-cm ridges with an in-row spacing of 15 cm.

***2. Nitrogen Nutrition:*** Application of nitrogen fertilizer at the rate of 36 kg nitrogen per feddan in two equal doses; three and seven weeks after planting.

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**Table 1. Soil chemical and physical properties of the trial site.**

| Chemical Properties | | Physical Properties | |
|---|---|---|---|
| % $CaCO_3$ | 2.0 | % clay | 65 |
| ECe (Ds/m): 0-30 cm | 0.3 | Air Dry Bulk Density (gm/$cm^3$) | 1.80 |
| 30-90 m | 0.4 | Coefficient of linear | |
| ESP: 0-30 cm | 2 | extensibility (COLE) | 0.17 |
| 0-90 m | 10 | Hydraulic Conductivity (cm/hr) | 0.24 |
| PH-Paste | 8.4 | Wetting Front (cm) | 22 |
| % O.C. | 0.680 | Avail. Water Cap. (cm): | |
| % N | 0.040 | 0-30 cm | 5.16 |
| Available P (mg P/kg soil) | 3 | 30-120 cm | 18.25 |
| Ext. K [cmol (+)/kg soil] | 0.38 | | |
| CEC [cmol (+)/kg soil] | 63 | | |
| Soluble Anions (meq/L) | | | |
| $SO_4^{-2}$ | 0–1.2 | | |
| $NO_3^{-1}$ | 0–1.3 | | |

Sources: Hamid and Saeed (2001), and SMSS-USDA/SSA (1982)

**Table 2. Accumulated analysis of variance for onion seed yield kg/fed combined over years.**

| Source of variation | df | SS | MS | F-Probability |
|---|---|---|---|---|
| Year | 3 | 544,468 | 181,489 | <.001 |
| Year.Reps | 10 | 15,930 | 1,593 | 0.110 |
| Nitrogen | 3 | 1,384,854 | 461,618 | <.001 |
| Year. Nitrogen | 9 | 96,145 | 10,683 | <.001 |
| Bulb size | 2 | 464,766 | 232,383 | <.001 |
| Year. Bulb size | 6 | 61,865 | 10,311 | <.001 |
| Nitrogen. Bulb size | 6 | 84,165 | 14,028 | <.001 |
| Year.Nitrogen.Bulb size | 18 | 42,941 | 2,386 | 0.003 |
| Residual | 110 | 108,087 | 983 | |
| Total | 167 | 2,803,220 | 16786 | |

**Table 3. Combined effect of mother bulb size and nitrogen nutrition on onion seed yield kg/fed at the Rahad during 1999-2003 Seasons.**

| Nitrogen Level kg/fed | Bulb Diameter (mm) | | | Nitrogen Mean |
|---|---|---|---|---|
| | 35 - <45 | 45 - <55 | 55 - <65 | |
| 0 | 198 [Y] I | 247 h | 266 h | 237 |
| 18 | 293 g | 447 cd | 432 d | 391 |
| 36 | 374 f | 538 a | 463 bc | 458 |
| 54 | 401 e | 541 a | 473 b | 472 |
| BS Mean | 317 | 443 | 409 | 389 |

Significance: N: ***, BS: ***, N X BS: ***
SE±: N = 4.84, BS = 4.19, N X BS = 8.4, CV (%) = 8.1

[Y] Values in the factorial matrix separated by Duncan's multiple range test, P = 0.05.
N = Nitrogen, BS = bulb size; *** = significant at P = 0.001.

**Table 4. Seasonal effects of mother bulb size and nitrogen nutrition on onion seed yield kg/fed at the Rahad during 1999-2003 seasons.**

| Nitrogen Level Kg/fed. | Bulb Diameter (mm) | | | Nitrogen Mean |
|---|---|---|---|---|
| | 35 - <45 | 45 - <55 | 55 - <65 | |
| | | 1999/00 | | |
| 0 | 128 [Z]d | 137 d | 168 cd | 144 |
| 18 | 213 c | 301 b | 340 b | 285 |
| 36 | 332 b | 427 a | 341 b | 367 |
| 54 | 364 ab | 432 a | 367 ab | 388 |
| BS Mean | 259 | 324 | 304 | 296 |
| Significance: N: *** BS: *** N X BS: * | | | | |
| SE± : N = 12.7, BS = 11.0, N X BS = 22.0, CV% = 12.9 | | | | |
| | | 2000/01 | | |
| 0 | 151 e | 159 e | 199 de | 170 |
| 18 | 266 d | 379 c | 451 bc | 366 |
| 36 | 421 bc | 547 a | 434 bc | 467 |
| 54 | 486 ab | 555 a | 497 ab | 513 |
| BS Mean | 331 | 410 | 395 | 379 |
| Significance: N: *** BS: *** N X BS: ** | | | | |
| SE±: N = 13.8, BS = 12.0, N X BS = 23.9, CV% = 10.9 | | | | |
| | | 2001/02 | | |
| 0 | 239 f | 326 e | 331 e | 299 |
| 18 | 337 e | 463 c | 450 c | 417 |
| 36 | 353 de | 571 a | 519 b | 481 |
| 54 | 368 d | 587 a | 496 b | 484 |
| BS Mean | 324 | 487 | 449 | 420 |
| Significance: N: *** BS: *** N X BS: *** | | | | |
| SE±: N = 5.1, BS = 4.4, N X BS = 8.8, CV% = 4.2 | | | | |
| | | 2002/03 | | |
| 0 | 274 f | 361 e | 367 e | 334 |
| 18 | 357 e | 498 d | 486 d | 447 |
| 36 | 389 e | 605 a | 556 bc | 516 |
| 54 | 402 e | 589 ab | 530 cd | 507 |
| BS Mean | 356 | 513 | 485 | 451 |
| Significance: N: *** BS: *** N X BS: ** | | | | |
| SE± : N = 8.4, BS = 7.3, N X BS = 14.6, CV% = 6.5. | | | | |

[Z]Values in the factorial matrix of each season separated by Duncan's multiple range test, P = 0.05.; N = Nitrogen, BS = bulb size; ***, **, * = significant at P = 0.001, 0.01 and 0.05 respectively.

**Table 5. Effects of mother bulb size and nitrogen nutrition on seed weight/umbel (cg) [φ] at Rahad during 1999-2003 seasons.**

| Nitrogen Level Kg/fed. | Bulb Diameter (mm) | | | Nitrogen Mean |
|---|---|---|---|---|
| | 35 - <45 | 45 - <55 | 55 - <65 | |
| 0 | 66 e | 72 d | 76 d | 71 |
| 18 | 75 d | 90 c | 90 c | 85 |
| 36 | 89 c | 111 a | 100 b | 100 |
| 54 | 90 c | 102 b | 98 b | 97 |
| BS Mean | 80 | 94 | 91 | 88 |
| Significance: N: *** BS: *** N X BS: *** | | | | |
| SE±: N X BS = 1.48, CV% = 6.3 | | | | |

[φ] Centigram = 0.01g.
Values in the factorial matrix separated by Duncan's multiple range test, P= 0.05
N = Nitrogen, BS = bulb size; ***= significant at P = 0.001

**Table 6. Effects of mother bulb size and nitrogen nutrition on number of seed stalks/plant and stalks height at Rahad during 1999-2003 seasons.**

| Treatments | Seed Stalks/plant (No.) | Stalk height (cm) |
|---|---|---|
| Bulb Size | | |
| 35 to <45 | 3.8 [Y]b | 70 c |
| 45 to <55 | 4.4 a | 72 b |
| 55 to <65 | 4.4 a | 74 a |
| *SE*± | 0.08 | 0.4 |
| Nitrogen Level (kg/fed) | | |
| 0 | 4.0 [Z]B | 66 C |
| 18 | 4.4 A | 72 B |
| 36 | 4.4 A | 74 A |
| 54 | 4.1 B | 74 A |
| SE± | 0.09 | 0.5 |
| CV% | 14.3 | 4.17 |

[Y]For bulb size effect; mean separation for values within a column (lower case letters) by Duncan's multiple range test, P = 0.05. [Z]For nitrogen effect; mean separation for values within a column (upper case letters) by Duncan's multiple range test, P = 0.05.