Response of Four Potato (Solanum Tuberosum L.) Varieties to Four Nano Fertilizers

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Abstract:
A field experiment was conducted at vegetable field, Department of Plant Production, Technical Agricultural College, Mosul, Iraq during spring season of 2020, to investigate the response of four potato varieties (Arizona, Florice, Laperla, Montreal) to four Nano fertilizers Kind (K, B, Zn, Fe 2 gm. L$^{-1}$) with recommend dosage of NPK as well as the recommend dosage of NPK 20:20:20 as 600 Kg.ha$^{-1}$ as control. The four potato varieties were sown on 26 February in loamy soil at drip irrigation system T-tap. Nano fertilizers were spraying at 2 gm. L$^{-1}$ constriction three times in the season. The treatments were arranged in factorial experiment in split plot with randomized complete block design with three replicates. The results showed Montreal variety give the higher value of average tuber weight (82.022 gm.), total and marketable yield of plant (1048.3, 1007.8 gm.), total and marketable yield of hectare (58.241, 55.993 ton.ha$^{-1}$), dry matter and starch in tuber (21.877 %, 15.500%). Spraying with four Nano fertilizers kind increase significantly all the parameters of yield and quality compared with control treatment an Zn nano give the higher value of number of tubers per plant (15.177), plant yield (1150.6 gm.), total yield (63.925 ton.ha$^{-1}$), and marketable yield (61.106 ton.ha$^{-1}$) while the higher value of dry matter (22.062 %), starch (15.667 %) an TSS (5.571%) was from K nano.

1- Introduction:
Potato (Solanum tuberosum L.), belonging to Solanaceae family, is one of the most important vegetable crops in the world, and in terms of human consumption came in the fourth grade after wheat, rice and corn. Its tubers are a good source of carbohydrates, vitamins and minerals [1]. The quality of potato tubers and their chemical composition are influenced by genetics, soil fertility, weather conditions and the applied chemical treatments. Many researchers study the effect of different cultivars on potato growth and yield. [2] study three varieties of potato (Agria, Laura, and Arrera) they found that Laura variety significantly superior than the rest varieties in number of tubers, plant yield and total yield. [3]...study eight varieties of potato (Bubu, Belete, Gudanie, Gabbisa, Badhasa, Chiro, Jarsob, and Dedafa), they concluded that the Badhasa cultivar was significantly higher in the number of tubers per plant, while Bubu give the higher marketable and total yield. [4] noted that Arizona cultivar significantly superior than Riviera and Agria cultivars in number of tubers per Plant, the average weight of the tuber, plant yield, total yield, and percentage of dry matter and starch in tubers. In an experiment carried out by [5] on five varieties of potato (Arnova - Arizona - Riviera - Sifra and Burren) observed that Arizona variety showed superiority in most of the quantitative characteristics (plant yield, marketable yield, and total yield) while Riviera cultivar showed the highest percentages of dry matter and starch in tubers. [6] revealed that the cultivar (Riviera) gave the highest tuber number per plant, plant yield, average tuber weight, tuber volume, and marketable and total yield compared with Actrice, Arizona, and Universal varieties. The
fertilizers are very important in plants growth, but most of the applied fertilizers are frequently lost due to the degradation by photolysis, leaching, hydrolysis, decomposition, etc. Thus, it is more essential to reduce nutrient losses in fertilization and to increase the crop yield through the advancement of new nanotechnology applications. Nanomaterials-based fertilizers and/or nanomaterials functionalized nutrients might have the properties such as crops improvement, specifically targeted, slow release of nutrients that regulate plant growth [7].

[8] revealed that when phosphatic fertilizers are applied to the soil, they often become insoluble (more than 70%) and are convert into complexes such as calcium phosphate, aluminum phosphate and iron phosphate in the soil.

Studies show that the use of nanofertilizers causes an increase in nutrients use efficiency, reduces soil toxicity, minimizes the potential negative effects associated with over dosage and reduces the frequency of the application. Hence, nanotechnology has a high potential for achieving sustainable agriculture, especially in developing countries [9]. Nano particles can enter the plants leaves through the stomata and transported to the different organs [10,11,12,13]. Leaf surfaces are highly porous at a nanometer scale and are the main gates for nutrients to enter into plants. Nanofertilizers have special advantages that differ from traditional fertilizers, as they have proven effective when used with many agricultural crops in growth and productivity due to their small size and increase in surface area leading to an increase in the absorption surface and thus the ability to improve the efficiency of nutrient use through specific mechanisms such as targeted delivery and slow release. Or controlled substances leading to increased photosynthesis and increased nutrient production in the plant [14]. To study the leaching of nitrogen in soil an experiment conducted on potato, the treatments included nano-nitrogen chelate (NNC), sulfur coated nano-nitrogen chelate (SNNC), sulfur-coated urea (SCU), and urea (U) at three levels of nitrogen input (46, 92, and 138 kg/N/ha), results showed that each treatment with nano fertilizer had significant effects on yield, leaching, and soil nitrate than urea treatment [15] A study of applying nanofertilizers (major elements + micro-elements) at a rate of 2 g. L\(^{-1}\) with three times the first after 45 days of emergence whereas the second spray after 15 days of the first while the ‘third spray was after 15 days of the second, the result show that the fertilizer combination of recommended dosage NPK + nanofertilizer gave the highest value of lave area, percentage of dry matter of vegetative growth, number of tubers per plant, total yield, starch percentage [16]. Foliar application of Nano chelate silicon fertilizes (NSF), Nano chelated potato specific fertilizer (NPS) and Nano chelated complete micro(NCM) on potato variety Riviera, 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, the results showed that tri combination spray treatment was significantly higher in fresh yield, dry tubers, chlorophyll, dry matter, fresh tubers yield biological yield, starch, protein, ascorbic acid [17]. The aim of this study was to investigate the response of yield and quality four potato varieties to four types of Nano fertilizers.

2-Materials and Methods:
The field experiment was implemented at vegetable field, Department of Plant Production, Technical Agricultural College, Mosul, Iraq during spring season of 2020. The aim of this study was to investigate the response of four potato cultivars (Arizona, Florice, Laperla, Montreal) to four Nano fertilizers kind at 2 gm. L\(^{-1}\) (K 27%, B 12%, Zn 9%) with recommend dosage of NPK, as well as the recommend dosage of NPK 20:20:20 at 600 Kg.ha\(^{-1}\) as control. The four potato cultivars were sown on 26 February in loamy soil, sprouted seed tubers were planted at 25 cm apart within the row at drip irrigation system T-tap [18]. The Nano fertilizers were spraying at 2 gm. L\(^{-1}\) constriction three times, first one after 15 days of spraying, the second after 20 days from the first, and the third after 20 days from the second. The treatments were arranged in factorial experiment in split plot with in randomized complete block design with three replicates. The other common agricultural practices were adopted for growing potato plants according to the recommendations of commercial potato planting in Mosul, Iraq. The data were recorded on the following parameters: number of tubers per plant, plant yield, total marketable yield, dry matter, starch, and total soluble solid (TSS) in tuber.

The results were statistically analysis according to the statistical analysis system (SAS) and compared with the means by Duncan multiple rang test at 0.05 level [19]
3- Results and Discussion:
Table (1) illustrate the effect of varieties and Nano fertilizers treatments in number of tubers per plant, it was found a significant superiority of florice variety on the other varieties, in the number of tubers per plant, as well as a significant superiority of the spraying of the four nano fertilizers over the comparison treatment and that the highest number of tubers was (15.177) from spraying Zn nano. The interaction treatment between varieties and fertilization, showed that the highest number of tubers was (17.467) from the interaction between the Floric and spraying with Zn nano fertilizer.

Table (2) revealed the effect of varieties and fertilizer treatments in average weight of tuber, it was found a significant superiority of Montreal variety on the other varieties, as well as a significant superiority of the spraying of the four nano fertilizers over the comparison treatment. The interaction treatment between varieties and fertilization, showed that the highest average weight of tuber (93.790 gm.) was from the interaction between the Montreal and spraying with K nano fertilizer. While the lowest average weight of tuber (58.393 gm.) was from the interaction treatment between Laperal variety and control.

Table (1) effect of varieties and Nano-fertilizer treatments in number of tubers per plant.

| Varieties | Fertilizer Treatments | Mean |
|-----------|----------------------|------|
| Arizona   | NPK (Control)        | 13.384 ab |
|           | +Nano Zn 2g. L⁻¹     | 14.200 a-d |
| Florice   | NPK                 | 15.543 a-d |
|           | +Nano Fe 2g. L⁻¹     | 14.200 a-d |
| Laperla   | NPK (Control)        | 8.067  F |
|           | +Nano B 2g. L⁻¹      | 14.253 a-d |
| Montreal  | NPK                 | 15.177 A |
|           | +Nano F 2g. L⁻¹      | 16.667 A |
|           | +Nano Zn 2g. L⁻¹     | 15.310 ab |
|           | +Nano B 2g. L⁻¹      | 17.467 A |
|           | +Nano K 2g. L⁻¹      | 15.853 a-c |

Table (2) effect of varieties and Nano-fertilizer treatments in average weight of tuber (gm.).

| Varieties | Fertilizer Treatments | Mean |
|-----------|----------------------|------|
| Arizona   | NPK (Control)        | 65.992 C |
|           | +Nano Zn 2g. L⁻¹     | 69.020 c-f |
| Florice   | NPK                 | 76.519 b-e |
|           | +Nano Fe 2g. L⁻¹     | 85.393 a-c |
| Laperla   | NPK (Control)        | 82.022 A |
|           | +Nano B 2g. L⁻¹      | 93.790 B |
| Montreal  | NPK                 | 77.470 A |
|           | +Nano F 2g. L⁻¹      | 72.136 ab |
|           | +Nano Zn 2g. L⁻¹     | 72.340 B |
|           | +Nano B 2g. L⁻¹      | 74.997 C |
|           | +Nano K 2g. L⁻¹      | 78.582 a-f |

Means followed by the same letter are not significantly different according to Duncan multiple range test at the probability of P=0.05 level.

Table (3 and 4) revealed the effect of varieties and fertilizer treatments in total and marketable yield of tubers per plant. It was found that Montreal variety gave the highest value (1048.3, 1007.8 gm.).
A significant superiority of the spraying with the four nano fertilizers over the control was found and the highest value (1150.6, 1099.9 gm) was from Zn nano. The interaction treatment between varieties and fertilization, showed that the highest total and marketable yield of tubers per plant (1334.3, 1299.3 gm) was from the interaction between the Montreal and spraying with Zn nano fertilizer. While the lowest value (537.0, 489.6 gm) was from interaction between the Arizona and control and from Laperla an control.

Total yield of Table (3) effect of varieties and Nano-fertilizer treatments in plant (gm.).

| Varieties | Fertilizer Treatments | Mean | Reconn. NPK (Control) | Reconn. NPK +Nano Zn 2g. L⁻¹ | Reconn. NPK +Nano Fe 2g. L⁻¹ | Reconn. NPK +Nano B 2g. L⁻¹ | Reconn. NPK +Nano K 2g. L⁻¹ |
|-----------|-----------------------|------|-----------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Arizona   | D                     | 537.0|                       | 1003.6 bc                   | 883.3                       | 986.4                       | 976.0                       | 877.2                       |
| Florice   | D                     | 600.3|                       | 1097.3                      | 1127.4                      | 1133.0                      | 1228.7 ab                   | 1037.3                      |
| Laperla   | D                     | 525.6|                       | 1167.3 ab                   | 1063.7                      | 983.0                       | 1023.4                      | 952.6                       |
| Montreal  | D                     | 605.0|                       | 1334.3                      | 1013.3                      | 1157.1 ab                   | 1131.9                      | 1048.3                      |
| Fertilizer Treatments | Mean | 566.9|                       | 1150.6                      | 1021.9                      | 1064.8 ab                   | 1090.0                      |

Means followed by the same letter are not significantly different according to Duncan multiple range test at the probability of P=0.05 level.

Yield of Table (4) effect of varieties and Nano-fertilizer treatments in marketable plant (gm.).

| Varieties | Fertilizer Treatments | Mean | Reconn. NPK (Control) | Reconn. NPK +Nano Zn 2g. L⁻¹ | Reconn. NPK +Nano Fe 2g. L⁻¹ | Reconn. NPK +Nano B 2g. L⁻¹ | Reconn. NPK +Nano K 2g. L⁻¹ |
|-----------|-----------------------|------|-----------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Arizona   | E                     | 510.3|                       | 936.7                       | 843.3                       | 928.6                       | 921.7                       | 828.1                       |
| Florice   | E                     | 568.3|                       | 1032.7 b                    | 1075.1                      | 1084.3                      | 1192.7 ab                   | 990.6                       |
| Laperla   | E                     | 489.6|                       | 1131.0                      | 1024.0                      | 947.0                       | 968.7                       | 912.0                       |
| Montreal  | E                     | 566.3|                       | 1299.3                      | 957.3                       | 1117.0                      | 1099.4                      | 1007.8                      |
| Fertilizer Treatments | Mean | 533.6|                       | 1099.9                      | 974.9                       | 1019.2 ab                   | 1045.6 ab                   |

Means followed by the same letter are not significantly different according to Duncan multiple range test at the probability of P=0.05 level.

Table (5) and (6) revealed the effect of varieties and fertilizer treatments in total and marketable yield of tubers per hectare. It was found that Montreal variety gave the highest value (58.241, 55.993 ton.ha⁻¹) of total and marketable yield respectively with significant differences than Arizona variety. A significant superiority of the spraying with the four nano fertilizers over the control was found and the highest value (63.925, 61.106 ton.ha⁻¹) of total and marketable yield respectively was from Zn nano.

The interaction treatments between varieties and fertilization, showed that the highest total and marketable yield of tubers (74.130, 72.185 ton.ha⁻¹) was from the interaction between the Montreal and spraying with Zn nano fertilizer. While the lowest value (29.201, 27.197 ton.ha⁻¹) was from the interaction between Laperla and control.
Yield (ton.ha.\(^{-1}\)). Table (5) effect of varieties and Nano-fertilizer treatments in total

| Varieties     | Fertilizer Treatments | Mean   |
|---------------|-----------------------|--------|
|               | Recomm. NPK           | Recomm. NPK | Recomm. NPK | Recomm. NPK | Recomm. NPK |
|               | (Control)             | +NanoZn 2g. L\(^{-1}\) | +Nano Fe 2g. L\(^{-1}\) | +Nano B 2g. L\(^{-1}\) | +Nano K 2g. L\(^{-1}\) |
| Arizona       |                       |         |         |         |         |
| D             |                       | 55.756  | bc      | 49.074  | bc      | 54.797  | bc      | 54.222  | bc      | 48.737  | B        |
| Florice       |                       | 60.963  | a–c     | 62.636  | a–c     | 62.944  | a–c     | 68.259  | ab      | 57.631  | A        |
| Laperla       |                       | 64.852  | ab      | 59.093  | bc      | 54.611  | bc      | 56.858  | bc      | 52.923  | ab       |
| Montreal      |                       | 74.130  | A       | 56.296  | bc      | 64.281  | ab      | 62.886  | a–c     | 58.241  | A        |
| Fertilizer    | Mean                  | C       | A       | B       | ab      | 59.158  | ab      | 60.356  | ab      |

Means followed by the same letter are not significantly different according to Duncan multiple range test at the probability of P=0.05 level.

Table (6) effect of varieties and Nano-fertilizer treatments in marketable yield (ton.ha.\(^{-1}\))

| Varieties     | Fertilizer Treatments | Mean   |
|---------------|-----------------------|--------|
|               | Recomm. NPK           | Recomm. NPK | Recomm. NPK | Recomm. NPK | Recomm. NPK |
|               | (Control)             | +NanoZn 2g. L\(^{-1}\) | +Nano Fe 2g. L\(^{-1}\) | +Nano B 2g. L\(^{-1}\) | +Nano K 2g. L\(^{-1}\) |
| Arizona       |                       |         |         |         |         |
| E             |                       | 52.037  | cd      | 46.852  | D       | 51.586  | cd      | 51.204  | Cd      | 46.006  | B        |
| Florice       |                       | 57.370  | E       | 59.725  | a–d     | 60.241  | 66.259  | ab      | 54.960  | A        |
| Laperla       |                       | 62.833  | b–d     | 58.899  | d       | 52.611  | b–d     | 53.815  | 50.669  | ab       |
| Montreal      |                       | 72.185  | 1–d     | 53.185  | 2–d     | 62.056  | 61.077  | 55.993  | 50.669  | ab       |
| Fertilizer    | Mean                  | C       | A       | B       | ab      | 56.624  | ab      | 58.089  | ab      |

Means followed by the same letter are not significantly different according to Duncan multiple range test at the probability of P=0.05 level.

Table (7 and 8) revealed the effect of varieties and fertilizer treatments in dry matter and starch in tuber. It was found that Montreal variety gave the highest value (21.877, 15.500 %) of dry matter and starch in tuber respectively with significant differences than Arizona variety. A significant superiority of the spraying with the four nano fertilizers over the control was found. The interaction treatments between varieties and fertilization, showed that the highest value of dry matter and starch % in tuber (23.510, 16.954 %) was from the interaction between the Laperla and spraying with K nano fertilizer. While the lowest value (17.653, 11.741 %) was from the interaction between Arizona and control in dry matter in tuber.
Table (7) effect of varieties and Nano- fertilizer treatments

| Varieties | Fertilizer Treatments | Varieties | Mean |
|-----------|-----------------------|-----------|------|
|           | Recomm. NPK (Control) | Recomm. NPK + NanoZn 2g. L\(^{-1}\) | Recomm. NPK + NanoFe 2g. L\(^{-1}\) | Recomm. NPK + NanoB 2g. L\(^{-1}\) | Recomm. NPK + NanoK 2g. L\(^{-1}\) |
| Arizona   | 17.653 | G a–f | 20.077 | 19.887 | 21.483 | 20.082 |
| Florice   | 17.910 | G e–g | 21.077 | 20.893 | 20.353 | 20.001 |
| Laperla   | 19.000 | fg c–g | 20.520 | 21.150 | 23.510 | 20.852 |
| Montreal  | 17.710 | G ab a–d | 22.800 | 22.613 | 22.913 | 21.877 |
| Fertilizer Treatments Mean | 18.068 | b 21.129 | a–f 21.118 | 21.135 | 22.065 |

Means followed by the same letter are not significantly different according to Duncan multiple range test at the probability of P=0.05 level.

Table (8) effect of varieties and Nano- fertilizer treatments

| Varieties | Fertilizer Treatments | Varieties | Mean |
|-----------|-----------------------|-----------|------|
|           | Recomm. NPK (Control) | Recomm. NPK + NanoZn 2g. L\(^{-1}\) | Recomm. NPK + NanoFe 2g. L\(^{-1}\) | Recomm. NPK + NanoB 2g. L\(^{-1}\) | Recomm. NPK + NanoK 2g. L\(^{-1}\) |
| Arizona   | 11.741 | G a–f | 13.989 | 13.729 | 15.150 | 13.903 |
| Florice   | 11.970 | G e–g | 14.788 | 14.625 | 14.145 | 13.831 |
| Laperla   | 12.940 | fg c–g | 14.292 | 14.854 | 16.954 | 14.588 |
| Montreal  | 11.792 | G ab a–d | 16.322 | 16.156 | 16.423 | 15.500 |
| Fertilizer Treatments Mean | 12.110 | B A | A A | A A |

Means followed by the same letter are not significantly different according to Duncan multiple range test at the probability of P=0.05 level.

Table (9) revealed the effect of varieties and fertilizer treatments in total soluble solid in tuber. It was found that Laperla variety gave the highest value of TSS (5.570%) with significant differences than Arizona and Florice variety. A significant superiority of the spraying with the four nano fertilizers over the control was found. The interaction treatments between varieties and fertilization, showed that the highest value of TSS in tuber (5.940%) was from the interaction between the Laperla and spraying with K nano fertilizer. While the lowest value (4.936%) was from the interaction between Arizona and control.
Table (9) effect of varieties and Nano-fertilizer treatments in total soluble solid (TSS) in tuber.

| Varieties | Fertilizer Treatments | Mean  | Recomn. | Mean  | Recomn. | Mean  | Recomn. | Mean  | Recomn. | Mean  | Recomn. |
|-----------|-----------------------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|
|           |                       |       |         |       |         |       |         |       |         |       |         |
|           |                       |       |         |       |         |       |         |       |         |       |         |
| Arizona   |                       | 4.936 | 5.513   | 5.406 | 5.186   | 5.426 | 5.294   | 5.186 | 5.406   | 5.294 | 5.186   |
|           |                       |       | B      |        |         | B     |         | B     |         | B     |         |
|           |                       |       | b – h  | d – i  | b – h   |       |         |       |         |       |         |
| Florice   |                       | 4.993 | 5.293   | 5.133 | 5.280   | 5.100 | 5.160   | 5.280 | 5.100   | 5.160 | 5.280   |
|           |                       |       | c – i  | f – i  | c – i   | g – i  | B       |       |         |       |         |
| Laperla   |                       | 5.180 | 5.606   | 5.440 | 5.686   | 5.940 | 5.570   | 5.686 | 5.940   | 5.570 | 5.686   |
|           |                       |       | e – i  | a – e  | b – h   | a – c  | A       |       |         |       |         |
| Montreal  |                       | 5.060 | 5.653   | 5.586 | 5.493   | 5.820 | 5.522   | 5.493 | 5.820   | 5.522 | 5.493   |
|           |                       |       | g – i  | a – d  | a – f   | a – g  | A       |       |         |       |         |
| Fertilizer Treatments |       | 5.042 | 5.516   | 5.391 | 5.411   | 5.571 | 5.571   | 5.391 | 5.411   | 5.571 | 5.391   |
| Mean      |                       |       | B      | A      | A       | A      | A       |       |         |       |         |

Means followed by the same letter are not significantly different according to Duncan multiple range test at the probability of P=0.05 level.

It was noted that there were significant differences between the varieties in quantitative and qualitative traits of potato. This may be due to genetic differences between the varieties caused by the variation in genetic factors responsible for vegetative growth traits. This results are in alignment with [3,4,5,6,]. Foliar application of micro-nutrients is an important method of (foliar) 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 translocated 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 [20]. Foliar spraying of micro-elements is very helpful when the roots cannot provide necessary nutrients [21]. Now it is known that plant leaves uptake some nutrients better than soil application and foliar spraying came in practice [22]. Six micronutrients, i.e. Mn, Fe, Cu, Zn, B and Mo are involved in photosynthesis, respiration and other biochemical pathways. Both macro and micronutrients availability influenced by soil chemical and physical properties [23,24]. The results of the study showed that the treatment of foliar different type of nanofertilizers (Zn, K, Fe, B) showed significant superiority over the control treatment, of all characteristics of yield and quality of tubers. Its role can be attributed to many physiological processes such as increased chlorophyll content in the leaves needed to raise the efficiency of photosynthesis [25]. Also Nano-fertilizer is characterized by unique features i.e., with high surface area and minuscule quantity, this leads to an increased absorption, impact on solubility and transportation of nutrients. Its impact upon plant growth are increased height, number of leaves, and leaf area which increased yield and quality characteristics.

The current study results of nano-fertilizer are harmonious with [12,16,26,27].

4. Conclusion:

It can be concluded from this study that Montreal cultivar is the best compared with the other three cultivars because it recorded the highest values of most yield and quality parameters. On the contrary, applying Zn nano as a spraying fertilizer increased significantly number of tubers per plant, plant total yield, plant marketable yield, total and marketable tubers yield of hectare.

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