Effect of DAP Fertilizer Source and Nano Fertilizers (Silicon and Complete) Spray on Some Growth and Yield Indicators of Rice (Oryza sativa L. cv. Anber 33)

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Abstract

In order to evaluate some growth and yield indicators of rice (cv. Anber 33) towards the various fertilizer treatments (DAP fertilizers and Nano fertilizers), a field experiment was implemented in the summer season of 2019 in one of the rice fields of Ghamas district/ Al-Diwaniyah Governorate located between the points (3509948. 464130) – East and (3509938. 464132) – North, with the total area of 435 m². The experiment consisting of two factors was designed according to the Randomized Complete Block Design (RCBD) with three replicates for each treatment, as the first factor represented by DAP fertilizer source consisted of four treatments (Control, M-DAP, O-DAP + micronutrients and O-DAP high K), while the second factor consisting of spraying Nano fertilizers consisted of four treatments (Control, Nano silicon, Nano complete and Nano silicon + Nano complete).

The studied indicators on the rice plant included chlorophyll content in leaves (SPAD unit), plant height (cm), biological yield (ton h⁻¹), grains yield (ton h⁻¹), harvest index (%), fertilization efficiency for production (%). Results showed the superiority of O-DAP + micronutrients fertilizer in achieving the highest chlorophyll content in leaves, biological yield, grains yield and fertilization efficiency for production compared with M-DAP fertilizer which achieved the highest mean of plant height, as well as O-DAP high K fertilizer which achieved the highest mean of harvest index. Also, spraying with Nano fertilizer habits with significant results on the studied indicators, especially with the treatment Nano (silicon + complete) that achieved the highest means for the majority of the studied indicators, and that their interaction between O-DAP + micronutrients fertilizer with Nano (silicon + complete) fertilizers achieved the highest means for the most important characteristics of the crop represented by the chlorophyll content in leaves, grains yield, fertilization efficiency for production.

Keywords: DAP, Nano Silicon, Nano complete, Rice (cv. Anber 33).

1.Introduction

1.1 Background

Rice (Oryza sativa L.) is one of the most important summer crops worldwide, and it is cultivated in a wide range of climatic regions extending from tropical countries to temperate subtropical countries to latitude 40 ° S and 50 ° N from the Equator, recording its cultivation In 114 of the 193 countries in the world [1].

Rice is one of the main staple cereal crops for more than half of the world's population, as the Asia-Pacific region produces and consumes more than 90% of the world's total rice production [2]. As for locally, the production of paddy crops in Iraq for the summer season 2019 was estimated at 574.7 thousand tons for the cultivated area 127.85 thousand hectars, an increase of 556.5 thousand tons for the 2018 season, which was estimated at 18.2 thousand tons for the cultivated area 5.425 thousand hectars, and Al-Diwaniyah Governorate ranked second in terms of total production by 39.3% [3].

The rice crop mostly depends on the soil conditions, in addition to providing accessible nutrients such as nitrogen, phosphorus, potassium, sulfur and zinc to meet the requirements of the plant from the large quantities of mineral nutrients for its growth, development and grain production, as fertilizer is the main input to increase agricultural production and productivity of the soil, Plants require a specific amount of some nutrients in a specific form to be added in time for their growth and development [4, 5].

Rice uptake large quantities of traditional mineral fertilizers during its growth due to the method of irrigating with immersion and the exposure of fertilizers to washing, volatilization and fixation on the surfaces of minerals in the soil being clay textures, so the unbalanced use of nutrients, with a great focus on supplementing the soil with micronutrients, may lead to a significant deficiency in other nutrients [6]. Also, balanced fertilization should not take place using all types of fertilizers.
Balanced fertilization means providing fertilizer in the soil to achieve availability of all nutrients in the soil and creating an optimal growth environment for the plant and the crop, as the natural needs of N, P and K fertilizers can affect the components of the rice crop. So there is no longer a need to add nutrients that have reached the optimum level, if the land has a high content of P and K, then only a low dose of fertilizer P and K is needed which is equivalent to P and K that is transported at the time of harvest, the nutrient source can be in the form of a single fertilizer, compound fertilizer, or a mixture of both [7], especially for cereal crops such as rice and maize, as there is a need for additional urea fertilizer because nitrogen fertilizer (urea) should not be given once one should be done gradually two to three times, because giving urea at the same time is very ineffective and most of it (more than 40%) will be lost through different soil mechanisms [8]. Fertilizer also plays an important role in modern agriculture, especially to increase rice production by providing single or multiple nutrients; Single chemical fertilizers such as N in the form of urea, P in the form of trisuperphosphate (TSP) or diammoniumphosphate (DAP) and K such potassium chloride (KCl) or their dual or triple mixture used for rice cultivation [9].

With the improvement of enhanced rice cultivars in addition to better techniques for soil and fertilizer management, rice production generally increases over the years, leading to a gradual increase in nutrient removal N, P and K (kg ha⁻¹) and thus the fertilizer consumption increases over the years [10]. On the other hand, modern high-yielding rice varieties consume much higher potassium compared to phosphorus or even nitrogen from the soil [11, 12]. Low crop yields are closely related to degradation of soil productivity, especially nutrient depletion [13] which can be attributed to either inadequate or unbalanced use of fertilizers [14].

The codified use of fertilizers is one of the important strategies for increasing rice production per unit area, and fertilizers play a crucial role in improving food production and quality, especially when introducing highly productive and responsive varieties of fertilizers, most crops grown like rice need large amounts of inorganic inputs [15]. Given the excessive consumption of chemical fertilizers and the resulting groundwater pollution and salinization of the soil, the use of nanofertilizers is very effective, as Rawat et al. [16] revealed that nanoscale fertilizers have the potential to act as a catalyst for plant growth and can enhance the exchange of plant gases and root efficiency. Furthermore, due to the slowness and control of nutrient release, nanofertilizers are able to increase the availability of nutrients in the root zone (Rhizosphere) [17]. The researches had shown that the soil has a difference in the total elements, especially nitrogen (N), phosphorous (P) and potassium (K), and it is more common as ingredients for commercial fertilizers, compared to other essential elements [18].

Foliar spraying of micronutrients and bio-stimulants is also an important method for foliar feeding and in some cases this method is more effective than adding through the soil [19], as the rationale for using foliar spray of silicon compounds is a resulting assumption that silicon leaf feeding can compensate for reduced root absorption in the event of a decrease in the availability of absorbable silicon in the soil, and the relatively complex absorption process of silicon by the roots resulting in improvement in the process of absorbing silicon and beneficial effects on the plant, as plants deprived of silicon are weaker in terms of skeletal structures are silicon-enriched plants, which indicates low growth, development and reproducibility [20], in addition to being more susceptible to biological and non-biological stresses, and these differences are results of roots ability of different plant species to absorb silicon in the form of Monosilicicacid (MSA) = Orthosilicicacid (OSA), but there are also differences in the genotype of silicone absorption [21], as MSA absorption in monocotyledonous plants is an active process.

Kinetic studies in rice show that the carrying of silicon wood by silicon transporters is carried out in the root wall whereas in dicotyledonous plants MSA is absorbed through the diffusion process, which leads to a significant decrease in MSA concentrations in the wood compared to monocotyledonous plants (ex. Rice) [22].

In the end result, nanofertilizers are the most technically advanced way to supply crops with mineral nutrients, compared to chemical fertilizers, and provide them with the nutrients needed for plant needs, reduce leakage, and thus improve the efficiency of fertilizer use, as enhancing the efficiency of fertilizer use and reducing its inputs has important implications for enhancing economic benefit and environmental.

1.2 Objectives

The combine application of traditional and nanopartic mineral fertilizers may create a continuous nutritional balance for the different growth stages of the rice plant, resulting in a reduction in the use of chemical fertilizers and the creation of a better environment for nutrient absorption in the plant, which is what the current study intends to achieve from the evaluation of the various fertilizing factors of DAP fertilizer sources applications through the soil and spray of Nano fertilizer (silicon and complete) on plant shoot with the aim of improving growth and yield of rice plant (cv. Anber 33) and determining the best treatment or combination to increase yield and production.

2. Materials and Methods

2.1 Description of Experimental Site

The experiment implementation site was chosen in the summer season of 2019 in one of the rice fields of the Ghamas district/ Al-Diwaniyah Governorate, which is located according to the Global Positioning System (GPS) between the points (3509948. 464130)-East and (3509938. 464132)-North, with the total of 435 m².
2.2. Experimental Design

The experiment consisting of two factors was designed according to the Randomized Complete Block Design (RCBD) with three replicates for each treatment [23] as the first factor represented by DAP fertilizer source consisted of four treatments (Control, Mineral DAP (M-DAP), Organic DAP + micronutrients (O-DAP + micronutrients) and Organic DAP high K (O-DAP high K)), while the second factor consisting of spraying Nano fertilizers consisted of four treatments (Control, Nano silicon, Nano complete and Nano silicon + Nano complete).

2.3. Soil Preparation, Sampling and Analysis

The field soil was prepared prior to planting by plowing, smoothing and leveling operations, and then a soil sample was taken by spade by digging a V-shaped hole with a depth of 0-30 cm from five sites represented by the four sides of the field and the center to be a representative sample of the field soil after being air-dried and ground with ceramic mortar and sieve it (2 mm), and then perform laboratory tests on it according to the methods mentioned by Estefan et al. [24], which included the electrical conductivity (EC) = 4.98 ds m⁻¹; pH = 7.5; Available-N = 15.0 mg kg⁻¹; Available-P = 3.24 mg kg⁻¹; Available-P = 93.0 mg kg⁻¹; Organic matter = 0.69 %; Cation-exchange capacity (CEC) = 28.34 meq 100 g⁻¹, Calcium carbonate = 32.87 g kg⁻¹, Soil texture = clay loam.

The experiment field was divided into three equal blocks separated from each other by a distance of 1 m, and each block was divided into 16 plaes (experimental unit), as the area of one plate reached 5.0625 m² (2.25 m × 2.25 m). The necessary irrigation and puncture channels were split by leaving a distance of 1 m between the experimental units to make these channels as well as between blocks.

2.4. Cultivation and Crop Management

On 06/15/2019, the dry rice seeds (cv. Anber 33), certified by the Rice Research Station in Al-Mishkhab District/ Najaf Governorate were planted with an amount of 120 kg seeds. h⁻¹ by using direct prose on the pre-prepared soil, then covering it with soil to prevent its erosion with irrigation water and its capture by birds.

The field was irrigated with the first irrigation (abundant) and then left to dry for 3-4 days, after which the irrigation of the germination was again irrigated, and then the irrigation process continued every 3 days until the plants reached the appropriate height so that the irrigation would continue without suffocation of the seedlings as a result of continuous immersion as well as the continuation of irrigation with this a period of time until the replanting stage on 1-3/ 8/ 2019, which requires an appropriate height for the water in the field in order to allow the transfer of plants from places with high density to places of low density (due to the death of seedlings or the failure of germination of some seeds). After 3 – 4 days of replanting, the field was dried for 3 days in order to give an opportunity to ventilate the soil and allow the roots to penetrate, because the presence of water after this stage in the form of immersion does not allow the roots to penetrate downward and to the sides, but a floated remain in water, and the irrigation process continues after that from time to time until the plants are fully ripe, the water was cut off before 15 days from harvest, as well as manually controlling the bush by weeding whenever necessary and before the fertilization applications.

2.5. Fertilization Applications

2.5.1. Soil Fertilization by Urea Fertilizer

It was added to all treatments by 300 kg h⁻¹ [25] in three batches; The first batch represented a quarter of the quantity (75 kg h⁻¹) and was added a month after the planting process, the second batch represented half of the quantity (150 kg h⁻¹) and was added a month after the first addition, while the third batch represented the last quarter ( 75 kg h⁻¹) it was added a month after the second addition process for the purpose of supplying plants with nutrients during the different growth stages [25].

2.5.2. Soil Fertilization by DAP Fertilizers

The first batch of DAP fertilizers (Iraqi production) mineral, organic + micronutrients and organiv high K were added after 35 days from the date of planting (Tillers stage) by 120 kg h⁻¹ [25], while the second batch (120 kg h⁻¹) was added a month after the addition of the first batch of the above-mentioned fertilizers after the patching process, for the purpose of continuing the process of supplying the plants with the nutrients needed for the stages of flowering.

2.5.3. Foliar Fertilization by Nano Fertilizers

Nano-chelated silicon (2 ml L⁻¹) and Nano complete (2 g L⁻¹) “Nano Chelated Cereal Specific Fertilizer” were added according to the instructions of their manufacturer (KHAZRA, Iran) using a spray method on the plant shoot, by two sprinkles; the first was before the flowering stage and the second was 14 days after the first sprinkling.

2.6. Studied Indicators

2.6.1. Chlorophyll Content in Leaves (SPAD unit)

Chlorophyll content was measured by using a portable SPAD-502 chlorophyll meter (MIMOLTA CO. LTD. JAPAN) to obtain a rapid estimate of the leaf chlorophyll content in real time in the field [26].
2.6.2. **Plant Height (cm)**
Plant height measured by tape measure from the soil surface level to the highest plant height at 100 % flowering [27].

2.6.3. **Biological Yield (ton h⁻¹)**
Biological yield was estimated from the weight of the harvested plants within the specified square meter of each experimental unit after being dried in the air for 5 days and converted into ton per hectare, which includes the weight of the total dry matter above the soil surface after air-drying the sample and its weight stability [28].

2.6.4. **Grains Yield (ton h⁻¹)**
Grains yield was estimated from the harvested plants after air-drying for 5 days, then threshed and separated the grain from straw, the grain yield was recorded in kilogram per square meter and then, mathematically convert to ton per hectare at 14 % moisture content [28].

2.6.5. **Harvest Index (%)**
Harvest index for the rice crop was estimated by using the formula:

\[
\text{Harvest index (\%)} = \frac{\text{Grains yield}}{\text{Biological yield}} \times 100
\]  

2.6.6. **Fertilizer Efficiency for Production (%)**
Fertilizer efficiency for production was calculated based on the formula:

\[
\text{Fertilizer efficiency for production (\%)} = \frac{\text{Grains yield (Treatment-Control)}}{\text{Grains yield of Control}} \times 100
\]  

2.7. **Statistical Analysis**
Results data were statistically analyzed using the Analysis of Variance test within the Analysis ToolPak package included within the Excel add-on [30]. The mean treatments were compared when the differences between them were significant by using the Least Significant Difference (LSD) test at the probability level (P ≤ 0.05) [23].

3. **Results**

3.1. **Chlorophyll Content in Leaves (SPAD unit)**
Results in Table 1. indicated that there were significant differences between DAP fertilizer source in the mean of chlorophyll content. The mean of chlorophyll content increased significantly according to the difference of DAP fertilizer source, the best of which was O-DAP + micronutrients fertilizer by giving it the highest mean of chlorophyll content in plant leaves reached 38.44 SPAD unit with an increase at 5.58 % compared to control plants that recorded 36.41 SPAD unit. Results of the effect of Nano fertilizers spraying gave a significant superiority to the different fertilizer treatments in increasing the chlorophyll content in leaves to high 38.28 SPAD unit by Nano silicon treatment compared with the characteristic content in the control plants (37.71 SPAD unit) with an increase at 4.28 %. The interaction between DAP fertilizer source and Nano fertilizer spraying gave a significant superiority to the chlorophyll content in leaves of rice plants compared with the lowest significant content recorded by control plants reached 33.53 SPAD unit, and the highest significant of chlorophyll content was the effect by the treatment with O-DAP + micronutrients fertilizer and Nano (silicon + complete), reaching 39.23 SPAD unit with an increase at 17.00 % on control plants.

| DAP fertilizer source (240 kg h⁻¹) | Nano fertilizers spray | Mean of DAP fertilizer source |
|-----------------------------------|------------------------|-------------------------------|
| Control                           | Control                | 33.53                         |
| M-DAP                             | Silicon (2 ml L⁻¹)     | 37.06                         |
|                                   | Complete (2 g L⁻¹)     | 36.63                         |
| O-DAP + micronutrients            | Silicon+Complete       | 36.40                         |
| O-DAP + high K                    |                        | 36.41                         |
| Mean of Nano fertilizers spray    | DAP = 0.056            | 37.69                         |
| LSD (P < 0.05)                    | Nano = 0.056           | 38.44                         |
|                                   | Interaction = 0.113    | 37.70                         |

3.2. **Plant Height (cm)**
From statistical analysis results of the data presented in Table (2), the significance of DAP fertilizer source, spraying of Nano fertilizers and the interaction between them was observed in the mean of plant height, the treatment by O-DAP high K fertilizer recorded the highest mean of plant height reached 158.04 cm and a 2.21 % increase on the control plants (154.62
cm), while a significant decrease was observed in the mean of height plant to 152.47 cm when treated by O-DAP + micronutrients fertilizer to 1.41 % compared with control plants. It was also noticed that spraying of Nano fertilizers on the plant shoot of rice increased significantly the mean of plant height from 151.03 cm for control plants to 156.55, 154.00 and 158.21 cm for plants treated with Nano fertilizers (silicone, complete, silicon + complete), respectively, by an increase on control plants reached 3.65, 1.97 and 4.75 %, respectively. The significant interaction between DAP fertilizer source and Nano fertilizers spray gave a significant difference to the plant height, as all treatments recorded a significant increase for rice plants on the control plants with the least significant mean of the trait 140.43 cm. It reached 163.74 cm, followed by a combination of M-DAP fertilizer with nano (silicone + complete), at a significant difference between them in registering 162.07 cm, and an increase rate over the control plants reached 16.60 and 15.41 %, respectively.

Table 2. Effect of DAP fertilizer source and Nano (Silicon and Complete) fertilizers spray on plant height (cm) of Rice (O. sativa L. cv. Anber 33)

| DAP fertilizer source (240 kg h⁻¹) | Nano fertilizers spray | Mean of DAP fertilizer source |
|----------------------------------|------------------------|------------------------------|
| Control                          | Control                | 140.43                       |
|                                  | Silicon (2 ml L⁻¹)     | 159.97                       |
|                                  | Complete (2 g L⁻¹)     | 154.35                       |
| O-DAP + micronutrients          |                        | 163.74                       |
| O-DAP + high K                   |                        | 154.04                       |
| Mean of Nano fertilizers spray   |                        | 154.35                       |
| LSD (P ≤ 0.05)                  | DAP = 0.222            | Nano = 0.222                 |

3.3. Biological Yield (ton h⁻¹)

Table 3. indicates the significant effect of DAP fertilizer source on the mean of biological yield, as it was high 18.68 ton h⁻¹ when treated with O-DAP + micronutrients fertilizer, compared with 16.72 ton h⁻¹ for untreated plants (control) with an increase at 11.72 %. Also, the significant effect of Nano fertilizers spraying on the shoot plant of rice gave the highest mean of biological yield reached 18.68 ton h⁻¹ when treating with Nano silicone + complete fertilizer with an increase at 14.74 % compared with untreated plants that recorded the lowest mean for the trait 16.28 ton h⁻¹. The interaction of the studied factors showed the significant effect of the biological yield, it showed the significant effect of the trait of biological yield, as it recording the lowest mean at 14.50 ton h⁻¹ in control plants compared with the highest mean of biological yield achieved by plants treated with O-DAP + micronutrients fertilizer and Nano silicone + complete fertilizer spray reached 19.69 ton h⁻¹, followed by the treatment with nano (silicon + complete) fertilizer only and treatment with O-DAP + micronutrients fertilizer with Nano (silicon + complete) fertilizer spray in recording the highest means for the target trait of 19.35 and 19.07 ton h⁻¹, respectively, and with an increase rate over the biological yield mean of the control plants reached 35.79, 33.45 and 31.52 %, respectively.

Table 3. Effect of DAP fertilizer source and Nano (Silicon and Complete) fertilizers spray on Biological yield (ton h⁻¹) of Rice (O. sativa L. cv. Anber 33)

| DAP fertilizer source (240 kg h⁻¹) | Nano fertilizers spray | Mean of DAP fertilizer source |
|----------------------------------|------------------------|------------------------------|
| Control                          | Control                | 14.50                        |
|                                  | Silicon (2 ml L⁻¹)     | 17.28                        |
|                                  | Complete (2 g L⁻¹)     | 15.77                        |
| M-DAP                            |                        | 19.35                        |
| O-DAP + micronutrients          |                        | 16.72                        |
| O-DAP + high K                   |                        | 18.68                        |
| Mean of Nano fertilizers spray   |                        | 17.14                        |
| LSD (P ≤ 0.05)                  | DAP = 0.059            | Nano = 0.059                 |

3.4. Grains Yield (ton h⁻¹)

Results of Table (4) showed that the grains yield for rice plant increased significantly due to the effect of different DAP fertilizer source compared with untreated plants (control), which recorded the lowest mean of grains yield reached 4.30 ton h⁻¹, and the highest mean of grains yield was recorded for plants treated with O-DAP + micronutrients fertilizer spray, followed by the treatment with Nano (silicon + complete) fertilizer in recording the highest significant of grains yield reached 4.74 ton h⁻¹ compared with the grains yield of the control plants 4.05 ton h⁻¹, with an increase at 17.04 %. The significant interaction between DAP fertilizer source and Nano (silicon + complete) fertilizer spray on the grains yield was 4.85 ton h⁻¹ compared with the lowest...
significant yield recorded by control plants 3.36 ton h\(^{-1}\), with an increase at 44.35 %, noting that all other treatments mentioned in the interaction recorded a significant superiority in the grains yield as compared to the control plants.

### Table 4. Effect of DAP fertilizer source and Nano (Silicon and Complete) fertilizers spray on grains yield (ton h\(^{-1}\)) of Rice (O. sativa L. cv. Anber 33)

| DAP fertilizer source (240 kg h\(^{-1}\)) | Control | Silicon (2 ml L\(^{-1}\)) | Complete (2 g L\(^{-1}\)) | Silicon+Complete | Mean of DAP fertilizer source |
|----------------------------------------|---------|--------------------------|--------------------------|-----------------|-----------------------------|
| Control                                | 3.36    | 4.64                     | 4.53                     | 4.66            | 4.30                        |
| M-DAP                                  | 4.07    | 4.70                     | 4.67                     | 4.75            | 4.55                        |
| O-DAP + micronutrients                 | 4.57    | 4.69                     | 4.76                     | 4.85            | 4.72                        |
| O-DAP + high K                         | 4.21    | 4.64                     | 4.69                     | 4.71            | 4.56                        |
| Mean of Nano fertilizers spray         | 4.05    | 4.67                     | 4.66                     | 4.74            |                             |

**LSD (\(P \leq 0.05\))**: DAP = 0.077, Nano = 0.077, Interaction = 0.154

### 3.5. Harvest Index (%)

Results of Table (5) indicated that the harvest index for rice plant (cv. Anber 33) was significantly due to the effect of different fertilizer treatments. Harvest index increased significantly from 25.71% for control plants to 26.65% for plants treated with O-DAP high K fertilizer with an increase at 3.66 % compared to a significant decrease in the control treatment with the effect of the treatment with M-DAP fertilizer and O-DAP + micronutrients fertilizer by 0.90 and 1.70 %, respectively. The significant effect of Nano fertilizers spraying on the harvest index, it was in the positive direction, the harvest index increased by 5.68, 7.50, and 2.42% from it was for control plants (24.81 %) due to the effect of spraying with Nano (silicon, complete and silicon + complete) respectively, which in turn recorded a harvest index reached 26.22, 26.67 and 25.41%, respectively. Interaction between the studied factors recorded the highest mean of the harvest index was 28.73 % at control treatment for Nano complete fertilizer, which did not differ significantly with 28.66% due to the effect of the combination consisting of O-DAP high K fertilizer with Nano silicone fertilizer compared to all other treatments mentioned in the interaction, including control treatment which the lowest mean harvest index was 23.17%, with an increase of 24.00 and 23.69 %, respectively.

### Table 5. Effect of DAP fertilizer source and Nano (Silicon and Complete) fertilizers spray on harvest index (%) of Rice (O. sativa L. cv. Anber 33)

| DAP fertilizer source (240 kg h\(^{-1}\)) | Control | Silicon (2 ml L\(^{-1}\)) | Complete (2 g L\(^{-1}\)) | Silicon+Complete | Mean of DAP fertilizer source |
|----------------------------------------|---------|--------------------------|--------------------------|-----------------|-----------------------------|
| Control                                | 23.17   | 26.85                    | 28.73                    | 24.08           | 25.71                        |
| M-DAP                                  | 25.00   | 25.54                    | 25.69                    | 25.69           | 25.48                        |
| O-DAP + micronutrients                 | 25.72   | 23.82                    | 26.14                    | 25.43           | 25.28                        |
| O-DAP + high K                         | 25.36   | 28.66                    | 26.11                    | 26.45           | 26.65                        |
| Mean of Nano fertilizers spray         | 24.81   | 26.22                    | 26.67                    | 25.41           |                             |

**LSD (\(P \leq 0.05\))**: DAP = 0.062, Nano = 0.062, Interaction = 0.125

### 3.6. Fertilization Efficiency for Production (%)

Table 6. showed higher fertilization efficiency for plants treated with different DAP fertilizer sources significantly compared with untreated plants. Fertilizer efficiency increased by 26.23, 44.56 and 28.31 % for plants treated with M-DAP fertilizer (35.27 %), O-DAP + micronutrients fertilizer (40.39 %) and O-DAP high K fertilizer (35.85 %) compared with control plants (27.94 %). The same table also showed that the fertilization efficiency for production with the effect of Nano fertilizers spraying was significantly superior in all treatments, which reached the highest when treated with Nano silicone fertilizers which recorded 41.17 % compared with 20.63 % for control plants and with an increase rate of 99.56%. Interaction between the study factors recorded the highest significant mean of fertilization efficiency for production 44.35% at the combination consisting of O-DAP + micronutrients with Nano (silicon + complete) fertilizers spraying and superior significantly over all means for the efficiency of fertilization for production with the effect of other combinations mentioned in Table 6.

### Table 6. Effect of DAP fertilizer source and Nano (Silicon and Complete) fertilizers spray on fertilization efficiency for production (%) of Rice (O. sativa L. cv. Anber 33)

| DAP fertilizer source (240 kg h\(^{-1}\)) | Control | Silicon (2 ml L\(^{-1}\)) | Complete (2 g L\(^{-1}\)) | Silicon+Complete | Mean of DAP fertilizer source |
|----------------------------------------|---------|--------------------------|--------------------------|-----------------|-----------------------------|
| Control                                | 0.00    | 38.18                    | 34.88                    | 38.69           | 27.94                        |
4. Discussion

The reason for the superiority of the DAP treatments is due to the effect of positive phosphorus in increasing the leaf area and its index, thus increasing the surface exposed to light as well as its absorption, which contributed effectively to increasing the products of the carbon assimilation process in the leaf as well as stored in other plant tissues that move later when forming seeds to increase their fullness and her weight gain [31]. Moreover, phosphorus is a major compound in seeds and an effective source of energy as it moves into newly formed grains to gain weight [32]. These results are consistent with results of Durgude et al. [33] and Anu Lavanya et al. [34] who found that the various applications of phosphorous significantly increased growth and yield indicators for rice.

The increase in all studied indicators for the rice plant (cv. Anber 33) due to the influence of DAP fertilizer sources (MDAP, O-DAP+ micronutrients and O-DAP high K) may be due to the size of plant shoot that leads to the accumulation of carbohydrates in grains resulting from photosynthesis and its role in the formation of proteins, amino acids and nuclear acids that leads to the increase of these indicators, as a result of applied DAP fertilizers containing nitrogen and phosphorous and their role in increasing the products of photosynthesis and its transfer to grains reflected positively on the characteristics of the yield, as well as the role of potassium in physiological processes in the plant such as the formation of proteins, chlorophyll and carbohydrate assimilation [35, 36], which was expected in the end from the role of DAP fertilizers in improving vegetative growth with increased nutrients availability in the soil, which led to improved nutrient uptake and increased photosynthesis products that in turn increased the quantitative characteristics of the crop [37].

The significant effect of Nano silicon fertilizer spray on increasing most of the studied traits, whether the effect process is caused by spraying single or combine with Nano complete fertilizer, the response of plants to nanoparticles depends on various factors, including the size, shape, method of application, chemical and physical properties of nanoparticles [38].

Recent studies have shown that Si-NPs may interact directly with plants and affect their shape and physiology in various ways, including adding structural color to plants, and helping to improve plant growth and yield [39, 40, 41]. Strout et al. [39] observed that silicon nanoparticles form a double layer in the epidermal cell wall after absorption, which may add structural color to plants. The effect was not limited to coloring; It has also been speculated that Si-NPs act as a booster that may act as a factor to prevent fungal, bacterial and insect infection, and may therefore increase disease resistance. Researchers also concluded that the silicon nanoparticles may reduce plant transpiration, thus, it makes plants more resistant to drought, high temperatures and humidity, and this is consistent with result of Al-Juthery et al. [41] on barley.

The increase in the physiological indicators of the rice plant resulting from the treatment with Nano complete fertilizer is due to its role in increasing the absorption of nutrients and water. The activity of the enzymes that stimulate the transport of macro and micronutrients helps them, Grover et al. [43] stated that nanoparticles can bind to protein carriers that penetrate cell walls, encouraging the increase in the transport of substances, supported by an increase in stem diameter and number of vessels [44]. These results are consistent with Afify et al. [45] on peanut, Al-juthery and Saadoun [46] on Jerusalem artichoke and Al-juthery et al. [47] on potato. On the other hand, the increase in the physiological indicators of the rice plant due to the effect of spraying Nano complete fertilizer enriched with micronutrients due to its role in increasing the number of leaves and the total leaf area reflected directly on the chlorophyll as a result of improving the Bio-activities and increasing the enzymatic activities leading to the stimulation of increasing chlorophyll as well as increasing the activity of catalytic enzymes to stop the production of ethylene and inhibit its action, which has a role in the activity of chlorophyllase, which destroys the chloroplasts, thereby Nano fertilizer elements that keep chloroplasts alive for a longer period and delay aging as well as stimulating photosynthesis enzymes [41]. These results are consistent with results of Nouraein [48] on maize and Al-juthery et al. [47] on potato.

The reason behind the effects of Nano complete fertilizer on increasing the yield of rice plants is due to the active role of nanoparticles are integrated elements in increasing the energetic and enzymatic reactions and due to the bulk surface area of the nanoparticles that increase the speed of the reactions leading to increase in the production and number of flower and thus increase number of panicles and their weight, as well as the number of grains and their yield, in turn, providing an active transport device that helps in transporting nutrients from leaves to grains, thereby increasing the nutrients that reach the grains, increasing their size and weight. These results are in terms with Al-Juthery et al. [42] on barley, Al-juthery and Al-Shami [49] on Solanum tuberosum, and Wasaya et al. [50] on Vigna radiata.

Conclusion

The most important findings of the current study on assessing various fertilizer treatments, whether mineral or organic DAP fertilizers applied by soil and Nano silicone or Nano complete fertilizers applied by foliar spray on rice plant (cv. Anber
that the fertilizer combination consisting of O-DAP + micronutrients fertilizer with Nano (silicon + complete) fertilizer achieved the highest significantly superior means of grains yield (ton h\(^{-1}\)), and fertilization efficiency for production (%).

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