Influence of foliar application of some nano-fertilizers in growth and yield of potato under drip irrigation

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Abstract. A field experiment was conducted in Autumn planting season 2018 at the Fields of In section 158 of the district 41 Husseiniya Province of Babylon, to investigate the influence of foliar application of Nano chelate silicon fertilizes (NSF) Nano chelated potato specific fertilizer (NPS) and Nano chelated complete micro(NCM) on growth and yield of potato variety Riviera. Foliar applied at 50, 100, 150 and 200 g or ml of all nanofertilizer types 100 L⁻¹ water or 2 kg nanofertilizers ha⁻¹ (as recommended) dissolved in 400 liters of water ha⁻¹. The experiment included spray of single (NSF), (NPS), (NCM), di (NS+NPS),(NS+NCM),(NPS+NCM), and tri combinations (NS+NPS+NCM), in addition to control (only water) using RCBD with 3 replicates. Growth and yield parameters tested were chlorophyll, dry matter, vegetative yield, fresh tubers yield, biological yield, starch, crude protein, ascorbic acid, AE( Agronomic efficiency) and WUE (Water use efficiency). The results showed that tri combination (NS+NPS+NCM) spray treatment was significantly higher followed by the di and single spray combinations. Fresh yield, dry tubers, vegetative yield and biological yield were (42.130, 9.327, 2.901 and 12.228 Mg ha⁻¹) respectively, compared with the control (28.440, 5.453, 2.240, and 7.693 Mg ha⁻¹), respectively. Tri combinations (NS+NPS+NCM) starch content, crude protein and ascorbic acid concentration (vitamin c) were (17.10 %, 9.08% and 185.33 mg kg⁻¹ f.w.), compared with the control treatment (12.22%, 7.79% and 136.33 mg kg⁻¹ f.w.).

Keywords: Nano silicon, potato, potato specific fertilizer, Drip irrigation, Agronomic efficiency, Water use efficiency.

1. Introduction

Silicon is the second structural element in the soil which is non-mobile in the plants. Although silicon is not essential element for plants, higher plants need it to have optimum growth (Tubanâ and Heckman, 2015). Plants generally require silica silicon to control biotic and abiotic stress (Laane, 2018). The presence of silicon reduces toxic metal elevation, increases water-use efficiency and photosynthesis rate in plants. Furthermore, silicon also acts as a bio protectant against fungal attack (Tantawy et al., 2015). Naturally, plants contain Si in appreciable concentrations, ranging from 1% to 10% or even higher of the dry matter. This difference of Si levels in different plant species have been attributed to the Si uptake ability of the roots (Savvas and, Ntatsi 2015). As the beneficial effect of silicon has been proved as shown above, the application of nano silicon can be more effective than the...
large applied particles which means a more efficient input use (Roohizadeh et al., 2015). The use of the new science, nanotechnology in agriculture has begun and will continue to have a significant effects in the main areas of breeding new crop varieties, development of new functional materials and smart delivery systems for agrochemicals like fertilizers. As the plants cell wall prevents the entrance of elements into cells, the nano particles which have diameters less than the cell wall pores size, therefore nano particles can easily cross the pores. Nano particles can enter the plants leaves through the stomata and transported to the different organs (Singh et al., 2017; Qureshi et al., 2018; Al-juthery et al., 2018; Al-juthery and Saadoun, 2018).

The potato (Solanum tuberosum L.) is one of humanity’s most important food and leading vegetable crop. Its volume of production ranks fourth in the world after rice, wheat, and maize (Faostat, 2013). Therefore, best management practice is very important in maximizing potato productivity. In semiarid lands, the loss of organic matter and low fertility are of great concern. Soils of these areas often have low to medium available (P), medium to high (K) and low of micronutrients, mainly (Fe), (B), (Mn) and (Zn). But these elements are required in trace amount for different physiological processes of potato crop (Dimkpa and Prem, 2016). Among these, boron and zinc play pivotal role in pollination and fruit development. Zinc is involved in hormone biosynthesis, cytoplasm synthesis, activation and function of different enzymes, protein synthesis etc. Boron plays active role in protein synthesis during seed and cell wall formation. Boron also helps in water and nutrient transportation from root to shoot (Noaema and Barbara, 2018). Manganese is associated with activation of enzyme like decarboxylase, dehydrogenase in photosynthesis. Iron is essential for chlorophyll development in cell without iron photosynthesis is not possible. Therefore, foliar application of macro and micro nutrients is one of the important approaches in achieving high productivity of potato in this region (Moinuddin et al., 2017).

The aim of this research was to determine the spray effects of nano chelated silicon fertilizer, nano chelated potato specific fertilizer, nano chelated complete micro and their interaction on growth and yield parameters of potato crop cultivar Riviera.

2. Materials and methods

Field experiment was carried out during autumn season 2018 at the Fields of In section 158 of the district 41 Husseiniya province of Babylon in a Silt clay loam soil with chemical and physical characteristics, shown in (Table 1), to study the influence of foliar applied of some nano fertilizers Nano silicon fertilizer (NSF) chelated silicon 2%, Nano chelated potato specific fertilizer (NPS) It contains 5% nitrogen, 4% Phosphorus, 20% potassium, 3% Magnesium, 2% calcium, 8% Sulfur, 3% Iron, 5% Zinc, 0.5% Copper, 0.5% Boron, 0.1% Molybdenum. and Nano chelated complete micro (NCM) It contains 8% Iron, 1.5% Zinc, 1.5% Manganese, 0.5% Boron, 0.5% Molybdenum, 0.5% Copper on growth and yield of potato (Solanum tuberosum L.) variety Riviera. The soil was prepared after plowing by the rotary plow. with drip irrigation system. A randomized block design with three replicates was used. All blocks treatments have been 1.5 m in width (two rows with 0.75 m width) and 3 m in length. with 8 treatments to foliar applied nano-fertilizers (Table 2.).

| Table 1. Some soil properties. |
|-------------------------------|
| property                  | value  | Estimated methods           |
| -------------------------- | ------ | ----------------------------|
| Particle size distribution |        |                             |
| Clay                       | 390    | Salim and Ali, 2017         |
| Silt                       | 489    |                             |
| Sand                       | 121    |                             |
| Texture                    | Si.C.L |                             |
| CEC Cmol kg^{-1}Soil       | 20.3   | Salim and Ali, 2017         |
| OM gm kg^{-1}Soil          | 17.0   | Salim and Ali, 2017         |
| Calcite gm kg^{-1}Soil     | 173    | Salim and Ali, 2017         |
At the stage of tubers maturity some parameters of growth and yield were estimated. Soil analyses were conducted before trial using methods mentioned in (Table 1) for physical and chemical soil properties. Total chlorophyll in the first expanded leaves was measured with a SPAD-502 Chlorophyll Meter (Minolta Camera Co. Ltd., Japan). Vegetative dry matter was estimated for 10 plants. Tubers dry matter yield Mg ha\(^{-1}\) was measured according to AOAC, (A.O.A.C, 2000).

Table 2. Shows the experiment treatments, spray concentrations and number of spraying.

| Tr. No. | Treatments of spraying | gm or ml per 100 L water* | gm or ml per 100 L water** | gm or ml per 100 L water*** | gm or ml per 100 L water**** |
|--------|------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| T1     | Control                | 0                         | 0                         | 0                         | 0                         |
| T2     | (NSF)                  | 50                        | 100                       | 150                       | 200                       |
| T3     | (NCM)                  | 50                        | 100                       | 150                       | 200                       |
| T4     | (NSP)                  | 50                        | 100                       | 150                       | 200                       |
| T5     | (NSF) + (NCM)          | 25+25                     | 50+50                     | 75+75                     | 100+100                   |
| T6     | (NSF) + (NSP)          | 25+25                     | 50+50                     | 75+75                     | 100+100                   |
| T7     | (NCM) + (NSP)          | 25+25                     | 50+50                     | 75+75                     | 100+100                   |
| T8     | (NSF)+ (NCM)+(NSP)     | 17+17+17                 | 33.3+33.3+33.3            | 50+50+50                  | 66.7+66.7+66.7           |

was determined by oven drying at 70°C for 24 h. Starch content was determined by using a polarimetric method (Liutskanov et al., 1994). Ascorbic acid (Vitamin C) was evaluated by dichlorophenolindophenol titration method (Ivanov and Popov, 1994). Total nitrogen was determined by Kjeldal’s method and multiplied by 6.25 to convert to crude protein (Tomov et al., 2009). The total produce from each net treatment was weighed with a digital balance in kg per treatment and was converted into Mg ha\(^{-1}\). Agronomic efficiency(AE) or fertilizer productivity kg fresh tubers kg\(^{-1}\) fertilizer = yield of the treated fertilizer – yield of control treatment / quantity of fertilizer added (Ali,2011). Dry vegetative yield Mg ha\(^{-1}\) was measured from five randomly taken plants at harvest and converted into Mg ha\(^{-1}\). Water use efficiency (WUE) was calculated as the ratio of potato yield (Y) to total crop water use (WU) as suggested by (Howell, 2000).

Statistical analysis of collected data was performed by using LSD test (Al-Sahuki and Whaib, 1990) of Genstat program. Statistical differences were considered significant at p<0.05.

3. Results

Total chlorophyll (SPAD unit): Table 3. showed that the treatments of spraying NSF, NPS and NCM with different combinations of single, di and tri have achieved significant effect in the chlorophyll content. The highest content was achieved in the tri combination T8 which was 47.8 SPAD unit compared to control T1 (35.4 SPAD unit).
Soft tubers yield (Mg ha\(^{-1}\)): T\(_8\) was (42.130 Mg ha\(^{-1}\)), significantly highest than all other treatments. For the single spray, the nano chelated potato specific fertilizer T\(_4\) (NPS) spray was 35.480 Mg ha\(^{-1}\). Significantly highest than T\(_3\) (NSF) which was 29.233 Mg ha\(^{-1}\) and T\(_5\) (NCM) which was 33.370 Mg ha\(^{-1}\) (Table 3).

Dry matter tubers yield (Mg ha\(^{-1}\)): Also the results showed that T\(_8\) (NSF+NPS+NCM) was significantly higher (9.327 Mg ha\(^{-1}\)) as compared with the control (5.453 Mg ha\(^{-1}\)) (Table 3).

Tubers dry matter Percentage %: T\(_8\) (NSF+NPS+NCM) recorded (22.11%), the highest tubers dry matter percentage, which was superior to all other spraying treatments, while the control treatment T\(_1\) recorded the lowest Percentage (19.11%) (Table 3).

**Table 3.** Effect of spraying of NSF, NPS and NCM in the chlorophyll content, soft tubers yield, dry tubers yield, vegetative yield, biological yield and tubers dry matter percentage.

| Tr. No. | Chlorophyll SPAD unit | Soft Tubers yield Mg ha\(^{-1}\) | Tubers Dry yield Mg ha\(^{-1}\) | Vegetative yield Mg ha\(^{-1}\) | Biological yield Mg ha\(^{-1}\) | Tubers dry matter % |
|---------|-----------------------|---------------------------------|---------------------------------|---------------------------------|--------------------------|---------------------|
| T\(_1\) | 35.4                  | 28.440                          | 5.453                           | 2.240                           | 7.693                    | 19.11               |
| T\(_2\) | 36.7                  | 29.233                          | 6.332                           | 2.467                           | 8.099                    | 19.30               |
| T\(_3\) | 38.9                  | 33.370                          | 8.000                           | 2.589                           | 9.380                    | 20.33               |
| T\(_4\) | 40.4                  | 35.480                          | 7.496                           | 2.680                           | 10.177                   | 21.11               |
| T\(_5\) | 37.4                  | 34.280                          | 7.165                           | 2.643                           | 9.808                    | 20.88               |
| T\(_6\) | 42.3                  | 36.390                          | 7.896                           | 2.724                           | 10.620                   | 21.66               |
| T\(_7\) | 44.6                  | 40.560                          | 8.338                           | 2.820                           | 11.157                   | 20.22               |
| T\(_8\) | 47.8                  | 42.130                          | 9.327                           | 2.901                           | 12.228                   | 22.11               |
| L.S.D\(_{0.05}\) | 1.07 | 5.358                          | 1.35                            | 0.62                            | 1.48                     | 0.73                |

Vegetative dry matter yield (Mg ha\(^{-1}\)): Table 3 showed that T\(_7\) (NCM + (NSP) and T\(_8\) (NSF+NPS+NCM) treatments have significant effects on the vegetative dry matter. T\(_7\) was (2.820 Mg ha\(^{-1}\)), T\(_8\) was (2.901 Mg ha\(^{-1}\)) compared with the control treatment T\(_1\) which was (2.240 Mg ha\(^{-1}\)).

Biological yield (Mg ha\(^{-1}\)): All treatments (Single spray treatments, di and tri combinations) of all type of nanofertilizers except T\(_1\) (NSF) had a significant effect on the biological yield, and achieved the highest biological yield in T\(_8\) (NSF+NPS+NCM) which amounted to (12.228 Mg ha\(^{-1}\)) compared with the control treatment T\(_1\) (spry water only) treatment (7.693 Mg ha\(^{-1}\)) (Table 3).

**Table 4.** Effect of spraying of NSF, NPS and NCM in the tubers nitrogen content in %, crude protein percentage, fresh tubers starch content %, ascorbic acid concentration (mg kg\(^{-1}\)) of fresh tubers, agronomic efficiency AE kg kg\(^{-1}\) and WUE Kg m\(^{-3}\).

| Tr.No. | N(%) tubers | Crude Protein (%) d.w. | Starch (%) f.w. | Ascorbic acid (mg kg\(^{-1}\) f.w.) | AE Kg kg\(^{-1}\) | WUE Kg m\(^{-3}\) |
|--------|-------------|------------------------|-----------------|------------------------------------|------------------|-------------------|
| T\(_1\) | 1.25        | 7.79                   | 12.22           | 136.33                             | 0                | 15.63             |
| T\(_2\) | 1.28        | 8.00                   | 12.55           | 139.97                             | 397              | 16.01             |
| T\(_3\) | 1.30        | 8.15                   | 13.44           | 155.00                             | 2465             | 18.33             |
| T\(_4\) | 1.33        | 8.33                   | 14.66           | 166.33                             | 3520             | 19.49             |
| T\(_5\) | 1.34        | 8.40                   | 14.33           | 160.33                             | 2920             | 18.84             |
| T\(_6\) | 1.38        | 8.60                   | 15.00           | 169.67                             | 3975             | 19.99             |
| T\(_7\) | 1.43        | 8.94                   | 16.30           | 180.03                             | 6060             | 22.29             |
| T\(_8\) | 1.45        | 9.08                   | 17.10           | 185.33                             | 6845             | 23.15             |
| L.S.D\(_{0.05}\) | 0.16 | 0.98                   | 1.24            | 6.72                               | 2679             | 2.95              |
**Tubers nitrogen content in %**; T₄ (NSF+NPS+NCM) was significantly higher than the other single, dual and control treatments in N content with (1.45% dry tuber matter). T₁ was the lowest in N concentration with (1.25% dry tuber matter) (table 4).

**Tuber crude protein content (%)**: Table 4. showed that both T₃ and T₄ treatments were significantly higher than the control, single and dual treatments in tuber crude protein content (%) .T₁, T₇, T₈ were 7.79%, 8.94%, 9.08% respectively.

**Starch (% fresh weight)**: from Table (4) it was found that starch was the maximum at the tri combination of (NSF+NPS+NCM) which amounted to (17.10% f.w.) and significantly superior to the dair combination and single treatment in addition the control.

**Ascorbic acid (mg kg⁻¹ fresh weight)**: Table 4. showed that there is a differential effect of single spray treatments ,dual and triple of NSF, NCM and NPS in the content of ascorbic acid (vitamin c) compared with the treatment of the control. T₈ (NSF+NPS+NCM) recorded the highest significant concentrating (185.33mg kg⁻¹ f.w.) while the control treatment (136.33mg kg⁻¹ f.w).

**Agronomic Efficiency (AE) or fertilizer productivity kg fresh tubers kg⁻¹ fertilizer**: Agronomic Efficiency (AE) results showed in Table (4) were (397 and 6845 kg kg⁻¹) for control and the tri nano (NSF+NPS+NCM) composition, respectively, with a significant superiority of the tri-combination on di and single treatments and control.

**Water use efficiency (WUE Kg m⁻³)**: table 4. showed treatments WUE. Statistical analysis showed significant difference between T₄, T₅, T₆, T₇, T₈ treatments compared with T₁( control). T₈ WUE was (23.15Kg m⁻³) while control WUE was (15.63Kg m⁻³).

4. Discussion

Foliar application of micro-nutrients is an important method of (folar) feeding and in some cases these applications are more effective than soil applications. Micro-nutrients are sprayed about four weeks after emergence or transplanting. Because many micro-nutrients are not readily trans located within the plant, a second spray is required two weeks later to cover the new foliage and it is required in midseason to correct deficiency (Ashaal and El-Ramady, 2017). Foliar spraying of micro-elements is very helpful when the roots cannot provide necessary nutrients (Singh and Khushboo, 2018). Now it is known that plant leaves uptake some nutrients better than soil application and foliar spraying came in practice (Moinuddin et al., 2017). Although in treatments of micronutrient in combinations can also be done in most cases. Once a potential deficiency has been diagnosed, a single compound spray can be used to prevent or correct deficiency (Dimkpa and Prem, 2016). Sometimes diagnose in deficiency symptoms is confused then mixture of nutrients may be applied.

Micronutrients is crucial for achieving higher yields. Six micronutrients, i.e. Mn, Fe, Cu, Zn, B and Mo are involved in photosynthesis, respiration and other biochemical pathways (Marschner, 2011). Both macro and micronutrients availability influenced by soil chemical and physical properties (Rengel, 2015; Noaema and Barbara, 2018). The results of the study showed that the treatment of foliar different type of nanofertilizers showed significant superiority over the others the treatments. Including the di, tri treatments of NSF, NCM and NPS. In most characteristics of vegetative growth and components of the studied yield. There was also a significant increase in the single treatments compared with control treatment. Its role can be attributed to many physiological processes such as increased chlorophyll content in the leaves needed to raise the efficiency of photosynthesis(Morales-Diaz et al., 2017). These increments may be due to the increase in productivity of the photosynthetic areas. The application of eight sprays with 4 mL/L (30 ppm Si) on potatoes grown in clay soil effected greater disease resistance against Phytophthora and a yield increase of 6.2% compared to the controls and an improved the proportion of large grade (size) tubers (Laane, 2018). The effects of 1, 2 and 4 mL.
L$^1$ sprays with (8–32 ppm Si) on three potato varieties showed in every case yield increases of up to 20%. Leaf size, chlorophyll content and nutrient status were improved significantly. The incidence of leaf blight was also reduced (Khan et al., 2017). The improvement of potato yield and it's components with foliar spray application of nanofertilizers increase crop growth up to optimum in low concentrations further increase in concentration may inhibit the crop growth due to the toxicity of nutrient (Ali-juthery et al., 2018). Potato is regarded as an indicator crop for soil K availability due to its high K requirement (Kumar and Girish, 2018). Potassium (K) is an essential plant nutrient that plays a very important role in plant growth and development. Its role is well documented in photosynthesis, increasing enzyme activity, improving synthesis of protein, carbohydrates and fats, translocation of photosynthetic, effects on metabolism of nucleic acids, proteins, vitamins and growth substances and plays an essential roles in enzyme activation, protein synthesis, photosynthesis, osmoregulation, stomata movement, energy transfer, phloem transport, cation-anion balance (Salam et al., 2014). Nano scale foliar is much superior to other foliars. All nutrients in the nano-fertilizers are at nano scale making it easier for it to penetrate into the plant leaves (Jamhohmadi et al., 2016; Singh et al., 2017; Jyothi and Hebsur, 2017; Ali and Al-juthery, 2017). It is a single package containing the micros and macros. The composition is designed to enhance photosynthesis efficiency significantly, thereby strengthening the liquid carbon cycle in the plant environment. Nano-fertilizers provide more surface area for different metabolic reactions in the plant which increase rate of photosynthesis and produce more dry matter and yield of the crop. It is also prevent plant from different biotic and abiotic stress compare with conventional fertilizers with sprinkler irrigation systems (Singh et al., 2017; Khan et al., 2017; Qureshi et al., 2018; Abobatta et al., 2018).

5. Conclusion
From the study, it is concluded that spraying Nano silicon fertilizer (NSF), Nano chelated potato specific fertilizer (NPS) and Nano chelated complete micro (NCM) gave significantly higher fresh tubers yield and most of the parameters of potato growth and yield than control. Hence, the best treatment for optimum enhancement of of starch, protein and vitamin C with implication for quality potato tubers. The results suggest that tri spray treatment (NSF+NCM+NPS) could be used in potato production, leading to maximum fresh tuber yield and high WUE and AE.

6. References

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