Studying the Effect of Different Fertilizers Types and Methods of Application on Nodulation, Growth and Yield of Some Chickpea Varieties Under Rainfed Conditions

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Abstract. This experiment was conducted in Sharya-Duhok area, Iraqi Kurdistan region under rainfed conditions during the season of 2018-2019 to study the nodulation status, growth and yield performance of two local varieties of chickpea (Shamy and Marakshy) in relation to three different fertilizers types and methods of application i.e. bio fertilizer (Corabac G) and seed priming in super phosphate 2% and Diammonium phosphate (DAP) in addition to control treatment. The experiment was designed by Randomized complete block design with four replications. The results clearly showed significant reduction in both number and dry weight of nodules per plant in fertilizer treatment as compared to untreated (control treatment), except seed priming in super phosphate 2% as it significantly enhanced the nodule dry weight displaying non responding of chickpea to soil fertilization in regards of nodules development. However the final seedyield was not significant in the study, but its highly correlated to the above ground biomass (r =0.74**) and number of seeds per plant (r = 0.33*); Shamy variety of chickpea was superior in number of branches, number of pods and seeds per plant, while the Marakshy variety was superior in the plant height, height of lowest pod, and weight of seeds. Regarding fertilizers treatments effects, both seed priming in super phosphate and DAP fertilizer treatments were significantly surpassed in number of branches, pods and seeds per plant. Shamy variety performed better in number of branches and seeds per plant with DAP fertilizer, while Marakshy produced the same traits better in seed priming treatment. Bio-fertilizer (Corabac G) was inferior in most of the studied traits of chickpea. Accordingly, the obtained results conclude that the nodulation in chickpea not respond to the soil application of fertilizers, while positively to seed treatment (priming). The results also suggest both method of fertilization (DAP and seed priming) for improving yield related components, but Corabac G bio fertilizer is not recommended under similar conditions.

1. Introduction

Chickpea (Cicer arietinum L.) is the third most cultivated legume in the world. India is considered the highest producer and consumer of this crop [1], it along with other seed pulsesare one of the main sources of food and feeding, they are rich in nutrients such as proteins, carbohydrates, starch, and fibers in which make them the main contributors in global food security to match the continuous increase of the world population at the time of global environment changing [2]. Furthermore, legume crops are able to fix natural atmospheric nitrogen (N₂) in association with symbiotic Rhizobium to a form in which the plant can utilize it [3] making them friendly associated to the environment. Chickpea crop is mostly sown on residual soil moisture with little rain opportunities, it’s grown worldwide in over 54 countries in 12.7 Mha with annual production of 12Mt [4].

Applying fertilizers on chickpea is not usually promoted among farmers and also many agronomists believe that this pulse cropdoesn’t require fertilization due to the short life period of this plant and their contribution on nitrogen fixation. But, Wolde-meskel et al.,[5] recorded 25% increase of chickpea yield in an experiment due to the phosphorus fertilizer application and also they stated that about 92% of the farmers from the study area observed 10% increase of their yield after their recommendation. Similarly Pegoraro et al.,[6] recorded significant increase of growth and yield of chickpea when phosphorus fertilizers are used. Bio-fertilizers are non-chemical substances consist of beneficial microorganisms enhance specific microbial growth in rhizospherewhenn incorporated in soil, and play vital role in nutrient mineralization, increase nutrient accumulation consequently increase crop yield without any deterioration of environment,they also reduce use of chemical fertilizer thus improve soil fertility and minimize production costs [7]. In this regard, Ahmed et al.,[8] also recorded significant improvement of chickpea growth and yield as well as improvement of root nodulation. On the other hand, Balai et al.,[9] reported that in chickpea production, balanced phosphorus fertilization is essential for establishing symbiosis with nitrogen fixing Rhizobacteria, stimulates roots and nodules and growth development as well as
enhancing the final seed yield. Method of fertilizer application is also critical in which show the rate of reaching this substances to the plant cells. Farooq & Siddique [10] demonstrated that fertilizer application through seed treatments such as seed priming improves the seedling emergence stand establishment, advances phenological events, and increases yield and seed nutrient contents, also these methods save farmers economy through using low doses compared to the traditional application in soil. In seed priming, seeds are partially hydrated to allow metabolic events to occur without actual germination, and then re-dried or directly sown which germinate faster leading to invigoration of seedlings; they reported 19% to 36% yield increase in chickpea when seed treated via seed priming with some micronutrients compared to non-treatments methods. Also, Monika et al., [11] recorded significant increase of chickpea yield by application of bio-fertilizers.

On the other hand, comfortability of chickpea varieties to the specific environment is of great important. Marjani & Rahimizadeh [12] illustrated significant differences among different chickpea genotypes at different growth stages and also, they reported positive correlation between number of seeds per plant and above ground biomass with final seed yield. Also, [1,13] reported significant difference among various chickpea varieties in Iraq and Syria respectively. Similarly, Alwawi & Wafaa [14] found significant differences among chickpea varieties including Marakshy in regards to yield and seed quality in Syria. Singh et al.,[15] concluded that pulses are the most important crops for nutritional security because of their high protein content; along with this, they also play an important role in soil health improvement by nutrient fixation and increment of microbial activity but due to low productivity farmers don’t prefer growing these crops. The productivity of chickpea is relatively low in Iraq and Kurdistan region as compared to the world standard measurements and this is probably because of the traditional cultural practices approached by the farmers as they don’t realize the contribution of fertilizers in enhancing chickpea yield and consequently characterized by low potential yield.

Therefore, a major objective of any agronomist program in this area is to evaluate new technology including fertilizers to improve their productivity. In this context, this study was considered to soil experiment the nodulation, growth and yield performance of some local chickpea varieties in relation to different fertilizers types and methods of application (bio fertilizer and seed priming in super phosphate and Diammonium phosphate) under rainfed conditions.

2. Materials and Methods
The research work of this experiment was carried out and funded within the JDA International Organization Projects in Sharya-Duhok area during the growing season of 2018/2019 to evaluate the nodulation status, growth and yield performance of two widely grown local varieties of chickpea (Shamy and Marakshy) in relation to three different fertilizers types and methods of application including; bio-fertilizer (Corabac G; Turkey granules = 20 kg ha⁻¹Corax-BionerZrt. ZeRubar Com. Bodabist, Hungary) and seed priming in super phosphate 2% and DAP (Diammonium phosphate: 18:46:0 in a recommended rate of 120 kg ha⁻¹) in addition to check or control treatment under rainfall conditions. The experiment was designed by Randomized complete block design with four replications. Meteorological data were collected from the station of the College of Agricultural Engineering Sciences; the nearest climate data station from the experiment site (Fig.1).
The field was plowed a week before sowing by disc plow which characterized by loamy soil with pH 7.6; NPK 130, 6.13 and 4.8 mg kg⁻¹ respectively and 1.21% organic matter. All soil properties analysis was conducted at the University of Duhok, College of Agricultural Engineering Sciences, Central Laboratory. Sowing date was at the end of March, 2019. The plot area was 6 m² (5 m long × 1.2 m); 0.2 m between lines (6 lines in each unit) with 5 m long; space between units = 0.5 m and between replications = 1m; 6 m² (1.2 x 5) ÷ 6 = 1 m² for each line. Seeds for each type were sow at the rate of 100 kg ha⁻¹ taking germination and seeds weight in consideration. For seed priming treatment, the specified amount of seed for each variety was soaked in a solution of 2% DAP (20 g +1 liter water) for ten hours before sowing. Weeds were controlled manually as required. Non effective pests were found to be controlled.

At the time of data measurements; five guarded plants from one of the middle rows were measured and then the average per one plant was calculated. For nodulation measurements, five plants from each unit were carefully pulled at the full flowering stage by hand shovel and laid on nylon surface under shelter, accurately cleaned and nodules were counted (continuous rainfall at this season was helpful for this measurement), then oven base used for nodules dry weight calculation. All possible growth and yield related traits (Plant height, height of lowest pod, number of branches, and biomass) were measured at the time. The yield was harvested at the beginning of June. The data was analyzed using GenStat version 10 program [16]. Duncan Multiple Range Test was used for the means compression at 5% level of propability.

3. Results and Discussions

3.1 Nodulation characters
Analysis of variation(ANOVA) for all of the studied traits are displayed in Table 1, and it’s clearly indicates significant influences of fertilizer treatments on nodule number and dry weight per plant, while the effect of chickpea varieties and their interactions with the fertilizer treatments was not significant. All of the fertilizer treatments significantly reduced the number of nodules compared to control unit. Also, nodules dry weight exhibited the same reduction when fertilizer treatment applied with the exception of seed priming in 2% of super phosphate solution which significantly enhanced the dry weight of nodules (66.3 mg,plant⁻¹) compared to Corabac G bio and DAP fertilizers (Table 2). The obtained results indicate positive contribution for the methods of fertilization with enhancing the growth and nodulation of chickpea. These results are in agreement with those of [10] as they stated that seed priming method of fertilization invigorates the seedlings and consequently improves the seedling emergence stand establishment.
Table 1. Analysis of variance (ANOVA) the studied traits in this study

| Source of variance | NNOD | NDRW | PH | HLP | NBRA | NPP | NSP | HSW | BIOM | GYH |
|--------------------|------|------|----|-----|------|-----|-----|-----|------|-----|
| VAR.               | 0.897| 0.253| 0.004| 0.401| 0.002| <.001| <.001| 0.791| 0.535 |
| FERT. TRAT.        | 0.017| 0.027| 0.210| 0.210| 0.045| 0.052| 0.002| 0.002| 0.411| 0.782|
| VAR.*TRAT.         | 0.043| 0.343| 0.277| 0.302| 0.034| 0.465| 0.025| 0.062| 0.219| 0.181|

* VAR.; varieties, FERT.; fertilizers, TREAT; Treatments, NNOD; number of nodules, NDRW; nodules dry weight, NBRA; number of primary branches, NPP; number of pods, NSP; number of seeds per plant, HSW, 100 seed weight, BIOM; Biomass, GYH; seed yield.

Table 2. Average values for nodulation characters of Chickpea types under different fertilizer treatments

| Fertilizer treatments | NNOD (No.) | NDRW (mg) |
|-----------------------|------------|-----------|
|                       | Shamy      | Marakshy  | Mean FERT. | Shamy  | Marakshy | Mean FERT. |
| Corabac G             | 12.00b     | 12.67b    | 12.33b      | 45.3b  | 44.7b     | 45.0c       |
| DAP                   | 14.67b     | 14.67b    | 14.67b      | 58.0b  | 58.0b     | 58.0bc      |
| Seed Priming          | 13.67b     | 17.33ab   | 15.50b      | 67.3b  | 65.3b     | 66.3ab      |
| Control               | 21.00a     | 17.67a    | 19.33a      | 111.3a | 69.3b     | 90.3a       |
| Mean of Chickpea      | 15.58a     | 15.33a    | Mean of Chickpea | 70.5a | 59.3a     |
| varieties             |            |           | varieties   |         |           |             |

* NNOD; number of nodules, NDRW; nodules dry weight, FERT.; fertilizers

3.2 Growth development

The effect of the studied factors on growth characters of chickpea varieties showed significant influences on plant height and height of lowest pod, while above ground biomass not affected significantly by the treatments involved in this study (Tables 1 and 3). Marakshy variety was superior in both plant height and height of lowest pod and recorded 29.85 cm and 19.67 cm, compared to 27.00 cm and 18.17 cm for Shamy variety respectively. Fertilizer treatments and their interactions with chickpea varieties were not significant in all these traits. Plant height is usually controlled genetically by the specific genes in each type of plants [13], but also growth conditions such as soil moisture (rainfall), atmospheric temperature and light competition can also affect remarkably on growth characters such as plant height and biomass.

Table 3. Average values for some agronomic characters of Chickpea types under different fertilizer treatments

| Fertilizer treatments | PH (cm)* | HLP(cm) | BIOM (kg.ha⁻¹) |
|-----------------------|----------|---------|----------------|
|                       | Shamy    | Marakshy| Mean FERT.    |
|                       |          |         | Shamy         | Marakshy | Mean FERT. |
| Corabac G             | 26.07a   | 31.40a  | 28.73a        | 19.93a   | 20.13a    | 20.03a      | 1057.7a | 881.6   | 969.7a |
3.3 Yield and its components

ANOVA table revealed significant influences of the experiment factors and their interactions on most of the yield contributed traits, while these significations haven’t reflected positively on the final seed yield (Table 1). Al-Shamy variety significantly produced higher number of primary branches per plant (2.9) compared to Marakshy. Also, Al-Shamy was superior in number of pods and seeds per plant, while Marakshy significantly was better in weight of 100 seeds as obtained 25.19 g compared to 22.11 g for Al-Shamy. As for the fertilizer treatments, both seed priming in super phosphate 2% and DAP fertilizer surpassed Corabac G and control units in number of primary branches per plant (3.1 primary branched for each), number of pods (12.8 and 11.1 pods), and number of seeds per plant (13.8 and 12.1 seeds) respectively. On the other hand, all the three fertilizer treatments were significantly inferior in weight of hundred seeds (HSW) as compared to the untreated or control unit. The interaction of chickpea varieties with the fertilizer treatments was only significant in number of primary branches and number of seeds per plant. Alshamy variety with DAP fertilizer was superior in these two traits (3.7 and 16.7) while Marakshy with seed priming treatment produced higher primary branches and number of seeds per plant (3.3 and 12.5 consequently). Neither the single effect of the studied factors nor their interaction was significant on the final seed yield (Table 4). The final seed yield was positively correlated with the above ground biomass and number of seeds per plant (Table 5). The results showed variation in the respond of chickpea varieties to the fertilizer treatments. It was clear that Al-Shamy performed better in the two main yield components (number of branches and seeds per plant) when DAP fertilizer applied while Marakshy produced the same traits better with seed priming treatment. On the other hand, Corabac G bio-fertilizer was inferior in all yield component traits as well as nodulation and thus further investigation are recommended to support these outputs. The obtained results are in agreement with those of [14, 12, 17, 12]; but dis-agree with the results of [11] in respect to bio-fertilizers.

Table 4. Average values for yield and its components characters of Chickpea types under different fertilizer treatments (mean of fertilizers and chickpea types)

| Fertilizer treatments | Yield and its components characters |
|-----------------------|-------------------------------------|
|                       | NBRA (No.) | NPP (No.) | NSP (No.) | HSW (g) | GYH (kg.ha⁻¹) |
| Corabac G             | 2.6b       | 10.0b     | 11.0bc    | 23.36b  | 969.7a        |
| DAP                   | 3.1a       | 11.1ab    | 12.1ab    | 23.23b  | 1077.8a       |
| Seed Priming          | 3.1a       | 12.8a     | 13.8a     | 22.46b  | 946.1a        |
| Control               | 2.4b       | 7.2b      | 8.2c      | 25.55a  | 1114.4a       |
| Mean of Chickpea      |            |           |           |         |               |
| varieties             |            | Mean      | Mean      |         |               |
| Al-Shamy              | 2.9a       | 12.7a     | 12.7a     | 22.11b  | 1016.1a       |
| Marakshy              | 2.7a       | 7.8b      | 7.8b      | 25.19a  | 1037.9a       |
* NBRA: number of primary branches per plant, NPP: number of pods per plant, NSP: number of seeds per plant, HSW: 100 seed weight, BIOM: Biomass, GYH: seed yield

|    | GYH* | BIOM | NBRA | NPP | NSP | HSW |
|----|------|------|------|-----|-----|-----|
| BIOM | 0.7382** |      |      |     |     |     |
| NBRA | 0.0043 | -0.1941 |      | 0.3785* |     |     |
| NPP | 0.1543* | -0.1072 | 0.505* | 0.8071* |     |     |
| NSP | -0.3233* | 0.0683 | 0.015 | -0.752 | -0.797 | 0.0036ns |
| HGW | -0.2412 | 0.1052 | -0.1941 | 0.0043ns |     |     |

* GYH: seed yield per hectare, BIOM, biomass yield per hectare, NBRA: number of branches, NPP: number of pods, NSP: number of seeds per plant, HSW, 100 seed weight.

4. Conclusion

The obtained results conclude that the nodulation in chickpea not respond to the soil application of fertilizers, while seed treatment (priming) with fertilizers enhance the nodulation. Both Al-Shamy and Marakshy varieties are recommended to farmers in dry areas. Also, the results suggested both method of fertilization (DAP and seed priming) for improving yield related components, but Corabac G bio fertilizer is not recommended under similar conditions of this study and also further investigation are suggested to support the gainiog results.

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