EFFECT OF PLANTING DISTANCES, PHOSPHORUS AND NITROGEN + FOLIAR FERTILIZATION ON GROWTH AND YIELD OF STEVIA CROP

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ABSTRACT: Two field trials were conducted in a administration field at Faqous Distrect, Sharquia Governorate in the two summer seasons of 2018 and 2019. This work was aimed to investigate the effect of planting distances, phosphorus and nitrogen fertilization on growth and productivity of stevia crop. The treatments consisted of two planting distances, 25cm and 50cm between hills; phosphorus fertilization, without and with 15.5kg P₂O₅/faddan as well as four nitrogen fertilization treatments (15and 30kg N /fad. each with and without foliar nutrient application). The results indicate that plant height and number of branches/plant did not significantly differed due to planting distances and phosphorus fertilization. Number of branches/plant was significantly increased by increasing nitrogen levels up to 30kg/fad. compared with 15kg N/fad. Significant increments were observed by 50cm planting distance and adding 100 kg super phosphate at the 2nd and 3 third cut only by number of leaves/plant in the first season. The results showed significant increments due to planting stevia on 50cm distance and adding 100kg superphosphate by plant fresh weight, leaves fresh and dry weights/plant in the two season and all cuts except the first one by leaves fresh weight in the first season. On the other hand, total fresh yield/fad. leaves fresh and dry yields/fad. were significantly higher by planting stevia at 25cm distance and adding 100kg superphosphate/fad. Concerning the effect of adding 30 kg N/fad. and foliar application, there were significant increments in all studied characters of stevia by all cuts in the two seasons except plant height, which the differences did not reach the level of significance. Positive significant interaction effects were detected only by the interaction between planting distance and phosphorus fertilization on plant fresh weight, total fresh yield/fad. Leaves fresh and dry yields/fad, also between planting distance and adding 30 kg/fad. nitrogen fertilization on leaves fresh weight, total fresh yield/fad. and leaves fresh and dry yields/fad.

Key words: Stevia (Stevia rebaudiana Bertoni), planting distance, phosphorus, nitrogen, foliar fertilization.

INTRODUCTION

Stevia (Stevia rebaudiana, Bertoni) is known as a natural sweetness plant in the world belong to the family asteraceae. Stevia leaves contain compounds about 250 to 300 sweeter than the table sugar (Kumar, 2002). Stevia crop was recently known and cultivated in Egypt for its sweetener leaves. The main substance of interest is stevioside which concentrate in stevia leaves. In Zagazig district at the experimental farm of the Faculty of Agriculture, stevia was cultivated since about 10 years and more than 10 years in Egypt. It is worthy to mention that the sweetness of stevia has no calories which is very suitable for diabetics. Stevia is an perennial herbs grown in Egypt in summer season and gave 3-4 cuts per year. Growth and yield of stevia crop are affected by agronomic practices, like planting distance, phosphorus and nitrogen fertilization as well as foliar nutrient application.

The highest amounts of stevioside were found in the upper young growing branches, whereas the lowest were found in the senescent branches (Bondarev et al., 2003). Growth and yield of stevia significantly increased when fertilized with NPK fertilizers (Chalapathi et al., 1999).

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Macronutrients, N, P and K as well as micronutrients Ca, Mg and sulfur S are important for growth of the plant tissue (Wiedenhoeft, 2006).

Kumar et al. (2013) stated that applying nitrogen with different forms help and encourage the rooting of stevia propagation in the Ms media and encourage the growth of twelve weeks old shoots. Planting stevia on ridges 70 cm width on the two sides of ridges with hill apacing, 15 cm under nitrogen fertilizer level 30kg N/ha., gave the maximum values of leaves fresh weight, leaves dry weight, fresh weight/ plant/ cut as well as stevioside percentage. On the other hand, planting stevia 50cm and 20cm between ridges and hills gave the highest number of branches/plant.

Growth and yield attributes of stevia plants significantly increased with the advancement of growth period, 60 DAP (Zaman et al., 2017). The recommended rate of NPK as 60, 30 and 50 kg/faddan, respectively added to stevia plants caused significantly increments in plant height, branches and leave number/ plant, leaves fresh yields/faddan., as well as total fresh and dry yield/ faddan. (Mostafa, 2019; Mohammed et al., 2019; Tadesse, 2019). Adding nitrogen had significant effects on plants height, number of branches, leaf area index (Gatie et al., 2021). Adding nitrogen fertilization and biofertilizers had significant effects on growth and yield and yield of stevia (Caballero et al., 2021; Youssef et al., 2021). The aim of this study was to investigate the influence of planting distance, phosphorus fertilization as well as nitrogen fertilization and nutrient foliar application on growth and yield of stevia under the conditions of Faquos district, Sharquia Governorate.

MATERIALS AND METHODS

Two field experiments were carried out in administration field at Faquos district, Sharqua Governorate, Faculty of Agriculture, Zagazig University during the summer seasons of 2018 and 2019. This work was conducted to study the effect of planting distance, phosphorus and nitrogen fertilization with foliar application on growth and yield of stevia (Stevia rebaudiana, Bertoni) crop variety Strecia every. Experiment included 16 treatments which were the combinations of two planting distance, two levels of phosphorus and four nitrogen fertilization treatments (two levels of nitrogen with and without foliar nutrient application) in three replications. Planting distances (25 and 50cm) were allocated in main plots and phosphorus levels (without and with 15.5 P2O5) were arranged in sub- plots, while the following four nitrogen treatments were distributed in the sub-sub plots:

1- 15 k g N/ faddan.
2- 15 k g N/ faddan + foliar nutrientation.
3- 30 k g N/ faddan.
4- 30 k g N/ faddan + foliar nutrientation.

The foliar nutrient (Biogreen) applied contains macro and micro nutrients. Each mg/kg contains the following major elements: Nitrogen (N) 18, phosphorous (P2O5) 18, potassium (K2O) 18, magnesium (Mgo) 1.5 and sulfur (S) 2.7 It also contains the following trace elements: Iron (Fe) 250, manganese (Mn) 170, zinc (ZN) 125, copper (Cu) 50 and boron (B) 35. The distance between ridges were 50 cm. The experimental soil was silty sand in texture. Physical and chemical soil properties are coarse sand 24.3%, silt 34.5% and clay 14.8% as well as organic matter 1.46%, total CaCo3 0.20%, PH 7.39%, N 0.07%, P 0.005% and K 0.008% ppm. Seedling of stevia plants in age of 45 day were transplanted at the first of April using one plant/ hill while in the second season were ratoons, plants.

Stevia plants yielded three cuts in the first season (2018), but gave two cuts only in the second one (2019). At each cut the following assessments were recorded:

1- Plant height (cm).
2- Branches No/plant.
3- leaves No/plant.
4- Plant fresh weight (g)
5- Leaves fresh weight/ plant.
6- Total fresh yield (kg/fadd.)
7- Leaves fresh yield (kg/fadd.)
8- Leaves dry yield (kg/fadd.)
Recorded data of stevia growth and yield were statistically analysis as split-split plot design in three replications, according to Gomez and Gomez (1984) and Analytical Software (2008). Duncan’s multiple range test was used to verify the significant differences between of treatments.

RESULTS AND DISCUSSION

Growth and yield of stevia are affected by some important agronomic managements such as planting distances, phosphorus and nitrogen fertilization as well as nutrient foliar application. Obtained results on growth traits and productivity of stevia in both seasons will presented and discussed under the three main headings as follows:

1- Effect of planting distances.
2- Effect of phosphorus fertilization.
3- Effect of nitrogen fertilization and foliar nutrition.

Effect of Planting Distance

The effect of planting distance on growth parameters and each of fresh and dry yields of stevia are presented in Tables 1, 2, 3, 4, 5, 6, 7, 8 and 9.

Planting stevia on 25cm distances had no significant increments on plant height and number of branches/plant, at all cuts in the two season compared with 50 cm planting. Also, number of branches/plant at all cuts showed insignificant increments when Stevia was planted on 50 cm distance in the two seasons compared with 25cm distance. Number of leaves/plant of 50cm distance was significantly higher at the second and third cut in the first season only, while did not reach the level of significance at the first season and at the two cuts in second season. On the other hand plant fresh weight at all cuts in the two seasons were significantly increased by 50 cm distance compared with 25 cm.

Leaves fresh and dry weights/plant was significantly increased by planting stevia on 50cm distance compared with 25cm distance at the second and third cuts in the first season and at the two cuts in the second season. These results were true in the two seasons and all cuts of stevia. The increments in number of leaves/plant fresh and dry weights/plant in stevia plants may be expected due to wide planting soil area which occupied by stevia plants grown at 50 cm distance, compared to its planted in narrow distances.

Leaves fresh yield/fad., (Table 8) was significantly higher by planting stevia at 25 cm distance compared with 50 cm distance at all cuts in the two seasons. The higher value of leaves fresh at 25cm distance was due to the higher plant number per unit area, which about twice it planted at 50 cm distance. Similar results were obtained by Shivani et al. (2019).

Phosphorus Fertilization

Concerning the effect of phosphorus fertilization on growth and yield traits of stevia (Tables1-9), the results revealed that plant height and number of branches/plant increased by adding 100 kg ordinary superphosphate, but these increments did not reach the level of significance. In all cuts and in the two seasons the increments in plant height were 4.6%, 4.1%, 10.3%, 4.6% and 4.6%in all cuts in the two seasons, respectively. Number of leaves/plant at the second and third cut of the first season as well as plant fresh weight were significantly increased due to adding 100 kg ordinary superphosphate in both growing seasons (Tables 3 and 4). Plant fresh weight was increased due to adding phosphorus fertilization by 16.8%, 33.2%, 57.9%, 54.5% and 54.4% in the two seasons and at all cuts, respectively, compared with check one.

Leaves fresh and dry weights/plant were significantly increased due to phosphorus fertilization in the first season, and second season but, did not reach the level of significance in the first cut at the first season (Table 5 and 6).

Adding 100 kg superphosphate caused significant increments in total fresh yield/faddan, leaves fresh yield/faddan and leaves dry yield/faddan in the two seasons as well as all cuts except leaves dry yield at the first cut in the first season (Tables 7, 8 and 9). The important organ of stevia plant is the leaves which contains namely the various steviosides types which consider
Table 1. Effect of planting distances, phosphorus and nitrogen + nutrient foliar fertilization on stevia plant height (cm) during summer seasons of 2018 and 2019

| Main effects and interactions | 1st season (2018) | 2nd season (2019) |
|-------------------------------|------------------|-------------------|
|                              | 1st Cut | 2nd Cut | 3rd cut | 1st Cut | 2nd Cut |          |
| Planting distance cm          |         |         |         |         |         |          |
| D 25 cm                       | 46.51   | 51.51   | 52.27   | 52.55   | 54.15   |          |
| D 50 cm                       | 46.35   | 51.35   | 49.96   | 52.37   | 53.95   |          |
| F- test                       | N S     | N S     | N S     | N S     | N S     |          |
| LSD 5%                        |         |         |         |         |         |          |
| Phosphorus fertilization (kg/fad.) |       |         |         |         |         |          |
| P 0 (without)                 | 45.39   | 50.39   | 48.39   | 51.28   | 52.83   |          |
| P 100 (kg/fad.)               | 47.47   | 52.47   | 53.38   | 53.64   | 55.27   |          |
| F- test                       | N S     | N S     | N S     | N S     | N S     |          |
| LSD 5%                        |         |         |         |         |         |          |
| Nitrogen fert. + foliar (kg N/fad.) |     |         |         |         |         |          |
| 15                            | 46.02   | 51.02   | 50.43   | 52.01   | 53.55   |          |
| 15 + foliar                   | 45.04   | 50.02   | 48.20   | 50.88   | 52.40   |          |
| 30                            | 47.40   | 52.40   | 50.35   | 53.57   | 55.20   |          |
| 30 + foliar                   | 47.25   | 52.25   | 55.50   | 53.38   | 55.02   |          |
| F- test                       | N S     | N S     | N S     | N S     | N S     |          |
| LSD 5%                        |         |         |         |         |         |          |
| Interactions effects          |         |         |         |         |         |          |
| D * P                         | N S     | N S     | N S     | N S     | N S     |          |
| D * N                         | N S     | N S     | N S     | N S     | N S     |          |
| P * N                         | N S     | N S     | N S     | N S     | N S     |          |
| D * P * N                     | N S     | N S     | N S     | N S     | N S     |          |

Where: NS and * refers to not significant and significant at 5% level, respectively.

Table 2. Effect of planting distance, phosphorus and nitrogen + nutrient foliar fertilization on No. of branches/ stevia plant during summer seasons of 2018 and 2019.

| Main effects and interaction | 1st season (2018) | 2nd season (2019) |
|------------------------------|------------------|-------------------|
|                              | 1st Cut | 2nd Cut | 3rd cut | 1st Cut | 2nd Cut |          |
| Planting distance cm         |         |         |         |         |         |          |
| D 25 cm                      | 18.95   | 20.95   | 21.90   | 21.41   | 22.05   |          |
| D 50 cm                      | 20.80   | 22.80   | 22.20   | 23.52   | 24.22   |          |
| F- test                      | N S     | N S     | N S     | N S     | N S     |          |
| LSD 5%                       |         |         |         |         |         |          |
| Phosphorus fertilization (kg/fad.) |       |         |         |         |         |          |
| P 0 (without)                | 18.68   | 20.68   | 19.60   | 21.12   | 21.75   |          |
| P 100 (kg/fad)               | 21.07   | 23.07   | 24.40   | 23.81   | 24.52   |          |
| F- test                      | N S     | N S     | N S     | N S     | N S     |          |
| LSD 5%                       |         |         |         |         |         |          |
| Nitrogen fert. + foliar (kg N/fad.) |     |         |         |         |         |          |
| 15                           | 15.70b  | 17.70b  | 18.20b  | 17.75b  | 18.29b  |          |
| 15 + foliar                  | 18.45ab | 20.45ab | 18.52b  | 20.85ab | 21.48ab |          |
| 30                           | 22.70a  | 24.70a  | 23.08ab | 25.65a  | 26.40a  |          |
| 30 + foliar                  | 22.66a  | 24.66a  | 27.70a  | 25.61a  | 26.37a  |          |
| F- test                      | *       | *       | *       | *       | *       |          |
| LSD 5%                       | 5.46    | 5.46    | 8.07    | 6.16    | 6.25    |          |
| Interactions effects         |         |         |         |         |         |          |
| D * P                        | N S     | N S     | N S     | N S     | N S     |          |
| D * N                        | N S     | N S     | N S     | N S     | N S     |          |
| P * N                        | N S     | N S     | N S     | N S     | N S     |          |
| D * P * N                    | N S     | N S     | N S     | N S     | N S     |          |

Where: NS and * refers to not significant and significant at 5% level, respectively.
### Table 3. Effect of planting distance, phosphorus and nitrogen + nutrient foliar fertilization on No. of leaves/stevia plant during summer seasons of 2018 and 2019

| Planting distance and interaction | 1st season (2018) | 2nd season (2019) |
|-----------------------------------|------------------|------------------|
|                                   | 1st Cut          | 2nd Cut          | 3rd cut | 1st Cut          | 2nd Cut          |
| D 25 cm                           | 390.5            | 270.3b           | 264.6b  | 441.3            | 454.4            |
| D 50 cm                           | 395.7            | 399.3a           | 386.8a  | 447.1            | 460.6            |
| F- test                           | N S              | *                | *       | N S              | N S              |
| LSD 5%                            | 54.38            | 102.64           |         |                  |                  |
| Phosphorus fertilization (kg/fad) |                  |                  |         |                  |                  |
| P 0 (without)                     | 372.6            | 275.9b           | 246.5b  | 421.0b           | 433.6b           |
| P 100 (kg/fad)                    | 413.6            | 393.8a           | 404.9a  | 467.4a           | 481.4a           |
| F- test                           | N S              | *                | *       | N S              | N S              |
| LSD 5%                            | 75.91            | 151.27           |         |                  |                  |
| Nitrogen fert. + foliar (kg N/fad)|                  |                  |         |                  |                  |
| 15 T                              | 296.0d           | 277.3c           | 289.9b  | 334.5d           | 344.6d           |
| 15 + foliar                       | 363.3c           | 330.3bc          | 275.7b  | 410.5c           | 422.8c           |
| 30                                 | 425.8b           | 339.8ab          | 309.1b  | 484.2b           | 495.6b           |
| 30 + foliar                       | 487.3a           | 392.1a           | 42802a  | 550.7a           | 567.2a           |
| F- test                           | *                | *                | *       | *                |                  |
| LSD 5%                            | 46.51            | 61.59            | 97.30   | 52.58            | 54.12            |

Where: NS * and refers to not significant and significant at 5% level, respectively.

### Table 4. Effect of planting distance, phosphorus and nitrogen + nutrient foliar fertilization on stevia plant fresh weight (g) during summer seasons of 2018 and 2019

| Planting distance and interaction | 1st season (2018) | 2nd season (2019) |
|-----------------------------------|------------------|------------------|
|                                   | 1st Cut          | 2nd Cut          | 3rd Cut | 1st Cut          | 2nd Cut          |
| D 25 cm                           | 111.90b          | 120.69b          | 116.29b | 136.39b          | 140.48b          |
| D 50 cm                           | 145.85a          | 161.95a          | 154.61a | 184.67a          | 195.21a          |
| F- test                           | *                | *                | *       | *                |                  |
| LSD 5%                            | 26.02            | 26.70            | 26.02   | 29.39            | 30.29            |
| Phosphorus fertilization (kg/fad) |                  |                  |         |                  |                  |
| P 0 (without)                     | 98.45b           | 111.63b          | 105.03b | 126.15b          | 129.94b          |
| P 100 (kg/fad)                    | 159.30a          | 171.01a          | 165.87a | 194.91a          | 200.75a          |
| F- test                           | *                | *                | *       | *                |                  |
| LSD 5%                            | 45.9             | 50.14            | 48.01   | 54.33            | 55.93            |
| Nitrogen fert. + foliar (kg N/fad)|                  |                  |         |                  |                  |
| 15 T                              | 107.01b          | 120.19b          | 113.59b | 135.83b          | 139.90b          |
| 15 + foliar                       | 130.15ab         | 143.34ab         | 136.73ab| 161.99ab         | 166.84ab         |
| 30                                 | 131.89ab         | 145.04ab         | 139.44ab| 163.90ab         | 165.82ab         |
| 30 + foliar                       | 146.45a          | 156.71a          | 153.05a | 180.40a          | 185.52a          |
| F- test                           | *                | *                | *       | *                |                  |
| LSD 5%                            | 29.96            | 30.92            | 29.79   | 32.14            | 33.26            |

Where: NS and * refers to not significant and significant at 5% level, respectively.
Table 5. Effect of planting distance, phosphorus and nitrogen + nutrient foliar fertilization on leaves fresh weight (g)/stevia plant during summer seasons of 2018 and 2019

| Main effects and interaction | 1st season (2018) | 2nd season (2019) |
|-----------------------------|------------------|------------------|
| Planting distance cm        | 1st Cut          | 2nd Cut          | 3rd Cut          | 1st Cut          | 2nd Cut          |
| D 25 cm                     | 60.55            | 50.44b           | 45.43b           | 54.28b           | 55.92b           |
| D 50 cm                     | 64.29            | 70.96a           | 68.35a           | 80.14a           | 82.59a           |
| F- test                     | N S              | *                | *                | *                | *                |
| LSD 5%                      | 10.54            | 9.68             | 10.91            | 11.20            |
| Phosphorus fertilization (kg/fad) |                |                  |                  |                  |
| P 0 (without)               | 59.85            | 49.04b           | 46.42b           | 55.41b           | 57.10b           |
| P 100 (kg/fad)              | 64.99            | 72.87a           | 67.35a           | 79.06a           | 81.42a           |
| F- test                     | N S              | *                | *                | *                | *                |
| LSD 5%                      | 7.00             | 13.45            | 15.24            | 15.81            |
| Nitrogen fert. + foliar (kg/fad) |                |                  |                  |                  |
| 15                          | 50.27            | 49.58c           | 46.63c           | 55.66b           | 57.33c           |
| 15 + foliar                 | 52.59b           | 58.70bc          | 56.08bc          | 66.35ab          | 68.32bc          |
| 30                          | 68.56a           | 60.38b           | 57.75ab          | 68.20a           | 70.31ab          |
| 30 + foliar                 | 73.65a           | 75.45a           | 67.09a           | 75.72a           | 81.06a           |
| F- test                     | *                | *                | *                | *                | *                |
| LSD 5%                      | 8.12             | 9.16             | 8.54             | 12.38            | 13.99            |
| Interactions effects        |                  |                  |                  |                  |
| D * P                        | N S              | *                | N S              | N S              | N S              |
| D * N                        | N S              | N S              | N S              | *                | *                |
| P * N                        | N S              | N S              | *                | *                | N S              |
| D * P * N                    |                  |                  |                  |                  |

Where: NS and * refers to not significant and significant at 5% level, respectively.

Table 6. Effect of planting distances, phosphorus and nitrogen + nutrient foliar fertilization on stevia leaves dry weight (g)/plant during summer seasons of 2018 and 2019

| Main effects and interaction | 1st season (2018) | 2nd season (2019) |
|-----------------------------|------------------|------------------|
| Planting distance cm        | 1st Cut          | 2nd Cut          | 3rd Cut          | 1st Cut          | 2nd Cut          |
| D 25 cm                     | 18.05            | 14.30b           | 14.85b           | 16.18b           | 16.67b           |
| D 50 cm                     | 18.57            | 21.20a           | 21.72a           | 23.91a           | 24.62a           |
| F- test                     | N S              | *                | *                | *                | *                |
| LSD 5%                      | 2.87             | 5.76             | 3.25             | 3.35             |
| Phosphorus fertilization (kg/fad) |                |                  |                  |                  |
| P 0 (without)               | 17.85            | 14.60b           | 13.84b           | 16.52b           | 17.02b           |
| P 100 (kg/fad)              | 18.78            | 20.80a           | 22.73a           | 23.57a           | 24.27a           |
| F- test                     | N S              | *                | *                | *                | *                |
| LSD 5%                      | 4.03             | 8.51             | 4.53             | 4.71             |
| Nitrogen fert. + foliar (kg/fad) |                |                  |                  |                  |
| 15                          | 15.16            | 14.70c           | 16.27b           | 16.60b           | 17.10c           |
| 15 + foliar                 | 15.69b           | 17.50bc          | 15.48b           | 19.79b           | 20.37bc          |
| 30                          | 20.45a           | 18.00ab          | 17.35b           | 20.33a           | 20.96ab          |
| 30 + foliar                 | 21.96a           | 20.70a           | 24.04a           | 23.47a           | 24.17a           |
| F- test                     | *                | *                | *                | *                | *                |
| LSD 5%                      | 2.42             | 3.26             | 5.16             | 3.69             | 3.79             |
| Interactions effects        |                  |                  |                  |                  |
| D * P                        | N S              | N S              | N S              | N S              | N S              |
| D * N                        | N S              | *                | *                | *                | *                |
| P * N                        | N S              | N S              | N S              | N S              | N S              |
| D * P * N                    | N S              | N S              | N S              | N S              | N S              |

Where: NS and * refers to not significant and significant at 5% level, respectively.
Table 7. Effect of planting distances, phosphorus and nitrogen + nutrient foliar fertilization on stevia total fresh yield (kg/fad.) during summer seasons of 2018 and 2019

| Planting distance cm | 1<sup>st</sup> Cut | 2<sup>nd</sup> Cut | 3<sup>rd</sup> Cut | 1<sup>st</sup> Cut | 2<sup>nd</sup> Cut |
|----------------------|-------------------|-----------------|-----------------|----------------|----------------|
| D 25 cm              | 3486.00a          | 3868.40a        | 3895.30a        | 4376.80a       | 4465.70a       |
| D 50 cm              | 2843.50b          | 2782.50b        | 2886.70b        | 3144.30b       | 3238.60b       |
| F- test              | *                 | *               | *               | *              | *              |
| LSD 5%               | 634.50            | 575.51          | 885.54          | 716.01         | 738.86         |
| Phosphorus fertilization (kg/fad) |                   |                 |                 |                 |                 |
| P 0 (without)        | 2428.60b          | 2839.90b        | 2690.00b        | 3204.10b       | 3305.40b       |
| P 100 (kg/fad)       | 2544.80a          | 3811.00a        | 4092.00a        | 4212.00a       | 4338.90a       |
| F- test              | *                 | *               | *               | *              | *              |
| LSD 5%               | 388.20            | 573.68          | 1393.49         | 441.67         | 451.28         |
| Nitrogen fert. + foliar (kg N/fad) |                   |                 |                 |                 |                 |
| 15                   | 2401.00c          | 4035.50a        | 2690.00b        | 3204.10b       | 3305.40b       |
| 15 + foliar          | 2544.80a          | 3811.00a        | 4092.00a        | 4212.00a       | 4338.90a       |
| 30                   | 3736.40a          | 4035.50a        | 4671.60a        | 4560.10a       | 4696.90a       |
| F- test              | *                 | *               | *               | *              | *              |
| LSD 5%               | 605.81            | 619.21          | 1104.29         | 684.78         | 704.85         |

Interactions effects

| D * P                | *                 | *               | *               | *              | *              |
| D * N                | N S               | N S             | N S             | N S            | N S            |
| P * N                | N S               | N S             | N S             | N S            | N S            |
| D * P * N            | *                 | N S             | N S             | *              | *              |

Where: NS and * refers to not significant and significant at 5% level, respectively.

Table 8. Effect of planting distances, phosphorus and nitrogen + nutrient foliar fertilization on stevia leaves fresh yield (kg/fad) during summer seasons of 2018 and 2019

| Planting distance cm | 1<sup>st</sup> Cut | 2<sup>nd</sup> Cut | 3<sup>rd</sup> Cut | 1<sup>st</sup> Cut | 2<sup>nd</sup> Cut |
|----------------------|-------------------|-----------------|-----------------|----------------|----------------|
| D 25 cm              | 1965.90a          | 2423.40a        | 2142.40a        | 2352.30a       | 2422.40a       |
| D 50 cm              | 1378.40b          | 1530.40b        | 1587.60b        | 1729.30b       | 1781.20b       |
| F- test              | *                 | *               | *               | *              | *              |
| LSD 5%               | 225.90            | 343.46          | 486.94          | 394.32         | 405.99         |
| Phosphorus fertilization (kg/fad) |                   |                 |                 |                 |                 |
| P 0 (without)        | 1490.60b          | 1561.90b        | 1479.50b        | 1765.00b       | 1817.90b       |
| P 100 (kg/fad)       | 1853.70a          | 2391.90a        | 2250.60a        | 2316.70a       | 2385.70a       |
| F- test              | *                 | *               | *               | *              | *              |
| LSD 5%               | 213.80            | 223.75          | 766.93          | 241.45         | 249.23         |
| Nitrogen fert. + foliar (kg N/fad) |                   |                 |                 |                 |                 |
| 15                   | 1428.00b          | 1443.20c        | 1645.90b        | 1677.70c       | 1726.90c       |
| 15 + foliar          | 1521.40ab         | 2321.60a        | 1381.10b        | 1804.30bc      | 1858.50bc      |
| 30                   | 1715.60ab         | 1923.20b        | 1854.80b        | 2173.30ab      | 2238.50ab      |
| 30 + foliar          | 2023.00a          | 2219.50ab       | 2569.40a        | 2508.10a       | 2583.30a       |
| F- test              | *                 | *               | *               | *              | *              |
| LSD 5%               | 501.86            | 524.04          | 607.29          | 376.59         | 387.68         |

Interactions effects

| D * P                | *                 | *               | *               | *              | *              |
| D * N                | N S               | N S             | N S             | N S            | N S            |
| P * N                | N S               | N S             | N S             | N S            | N S            |
| D * P * N            | N S               | N S             | N S             | *              | *              |

Where: NS and * refers to not significant and significant at 5% level, respectively.
Table 9. Effect of planting distance, phosphorus and nitrogen+ nutrient foliar fertilization on stevia leaves dry yield (kg/faddan) during summer seasons of 2018 and 2019

| Main effects and interaction | 1<sup>st</sup> season (2018) | 2<sup>nd</sup> season (2019) |
|-----------------------------|-----------------------------|-----------------------------|
| Planting distance cm        | 1<sup>st</sup> Cut | 2<sup>nd</sup> Cut | 3<sup>rd</sup> cut | 1<sup>st</sup> Cut | 2<sup>nd</sup> Cut |
| D 25 cm                     | 645.62a | 749.40a | 771.20a | 846.40a | 872.10a |
| D 50 cm                     | 428.10b | 550.90b | 571.50b | 622.50b | 641.20b |
| F- test                     | *       | *       | *       | *       | *       |
| LSD 5%                      | 121.10  | 125.65  | 175.19  | 142.19  | 146.37  |
| Phosphorus fertilization (kg/faddan) |             |             |             |             |             |
| P 0 (without)               | 508.30  | 562.30b | 532.60b | 635.40b | 654.40b |
| P 100 (kg/faddan)           | 565.42  | 738.10a | 810.20a | 834.10a | 858.90a |
| F- test                     | *       | N S     | *       | *       | *       |
| LSD 5%                      | 76.81   | 275.77  | 86.32   | 89.14   | N S     |
| Nitrogen fert. + foliar (kg N/faddan) |             |             |             |             |             |
| 15                          | 429.64c | 574.90bc | 595.60b | 604.00c | 621.90c |
| 15 + foliar                 | 510.60bc| 799.00a | 497.30b | 649.60bc| 669.00bc|
| 30                          | 563.08ab| 534.40c | 667.70b | 782.30ab| 805.80ab|
| 30 + foliar                 | 644.14a | 692.30ab| 924.90a | 902.90a | 929.90a |
| F- test                     | *       | *       | *       | *       | *       |
| LSD 5%                      | 119.60  | 119.99  | 218.61  | 135.69  | 139.52  |

Interactions effects

| D * P | N S | * | * | * | * |
| D * N | N S | * | * | * | * |
| P * N | N S | N S | N S | N S | N S |
| D * P * N | N S | N S | N S | N S | * |

Where: NS and * refers to not significant and significant at 5% level, respectively.

The results showed non significant effects for nitrogen fertilization with or without nutrient foliar application on plant height at the different cuts in both seasons. On the other hand, there were positive significant effects for increasing nitrogen fertilization up to 30kg N/faddan as well as nutrient foliar application on number of branches/plant, number of leaves/plant, plant fresh weight, leaves fresh and dry weights/plant (Tables 2-6).

Stevia total fresh yield/faddan, leaves fresh and dry yields/faddan were significantly increased due to increasing nitrogen fertilization up to 30kg N/faddan, and with adding foliar nutrient fertilization compared with adding 30kg N/faddan. On the other hand, foliar application of nutrient fertilization had significant increments in values of total fresh yield/faddan, leaves fresh yield/faddan and leaves dry yield/faddan (Tables 7-9).

Adding 30 kg N/faddan increased leaves fresh yield at the three cuts by 41.6%, 53.8% and 56.2% in the first season and by 49.5 % and 44.6 % at the two cuts in the second season, respectively. Vegetative growth parameters as well as total leaves yield/faddan of stevia plants as nature sweetness compounds. Phosphorus fertilization increased leaves fresh yield / faddan by 14.3%, 53.1%, 52.1%, 31.3% and 31.2% in the three cuts of the 1<sup>st</sup> season and the two cuts in the 2<sup>nd</sup> season, respectively. Phosphorus fertilization had exerted a profound significant improving impact on values of stevia fresh and dry weights of leaves/plant and per faddan.

Stimulating effect of P on cell division and biosynthesis of organic compounds especially carbohydrates could gives a logical explanation for the improving impact of P on stevia yield and yield components traits.

These results are in agreement with those obtained by Mohammed, Mona (2019), Mostafa (2019) and Tadesse (2019).

**Nitrogen Fertilization and Foliar Nutriention**

The effect of nitrogen fertilization as well as nutrient foliar application on each of plant height, number of branches/plant, number of leaves plant, leaves fresh weight/plant, leaves dry weight/plant, total fresh yield/faddan, leaves fresh yield/faddan and leaves dry yield/faddan are presented in Tables (1-9).
were increased as nitrogen fertilizer increased from 15 up to 30 kg N/fadd. Such finding might be attributed to the effective role of N as an essential constituent of protein, amino acids, co-enzymes, and certain hormones as well as chlorophyll. Also, its role in the synthesis of sucrose and reactions involving the utilization of sucrose as energy source for plant growth.

Foliar nutrient application increased leaves fresh yield/faddan when added with 15 and 30 kg N/faddan by 6.5% and 17.9% in the first cut and by 60.4% and 15.49% in the second cut as well as by 19.1% and 38.5% in the third cut of the first season.

This finding is expected, since foliar nutrient contains macro and micro elements whom activates most of enzymatic reactions of metabolic processes. And, presented in the formula structure of photosynthetic pigments in plant.

Similar results concerning growth characters and yield of stevia as affected by nitrogen and nutrient foliar application were found by Zaman et al. (2017), Mohamed, Mona et al (2019), Mostafa, (2019), Caballero, et al. (2021) and Gatie et al. (2021).

REFERENCE

Analytical Software (2008). Statistics version 9, Analytical software, Tallahassee, florida, USA.

Bondarev, N.I., M.A. Sukhanova, O.V. Reshetnyak and A.M. Nosov (2003). Stevia glycoside content in different organs of Stevia rebaudiana and its dynamics during ontogeny. Biologia Plantarum, 47: 261-264.

Caballero, E.C., J.H. Burgos, A. Jarma-oroçco, J.J. Navas and L.R. Paez (2021). Macroelements and Microelements in the soil and their relationship with the content of steviol glucosides in Stevia rebaudiana, Bert from five regions of Colombia. Horticulture, 7 (547): 1-15.

Chalapathi, M.V., S. Thimmegowda, G.G.E. Rao, N. Devakumar and J. Chandraprakash (1999). Influence of fertilizer levels on growth, yield and nutrient uptake of raton crop of stevia (Stevia rebaudiana). J. Med. and Aromatic Plant Sci., 21 (4): 947- 949.

Gatie, K.D., A.A. Ali and K.H. Mohsen (2021). Stevia (Stevia rebaudiana, Bertoni) responds to different levels of nitrogen and potassium fertilizers in loamy sand soil. Al- Muthanna J. Agric. Sci. 8 (2): 1-12.

Gomez, K.A. and A.A. Gomez (1984). Statistical Procedures for Agricultural Research John Wiley and Sons Inc., Singapore, 680.

Kumar, V.R. (2002). Medicinal and Aromatic Plants. Green Media International. Bangalore, 90-91.

Kumar, S., R. Sharma and R. Prasad (2013). Yield, nutrient uptake, and quality of stevia as affected by organic sources of nutrient. Commun, Soil Sci., plant Anal, 44 (21): 3137-3149.

Mohammed, Mona, H.M., A.A.A. Meawad, E.E.A. M. El-Mogy and M.A. Abdelkader (2019). Growth, yield components and chemical constituents of (Stevia rebaudiana Bert), as affected by humic acid NPK fertilization rates, Zagazig J. Argic. Res., 46 (1): 13-26.

Mostafa, H. Sh. (2019). Impact of NPK fertilization and Lithovit rates on growth, yield components and chemical censitutents of (Stevia rebouianca Bert). Plant. Mid. East J. Appl. Sci., 9 (2): 412-420.

Tadesse, N. (2019). The response of stevia (Stevia rebaudiana Bert.) to nitrogen and phosphorous fertilizer rates at Menagesha, West Ethiopia. Int. J. Res. Studies in Agric. Sci. 5 (10): 34-39.

Wiedenhoft, A.C. (2006): Plant nutrition. Hopkins WG (eds) The Green World, Chelsea House Publisher, New York, 16-43.

Youssef, M.A., A.F. Yousef, M.M. Ali, A.I. Ahmed, S.F. Lam lol, W.R. Strobel and H.M. Kalaji (2021). Exogenously applied nitrogenous fertilizers and effective microorganisms improve plant growth of stevia (Stevia rebaudiana Bertoni) and soil fertility. AMB Express 11-133.

Zaman, M.M., T. Chowdhury, K. Nahar and A.H. Chowdhury (2017): Effect of cow dung as organic manure on the growth, leaf biomass yield of (Stevia rebau ddiana Bert.) and post harvest soil fertility. J. Bangladesh Agric. Univ. 15 (2): 206-211.
تأثير مسافات الزراعة والتمثيل الفوسفاتي والنيتروجيني على نمو ومحصول استيفيا

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أجريت تجربة نقل حقلية في مزرعة استشادية في فقاوس محافظة الشرقية في الموسم الصيفي للعام 2018، وذلك لدراسة تأثير مسافات الزراعة، التمثيل الفوسفاتي، والنيتروجيني مع إضافة التسميد الورقي على نمو محصول استيفيا صنف الرمل. تم زراعة في أول أبريل في كل المجموعات، حيث تم نسج أشجار مختلفة بمسافات 25 سم، 50 سم داخل الخرائط و100 سم بين الخرائط في القطع الرئيسية، والتمثيل الفوسفاتي في صورة سوبر فوسفات أحادي الكالسيوم في كميات مختلفة دون 15 كجم ب/ أ/ فدان، 15 كجم ب/ أ/ فدان. 

بينما أضيف التسميد الورقي في صورة نترات أموميوم في 4 معاملات 15 كجم/ فدان بدون تسميد ورقي، 15 كجم/ فدان مع التسميد الورقي بعمل 1 كجم/ فدان، وكذلك 30 كجم نترات الورقي دون التسميد الورقي، ومع إضافة التسميد الورقي كأحمضي في المحمول الفسفور، وفوسفات الورقي وفوسفات الورقي وفوسفات الورقي. 

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