ZANCO Journal of Pure and Applied Sciences
The official scientific journal of Salahaddin University-Erbil
https://zancojournals.su.edu.krd/index.php/JPAS

ISSN (print):2218-0230**, ISSN (online):** 2412-3986**, DOI: http://dx.doi.org/10.21271/zjpas**

RESEARCH PAPER

Response of Two Sunflower (*Helianthus annuus L.*) Genotypes to Foliar Application of Different Nano Fertilizers.

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A B S T R A C T:

A field experiment was conducted at two locations in Sulaimanya governorate (Ranya and Saruchawa) during the autumn growing season of 2021 to investigate the effect of different sources of Nano fertilizer on the growth, yield, and quality of two sunflower genotypes. A factorial experiment was conducted using a randomized complete block design (RCBD) with three replicates which included sunflower genotypes (Velko and Baroloro) and Nano foliar fertilizer (Control, Nano Zn, Nano NPK, Super Nano, and Nano Fe). The statistical analysis indicated a significant effect of both factors and their interactions on most of the studied traits. The results indicated that the Velko genotype requires a shorter period for all growth stages, moreover recorded maximum seed yield (5.73 and 5.86) t ha^{-1} at both locations. On the other hand, the results showed that Super Nano fertilizer affected significantly most of the studied traits and obtained the highest value for leaf area (56.11and 61.72 cm^2), leaf area index (1.23and 1.36), head diameter (11.76 and 13.55), head weight (191.23 and 245.21), seed index (70.05 and 72.29), seed yield (5.73 and5.86) t ha^{-1}, and oil (37.76 and 38.60) % in addition to protein (19.83 and 23.40) %. at both locations respectively. The interaction treatment (Velko x Super Nano) recorded the highest value of oil and protein content (37.93, 38.61) % and (24.50, 24.25) %, on the other hand, the lowest values for most of the studied characters were recorded from Baroloro and Control treatment.

KEY WORDS: *Sunflower genotypes; Nano fertilizer; Growth; Yield; Quality.*
DOI: http://dx.doi.org/10.21271/ZJPAS.34.5.13
ZJPAS (2022) , 34(5);141-153 .

1. INTRODUCTION:

Sunflower is one of the most important oil crops in the world and comes second after soybean in Iraq (Al- myali et al ., 2020). Sunflower seed contains a high percentage of oil (40-50 %) and protein 26% (Petraru; *et al.*, 2021). It is measured as the best vegetable oil in the world because it is distinguished by four important fatty acids, which are [linoleic (18:2), stearic (18:0), palmitic (16:0), and oleic (18:1)] acids, among them, linoleic acid has a quite high concentration (Esmaeilian *et al.*, 2012). So it is used in medicine making foods. (Al- myali et al ., 2020). It contains low cholesterol, and for this reason, becomes a vital basis of the human diet (Sumon *et al.*, 2020).

The choice of genotype is an important facet of the production process, its effect is often underrated and is one way of ensuring higher returns at a little extra cost. (Kumar and Nagesh, 2019). Sustainable agriculture systems rely on environmentally friendly technologies based on biological and physical treatments in crop production (Awan et al., 2011). Nano fertilizers have an important role in the biochemical and physiological processes of yields by rising the availability of nutrients as Nano-fertilizers have a high surface area, sorption capacity, and controlled-release moving to targeted sites, and have been measured as smart delivery systems (Kumar and Nagesh, 2019). The present study was planned because there are no or few studies on the application of Nano fertilizers in Iraqi Kurdistan region. Keeping these aspects in view,

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Article History:
Received: 06/06/2022
Accepted: 16/07/2022
Published: 20/10 /2022

the efficiency of Nano fertilizers for two different genotypes should be acknowledged clearly and this will create the angle of vision for the application of Nano fertilizers in the semi-arid region and calcareous soil., this study aimed to investigate the effect of some Nano fertilizers Nano-iron, Nano-zinc, Nano-NPK, and super-Nano foliar application in comparison with control on growth, yield, its components, and quality of two sunflower genotypes.

2.MATERIALS AND METHODS

Two field experiments were conducted during the autumn growing season (2021-2022) in Sulaimanya governorate, the first was in Rayna city, at the campus of Raparen
University, (Latitude 36.231806 N and Longitude 44.863192 E), an elevation of 578 m above sea level, the second was at Saruchawa (latitude 36. 25587 N, and longitude 44.76534 E) with an elevation of 542 meters above sea level fig 1. Shows the location map of the two experimental sites, to study the Nano fertilizer Impact on the Growth, Yield, and Quality of two sunflowers (*Helianthus annuus L*.) genotypes.
A factorial experiment had been carried out using a randomized complete block design (RCBD) with three replications, represented soil samples were taken from both fields after tillage at depth of 30 cm, samples were air-dried then sieved using 2mm sieves, and then packed for analysis as shown in , Table 1.Sunflower seeds were sown manually (10 and 12 June) at Saruchawa and Ranya locations respectively, the drip irrigation system was used, for homogeneity in the water distribution, Also the metrological data of both location was shown in fig.2.Each replicate consists of 10 experimental units, the area of them was (2 x 2.10) m^2 which consists of five rows, and the distance between them was 50 cm and 30 cm between plants.

2.1. Treatment was represented by the combination of levels of two factors:

2.1.1. The first factor is sunflower genotypes which included:

a. Baroloro, its origin is from (Germany.)
b. Velko, its origin is from(Romania .), (Mahmood et al ., 2019) .

2.1.2 The second factor included fertilization treatments which included:

a- (F_1) Control or spray only distilled water
b-(F_2) Nano chelated Zn 12% at rate of (200 ppm kg ha^{-1})
c- (F_3) Nano NPK (20:20:20) (Khazra Nano chelated) at rate of (200 mg L^{-1}).
d- (F_4) Super Nano-fertilizer which contain (6% N, 3% P, 17% K, 4% Fe, 4% Zn, 2% Mn, 0.5% Cu, 0.5% B, 0.1% Mo, 1% Ca, 3% Mg, and 6% S) at rate of (200 mg L^{-1}).
e- (F_5) Nano chelated iron 9%. At rate of (200 ppm kg ha^{-1})

Spraying of Nano Fertilizers done after 30 days from sowing. Normal cultural practices of growing sunflower were conducted in the usual manner followed by the farmers, Squirrels and snails were used for bird protection, weeding cum thinning, insect and disease control measures were done whenever it is necessary, and harvesting is done on 15 and 20th September 2021 at Saruchawa and Rayna respectively.

2.2. Studied traits included the following:

2.2.1. Physiological traits; which included growth stages of sunflower.

The sunflower growth stages scale proposed by, Schneiter and Miller (1981),
a. Period from sowing to emergence stage.
b. Period from sowing to % 50 blooming.
c. The period from sowing to 50 % flowering.
d. The period from sowing is % 50 seed filling.

2.2.2. Vegetative growth traits

a. Leaf area (cm^2).
Random representative samples from 50 cm^2 at a 50 % blooming stage were calculated using Image J software (Easlon and Bloom, 2014).
b. Leaf area index, $\mathbf{LAI = \frac{Total\ leaf\ area}{ground\ area}}$ **……… (1)**

2.2.3. Yield and yield components:

Random representative samples of ten plants were selected at the full maturity stages from each experimental unit to estimate the following characteristics:
a. Head diameter (cm). Measured with a meter-tape across the center of the head. Ten plant selected randomly in each plot, averaged to get a single head diameter
b. Head weight (g). weight the selected head (g) and averaged to get a single head weight.

c. Seed index (g). For calculating seed index, wight of 500 seeds of (10) plant / plot were determined randomly and multiplied by two.

d. Seed yield (t ha^{-1}).

All plants in each plot were hand-harvested to determine seed yield was threshed, sieved, and cleaned to determine the seed yield g / plot after that convertetd to t ha^1

2.2.4. Sunflower quality measurement:

a. Oil content %

Oil % was determined using the oil extraction method by (A.O.A.C. 1980).

b. Protein content %

Protein % was determined according to the equation described by Krul, (2019) as follows:
Protein % = N% x 6.25 .... (2).

Statistical analysis:

The data were statistically analyzed with the method of analysis of variance (ANOVA) for randomized complete block design (RCBD) using the SPSS program version 28, the difference among means of treatments was tested using Duncan's multiple range test at the level of significant 5%. (El-Sahooki and Wahib, 1990).

The charts were drawn using the Excel software package.

3. RESULTS

3.1Effect of sunflower genotypes , Nano fertilizer and their interaction on physiological traits:

a. Period from sowing to emergence (Day).

Fig 3. Shows the significant effect of genotypes, on the period from sowing to emergence at both locations.Velko genotype needed the lowest value (4.53 and 5.20) day while Baroloro genotype require longer period values (5.33 and 5.53 days) from sowing to emergence stage, at Ranya and Saruchawa locations respectively.

b. Period from sowing to 50 % blooming (Day).

It is evident from fig4, that period from sowing to 50 % blooming was influenced statistically by each of the genotypes, fertilizer types, and their interactions at both locations. The maximum period (37.40 and 36.67) days was recorded for the Baroloro genotype, while the minimum period (36.66 and 34.86) days were obtained for the Velko genotype at (Ranya and Saruchawa locations).Types of fertilizer also affected significantly this trait at both locations, days from sowing to 50% blooming tended to decrease significantly from (37.83 to 36.16) days by the control treatment compared with the application of Nano- NPK at Ranya location. Saruchawa recorded minimum values (35.00) days. By the application of Nano-NPK fertilizer and maximum value of Control at Saruchawa and Ranya locations. The interaction between genotype and fertilizers in (fig 4) revealed that (Control x Baroloro) exhibited the highest value (39.00 and 37.66) days for both locations, furthermore the lowest period (35.67 and 34.00) was recorded for the interaction treatment (Nano NPK x Velko) and (Nano Zn x Velko) at both locations respectively.

c. Period from sowing to 50 % flowering (Day).

The data in fig 5. Also indicated that there were significant differences between the two genotypes on this trait at both locations. Both genotypes have the same manner as in fig 5 with an increase of (2.43 and 2.02) days for Baroloro genotype compared to Velko in both .locations respectively. Control in Ranya location requires a longer period (62.33 days), while Nano-Zn obtained the lowest value (59.75 days) to reach 50 % flowering, moreover, maximum and the minimum period (61.00 and 58.16) days was recorded from control and Nano-Zn application at Saruchawa location. The two-factor interactions (Control x Baroloro) and (Nano -Zn x Velko) exhibited the highest (63.33 days) and lowest (57.83days) period at the Ranya location. Respectively. While in Saruchawa location the interactions of genotype and fertilizer were (Control x Baroloro) and (Nano-Zn x Velko) exhibited the highest (62.00 days) and lowest (57.66 days).

d. Period from sowing to 50 % seed filling (Day).

Close examination of fig 6. Revealed that**,** sunflower genotypes affect significantly the period from sowing to 50 % seed filling at both locations. Velko genotype requires a shorter period (82.06 and 79.90) days and while Baroloro require longer days (83.26 and 81.12) at (Ranya and Saruchawa locations). As with most sunflower growth stages, fertilizer types were affected significantly at both locations, with control needs (3.15 and 2.58) days more to reach 50 % seed filling compared with Super Nano fertilizer. The interaction between fertilizers and sunflower genotypes in fig. 6 revealed that (Control x Baroloro) and (Nano NPK x Velko) exhibited the highest and lowest period (84.33 and 80.33) days at Ranya field while (Control x Baroloro) and (Super-Nano x Velko) values were recorded at Saruchawa location (82.66 and 77.65) days.

3.2 Effect of sunflower genotypes , Nano fertilizer and their interaction on Vegetative growth:

a. Leaf area (cm^2) and b. Leaf area index.

Table 2. And 3. Present the Leaf area (cm^2) and Leaf area index of the studied genotypes in response to foliar application of Nano Fertilizer, it was noticed that the Velko genotype exhibited superiority over the Baroloro with maximum values (49.21 and 55.23 cm^2) and (1.08 and 1.21) for both traits at both locations

On average, the fertilizer application had a significant effect on the two studied traits, the highest mean value (56.12 and 61.72) cm^2 and (1.23 and 1.36) was obtained in Super Nano followed by Nano-NPK and Nano-Zinc and Nano Fe in both locations for the two traits. These treatments showed (50.35, 29.58 ,19.69 and 6.65) % and (41.85,23.51 12and 1.24) % increase in leaf area and leaf area index over control for Ranya location while, (50.00 ,29.27 ,19.51and 6.10)% and (41.67,22.92,11.46 and 1.04)% recorded the increase in both traits for Saruchawa location respectively.

On the other hand, tables 3 and 4. Revealed that (Super Nano x Velko) and (Control x Baroloro) noted that the highest and lowest value at both locations for leaf area and leaf area index, with values (61.12 and 32.61) cm^2 and (65.78 and 37.38) cm^2 and (1.34 and 1.45) and (0.72 and 0.82) respectively.

3.3 Effect of sunflower genotypes , Nano fertilizer and their interaction on yield and its components:

a: Head diameter (cm) and b. Head weight (g).

Close examination of Tables 4 and 5. Shows that the Velko genotype surprises Baroloro genotypes in head diameter (cm) and head weight for both locations with an increase of (7.79% and 14.28% for Saruchawa compared with Ranya for the two traits.

The head diameter (cm) was improved significantly due to the sole applications of Nano fertilizer, the order of effectiveness is Super-Nano >Nano-NPK > Nano- Fe > Nano- Zn > Control, indicating the significant role of Super-Nano at Ranya and Saruchawa locations, whilst for head diameter ranks was Super-Nano >Nano-NPK > Nano- Zn > Nano- Fe > Control at both locations. The highest values (11.76 and 13.55) cm and (191.23 and 245.21) g were obtained for Super-Nano for the two traits. The interaction treatments (Super Nano x Velko) and (Control x Baroloro) resulted in the highest (12.15 cm) and lowest (9.58cm) head diameter respectively, at the Ranya field, with the same aspect for Saruchawa with values (14.13and 10.21) cm. Moreover, the same interaction treatment was noticed for the head weight (g) with the highest values (195.30 and 259.95) g and (114.39 and 111.97) lowest value for head weight.

c. Seed index (g).

It appears from the previous results in table 6.That the 1000 seed weight of Velko was superior to that of Baroloro in both locations, the maximum value (64.47 and 67.51) g. Obtained for Velko and Baroloro (62.70 and 65.41) g had the minimum value.

On average, Data in (table 6.) indicated that foliar application Super-Nano recorded the highest mean value at Ranya and Saruchawa with values (70.05 and72.29) g. whilst the lowest seed index (57.96 and61.77) g was observed from control treatment at both locations respectively. Moreover, it was noticed that there was a significant interaction between genotypes and fertilizer types. The maximum mean value (70.35) g was founded at Ranya from the interaction treatment of (Velko * Super-Nano), as compared to the control treatment. Similar results were obtained in the second location, with values (74.17 and 61.22) g.

d. Seed yield (t ha^{-1}).

Seed yield considered the most important parameter, it is an ultimate goal and facilitates the evaluation to check out the effectiveness of all treatments hence it should be, it is an absolute product of final mechanisms, physiological and morphological processes occurring in plants during growth and development. Data from table 7. Demonstrates that seed yield was significantly affected by the two sunflower genotypes in response to Nano foliar application at the two locations. Table 7. Shows a significant effect of genotypes, Velko genotype surprised Baroloro with a (3.92 and 5.66) % increase for both locations, the maximum mean values (5.30 and 5.41) t ha^{-1} were recorded. When Super-Nano was applied as compared to the control treatment, there was an increase in seed yield, such increases were particularly significant at ($P \leq 0.05$) at both locations, with the highest mean value (5.73 and 5.86) t ha^{-1} while the lowest value (4.88 and 4.44) t ha^{-1} was recorded from the control treatment in both location, the seed yield increase (17.42 and 31.98) % increase over control for both locations respectively. The interaction treatments show maximum value (5.84 and 5.93) t ha^{-1} which was found at both locations from (Velko * Super Nano). On contrary, the interaction treatment (Baroloro * Control) recorded the lowest value (4.84 and 4.26) t ha^{-1} with an increase in seed yield (20.66 and 37.56 %) respectively at both locations The increase in yield per se occurred on account of locations shows an increase 2.08% in Saruchawa comparing with Ranya field.

3.4 Effect of sunflower genotypes , Nano fertilizer and their interactions on sunflower quality measurement.

a. Oil content (%).

Sunflower genotypes used in the current study, showed the different amounts of oil content, this difference between them was significant at 5%, the highest value (36.41 and37.42) % was recorded for Velko genotype and the lowest value ((36.06 and 36.53) % was recorded for Broloro genotype at both locations respectively. Moreover, the results indicated that the application of Super Nano recorded the highest oil percentage, with values of (37.78 and 38.60) % for both locations respectively. Oil content were assorted as: Super Nano > Nano NPK > Nano Fe > Nano Zn > Control in Rayna while in Saruchawa was Super Nano > Nano NPK > Nano Zn > Nano Fe > Control. Concerning the interaction between sunflower genotypes and the application of fertilizer, it was also found to be significant, the greatest value (37.93 and 38.61) % were recorded from interaction treatments (Velko * Super Nano) for both locations respectively. While the minimum oil content (33.64 and 35.30) was recorded for the interaction treatment (Control x Baroloro) at both locations.

b. Protein (%) .

Table 9. showed protein content of two sunflower genotypes as influenced by foliar spray of Nano fertilizer types, there was an increase in seed protein content in Velko genotype which surprised the Baroloro genotype in both locations, with the highest and lowest value (19.82 and 20.50) % and (14.66 and 18.62) % respectively was recorded. The results also revealed that the protein% under Super–Nano fertilizer was noticeably different from the rest of the fertilizer types. This implies that fertilization treatment with Super Nano was the most effective treatment for these traits. The highest values (19.83 and 23.40) % were shown for Ranya and Saruchawa locations respectively with an increase in protein content (38.57 and 45.98) % compared with control treatments, whilst the lowest values were (14.31and 16.03) % for both locations were recorded from the control treatment. Table 10 explained also the significant effect of interaction treatments on protein content, the maximum mean value (24.50 and 24.25) % were observed from interaction treatments of (Velko * Super Nano) fertilizer for both locations respectively, and the lowest value (12.66 and 14.63) %. Was obtained from the interaction treatment of (Baroloro * Control) for both locations respectively

4. DISCUSSION

The result is in fig 3. Showed that the Velko genotype was earliest than the Baroloro genotype in the period from sowing to the emergence stage. This may be due to genetic variations, this result is similar to those obtained by Avazabadian, *et al.*, (2012) they showed significant differences among sunflower genotypes in their growth stages.

At both locations, Velko genotype surpassed Baroloro in the period from sowing to 50 % blooming, as shown in fig 4. These results support the conclusion that has been arrived by Avazabadian *et al.*, (2012) they indicated that the record cultivar is quick elongation for all stages of growth and development in comparison with other cultivars. Moreover, Mahmood et al., (2019) recorded the same results, he revealed that there were significant differences between the studied two genotypes Velko and Baroloro in growth traits.

Days from sowing to 50% blooming tended to decrease significantly with the application of Nano- NPK compared with control treatment at both locations fig 4. This may be due to the Nano fertilizer being the source for the three essential nutrients; for this reason, they created the best condition for growth.

Fig 4. revealed that the interaction treatment of (Control x Baroloro) exhibited the highest period in both locations, these results support the conclusion that has been arrived by Salama, (2012), he showed that application of Nano fertilizer had a stimulating effect on the growth of the corn, the results also showed that Saruchawa location created the best condition for sunflower genotypes. This may be due to the higher rate of humidity fig 2.

Application of Nano-Zn affected significantly on flowering time at both locations fig 5. This may be due to the role of Zinc which plays an important role in the production of biomass, chlorophyll synthesis, pollen function and fertilization. Dordas and Sioulas, (2009), while in Saruchawa the existent study established that the foliar NPK application fertilizers significantly improved the growth characteristics of sunflower compared to the rest of the treatments.

The interaction treatments between fertilizers and sunflower genotypes in fig. 4 and 5 revealed that (Nano-Zn x Velko) exhibited a shorter period this result is confirmed by Al-Doori, (2017) was showed a significant effect of the interaction between zinc and boron foliar application and sunflower genotypes.

Data presented in fig 6. indicated that Velko genotype requires a shorter period for seed filling, this may be due to the differences in genetic properties and phenotypic effects which caused the variation in this trait. Aboelkassem, (2021), showed significant differences among sunflower genotype on all growth traits. Nano fertilizers have a vital role in the biochemical and physiological roles of the plant by raising the availability of elements, helping improve metabolic processes and supporting meristematic activities causing higher apical growth and photosynthetic area.

The interaction treatments of (Super-Nano x Velko) in Saruchawa and (Nano NPK x Velko) in Ranya location recorded a shorter period to reach 50% seed filling, the differences between the two locations in response to Nano fertilizer with Velko genotype may be due to the differences in soil fertility for the two locations (table 1). This result agrees with Al-Doori, (2017).

The maximum mean values for (leaf area and leaf area index) at both locations, were recorded from Velko genotype, this may be attributed to genetic reasons and their interaction with the soil and environment. This result agrees with the finding of Chapman et al,. (1993) and Aliatiyah and Kadhim, (2017), they indicated to significant differences among genotypes in their effects on the leaf area and leaf area index.

Also, it was noticed that among the fertilizer types Super-Nano obtained the highest leaf area and leaf area index, and the lowest value was recorded for Control in both locations, this may be due to the synergetic role of Super-Nano in enhancing crop growth, due to the presence of both macro and micronutrients in this type as reported by Zeidan et al., (2010).

The interaction between fertilizers and sunflower genotypes is revealed in table 2, and table 3, showed that (Super- Nano x Velko) exhibited the highest values of leaf area and leaf area index. This result agrees with Al-Doori, (2014), who showed that the leaf area of sunflower was significantly affected by the interaction of genotype and fertilizer.

The studied genotypes affected significantly head diameter and head weight, tables 4 and 5 showed that Velko genotype as most of the studied traits recorded the highest value. This result was in harmony with Idris et al., (2016) who observed that there were different effects between genotypes on head diameter.

The application of Super Nano caused a significant increase in head diameter as compared to control treatment for both locations respectively, then an increase in head weight. This may be due to the role of micro in the mix with macro-nutrients in improving the growth of sunflowers. This result agrees with the finding of Muzzamil et al., (2009) informed that the application of NPK and micronutrients improves the growth traits of sunflowers.

Like most of the studied traits, Velko genotype recorded the highest value of 1000 seed weight in both locations table 6. This result is supported by a previous study by Hafez *et al.*, (2021) they observed that the differences among genotypes significantly affect the weight of the seed index. On average, Data in table 6, indicated that Super-Nano foliar application recorded the highest seed index value ,while the lowest value was observed from control treatment at both locations, this result agrees with the finding of Esmail et al.,(2014) they noted the significant effect of fertilizer on the seed index of flax.

The maximum mean value of seed index was founded for (Velko * Super-Nano) at Ranya and Saruchawa locations as compared to the control treatment. Similar results were obtained by Ahmad *et al.*, (2017) they notcied the role of fertilization by NPK on the interactions with sunflower variety, the evidence from the interaction treatment between Fertilizer × Varieties caused maximum value (53.23 g) which noted for variety SF-187 and NPK at the rate of 200-80-80 kg ha^{-1}. While the minimum weight of a thousand seeds (38.63 g) was noted for the Peshawar-93 variety that was given NPK dose at the rate of 40-40-40 kg ha^{1}.

In table 7, we can observe that Velko genotype exceeded Baroloro in seed yield .The superiority of the Velko genotype in the maximum achene treats may be owing to that the Velko genotype required superior vegetative growth and hence photosynthesis, The maximum value of most of the studied traits as shown in tables (2, 3, 4, 5, and 6,) is higher in Velko genotype which led to more carbohydrate accumulation then translocated from the source (leaf, stem) to the sink (seed). Similar result was observed by Hamza et al., (2011) Mahmood, (2021) b, they showed the significant effect of safflower varieties on the seed yield.

Also table7. Indicated to the significant effect of fertilizer types on seed yield at both locations. The highest values for Ranya and Saruchawa locations were recorded from Super Nano fertilize. This may be due to the role of Super Nano in increasing most of the studied traits as mentioned before. These results agree with Mahmood, (2021)a, who observed a significant effect among sunflower and NPK fertilizer. The highest value from the interaction treatment of (Velko * Super Nano) was recorded for seed yield. In general, differences between the two locations may be due to soil properties and environmental conditions (Table 1 and fig1). This result agrees with (Ahmad *et al.*, 2017).

The data in table (8 and 9) illustrates the significant effect of genotypes for oil and protein content at both locations, the highest value was recorded for Velko genotype and the lowest value was recorded for Baroloro. This may be due to the difference between their genetic properties as mentioned before and affected by environmental factors during all stages of growth and development, the highest seed oil and protein, % observed at Saruchawa location in comparison with Ranya location, this may be due to confirming the suitability of this location for sunflower cultivation (Table.1). Mahmood, (2019) mentioned the effect of environment and growth stages in oil and protein synthesis. This result was agreed with (Mahmood and Muhammad, 2018).

The oil and protein % stayed one of the most important evaluation parameters of sunflower quality, which may be affected by Nano fertilizer which is shown in tables (8 and 9). The results indicated that the application of the super –Nano foliar produced the highest oil and protein content. Similar results were reported by (Hama et al., 2015); and (Hafez *et al.*, 2021). They showed a significant effect of the fertilizer on the oil and protein %. Moreover, the interaction treatments also had a significant influence on seed oil and protein %, (Velko * Super Nano) recorded the highest values .This may be due to the role of soil fertility in both locations. Similar results were reported by (Hama et al., 2015).

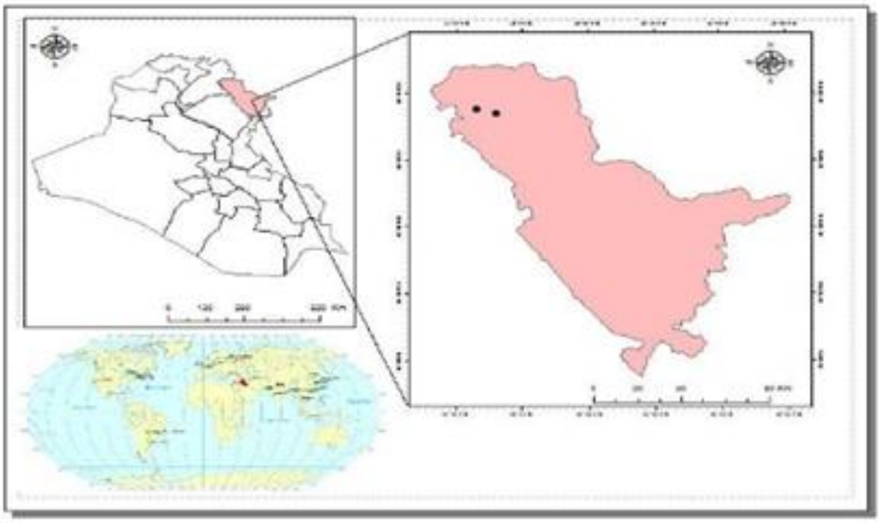


Fig. 1. The location map of the experimental site.

Table 1. Soil physical and chemical properties (Ranya and Saruchawa) locations.

Soil properties		Units	Saruchawa	Rayna
Particle distribution Size	Sand	%	12.8	5.3
	Silt		50	60
	Clay		37.2	34.7
Soil texture			Silty clay loam	Silty clay loam
Soil pH			7.90	7.62
ECe		dSm^{-1}	0.4	0.5
Organic matter content		%	1.0	0.5
Total nitrogen		%	0.11	0.05
Available Phosphorous		ppm	22.5	7.5
Potassium		ppm	148	110

***The soil properties tests were conducted at the Directorate of Agriculture Research Center-Erbil.**

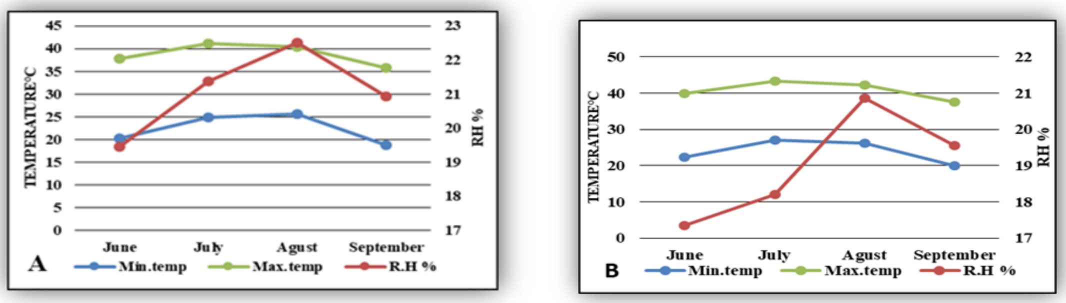


Fig. 2. Metrological data recorded at A. Saruchawa B. Ranya location during growing season 2021.

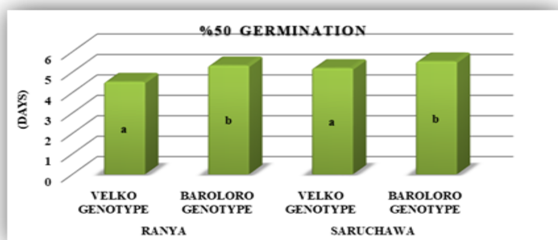
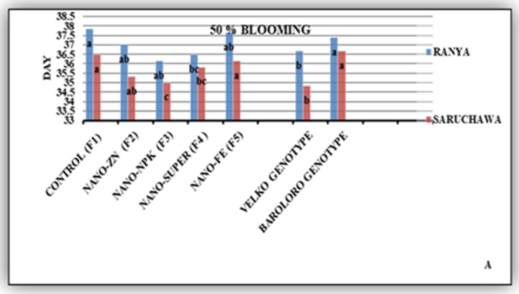


Fig .3. Period from sowing to emergence as affected by sunflower genotypes.



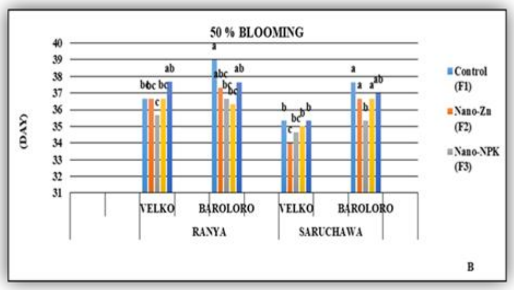
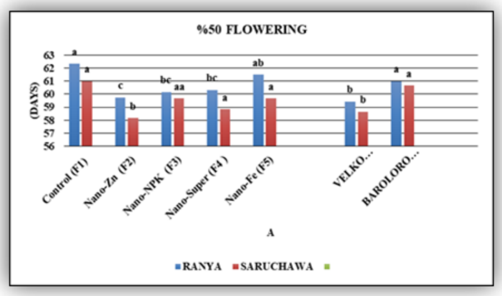


Fig. 4. Effect of sunflower genotypes, Nanofertilizer and their interactions to period for % 50 blooming, A = genotype, and type of fertilizers, B= two-factor interactions.



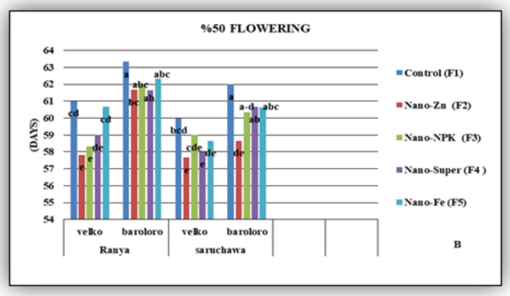
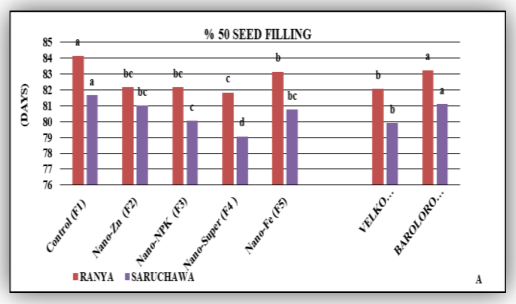


Fig. 5. Effect of sunflower genotypes, Nanofrtilizer and their interactions to period for % 50 flowering, A = genotype, and type of fertilizers, B= two-factor interactions



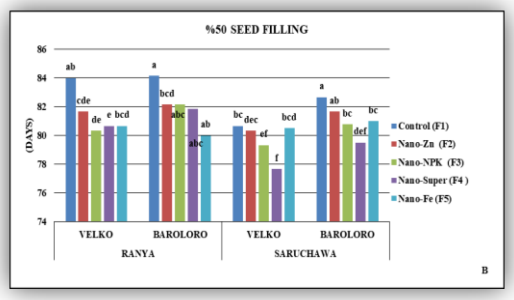


Fig. 6. Effect of sunflower genotypes, Nano fertilizer and their interactions to period for 50 % seed filling A = genotype, and type of fertilizers, B= two-factor interactions

Table 2. Effect of sunflower genotypes,Nano fertilizer and their interactions on leaf area (cm^2).

Fertilizer treatment types			Control (F_1)	Nano-Zn (F_2)	Nano -NPK (F_3)	Nano Super (F_4)	Nano-Fe (F_5)	Mean of genotype
Locations	Ranya	Velko	44.02^f	48.41^d	50.6^c	61.12^a	42.04^g	49.21^a
		Baroloro	32.61^j	40.94^h	46.0^e	51.16^b	35.58^i	41.27^b
	Fertilizer types mean		37.32^e	44.67^c	48.3^b	56.11^a	39.80^d	
	Saruchawa	Velko	49.64^f	53.91^d	56.9^c	65.78^a	49.93^f	55.23^a
		Baroloro	37.38^i	43.55^g	50.7^e	57.67^b	38.18^h	45.51^b
	Fertilizer types mean		43.51^e	48.73^d	53.8^b	61.72^a	44.05^d	

Values with different letters within columns indicate significant differences at 5% according to Duncan's multiple range test.

Table 3. Effect of sunflower genotypes,Nano fertilizer and their interactions on leaf area index.

Fertilizer treatment types			Control (F_1)	Nano-Zn (F_2)	Nano -NPK (F_3)	Nano Super (F_4)	Nano -Fe (F_5)	Mean of genotype
Locations	Ranya	Velko	0.92^{f}	1.06^{c}	1.11^{b}	1.34^{a}	0.97^{e}	1.08^{a}
		Baroloro	0.72^{i}	0.90^{g}	1.01^{d}	1.12^{b}	0.78^{h}	0.91^{b}
	Fertilizer types mean		0.82^{e}	0.98^{c}	1.06^{b}	1.23^{a}	0.87^{d}	
	Saruchawa	Velko	1.09^{f}	1.18^{d}	1.25^{c}	1.45^{a}	1.10^{f}	1.21^{a}
		Baroloro	0.82^{h}	0.96^{g}	1.12^{e}	1.27^{b}	0.84^{i}	1.00^{b}
	Fertilizer types mean		0.96^{d}	1.07^{c}	1.18^{b}	1.36^{a}	0.97^{d}	

Values with different letters within columns indicate significant differences at 5% according to Duncan's multiple range test.

Table 4. Effect of sunflower genotypes,Nano fertilizer and their interactions on head diameter (cm).

Fertilizer treatment types			Control (F_1)	Nano-Zn (F_2)	Nano-NPK (F_3)	Nano Super (F_4)	Nano-Fe (F_5)	Mean of genotype
Locations	Ranya	Velko	10.50^{c}	10.60^{c}	11.76^{b}	12.15^{a}	11.49^{b}	11.30^{a}
		Baroloro	9.58^{d}	9.87^{d}	10.66^{c}	11.38^{b}	10.67^{c}	10.47^{b}
	Fertilizer types mean		10.04^{c}	10.23^{c}	11.21^{b}	11.76^{a}	11.08^{b}	
	Saruchawa	Velko	10.50^{f}	11.70^{d}	12.34^{c}	14.13^{a}	12.22^{c}	12.18^{a}
		Baroloro	10.21^{g}	11.62^{de}	11.42^{c}	12.96^{b}	11.41^{e}	11.52^{b}
	Fertilizer types mean		10.35^{d}	11.66^{c}	11.88^{b}	13.55^{a}	11.81^{bc}	

Values with different letters within columns indicate significant differences at 5% according to Duncan's multiple range test.

Table 5. Effect of sunflower genotypes,Nano fertilizer and their interactions on head weight (g).

Fertilizer treatment types			Control (F_1)	Nano-Zn (F_2)	Nano-NPK (F_3)	Nano Super (F_4)	Nano-Fe (F_5)	Mean of genotype
Locations	Ranya	Velko	122.30^{h}	165.15^{ed}	175.30^{c}	195.30^{a}	163.19^{e}	164.29^{a}
		Baroloro	114.39^{j}	158.00^{f}	167.20^{d}	187.17^{b}	141.10^{g}	153.57^{b}
	Fertilizer types mean		118.34^{e}	161.57^{c}	171.35^{b}	191.23^{a}	152.14^{d}	
	Saruchawa	Velko	111.97^{j}	159.17^{g}	235.27^{b}	259.95^{a}	164.32^{f}	187.75^{a}
		Baroloro	120.05^{i}	187.25^{e}	195.03^{d}	230.48^{c}	149.17^{h}	174.77^{b}
	Fertilizer types mean		116.01^{e}	173.21^{c}	215.15^{b}	245.21^{a}	156.72^{d}	

Values with different letters within columns indicate significant differences at 5% according to Duncan's multiple range test.

Table 6. Effect of sunflower genotypes,Nano fertilizer and their interactions on seed index (g).

Fertilizer treatment types			Control (F_1)	Nano-Zn (F_2)	Nano-NPK(F_3)	Nano Super (F_4)	Nano-Fe (F_5)	Mean of genotype
Locations	Ranya	Velko	58.08^{f}	62.80^{d}	69.57^{b}	70.35^{a}	61.50^{e}	64.47^{a}
		Baroloro	55.08^{g}	60.88^{e}	67.02^{c}	69.85^{ab}	60.79^{e}	62.70^{b}
	Fertilizer types mean		57.96^{d}	61.84^{c}	67.93^{b}	60.05^{a}	61.15^{c}	
	Saruchawa	Velko	62.32^{ef}	64.95^{d}	71.21^{b}	74.17^{a}	64.90^{d}	67.51^{a}
		Baroloro	61.22^{f}	63.26^{e}	69.80^{c}	70.42^{b}	62.35^{ef}	65.41^{b}
	Fertilizer types mean		61.77^{d}	64.10^{c}	70.50^{b}	72.29^{a}	63.62^{c}	

Values with different letters within columns indicate significant differences at 5% according to Duncan's multiple range test.

Table 7. Effect of sunflower genotypes,Nano fertilizer and their interactions on seed yield (g).

Fertilizer treatment types			Control (F_1)	Nano-Zn (F_2)	Nano-NPK(F_3)	Nano Super (F_4)	Nano-Fe (F_5)	Mean of genotype
Locations	**Ranya**	**Velko**	**4.90^{f}**	**5.20^{de}**	**5.42^{c}**	**5.84^{a}**	**5.16^{e}**	**5.30^{a}**
		Baroloro	**4.84^{f}**	**4.92^{f}**	**5.26^{d}**	**5.62^{b}**	**4.85^{f}**	**5.10^{b}**
	Fertilizer types mean		**4.63 ^{g}**	**5.48^{c}**	**5.78 ^{b}**	**5.93^{a}**	**5.01 ^{d}**	
	Saruchawa	**Velko**	**4.63^{g}**	**5.48^{c}**	**5.78^{b}**	**5.93^{a}**	**5.22^{d}**	**5.41^{a}**
		Baroloro	**4.26^{h}**	**5.12^{e}**	**5.50^{c}**	**5.79^{b}**	**4.95^{f}**	**5.12^{b}**
	Fertilizer types mean		**4.44^{e}**	**5.30^{c}**	**5.64 ^{b}**	**5.86^{a}**	**5.08 ^{d}**	

Values with different letters within columns indicate significant differences at 5% according to Duncan's multiple range test.

Table 8. Effect of sunflower genotypes,Nano fertilizer and their interactions to oil %.

Fertilizer treatment types			Control (F_1)	Nano-Zn (F_2)	Nano-NPK (F_3)	Nano Super (F_4)	Nano-Fe (F_5)	Mean of genotype
Locations	**Ranya**	**Velko**	**35.03^{i}**	**36.17^{g}**	**36.83^{c}**	**37.93^{a}**	**36.44^{e}**	**36.41^{a}**
		Baroloro	**33.64 j**	**35.87^{h}**	**36.65^{d}**	**37.60^{b}**	**36.25^{f}**	**36.06^{b}**
	Fertilizer types mean		**34.33^{e}**	**36.01^{d}**	**36.73^{b}**	**37.76^{a}**	**36.34^{c}**	
	Saruchawa	**Velko**	**36.19^{g}**	**37.44 ^{d}**	**37.66^{c}**	**38.61^{a}**	**37.23^{e}**	**37.42^{a}**
		Baroloro	**35.30^{j}**	**35.94^{h}**	**36.98^{f}**	**38.57^{b}**	**35.80^{i}**	**36.53^{b}**
	Fertilizer types mean		**35.75 ^{e}**	**36.69^{c}**	**37.32^{b}**	**38.60^{a}**	**36.50^{d}**	

Values with different letters within columns indicate significant differences at 5% according to Duncan's multiple range test.

Table 9. Effect of sunflower genotypes,Nano fertilizer and their interactions to protein %.

Fertilizer treatment types			Control (F_1)	Nano-Zn (F_2)	Nano-NPK(F_3)	Nano Super (F_4)	Nano-Fe (F_5)	Mean of genotype
Locations	**Ranya**	**Velko**	**15.97^{f}**	**21.63^{b}**	**20.03^{c}**	**24.50^{a}**	**17.03^{e}**	**19.82^{a}**
		Baroloro	**12.66 ^{j}**	**13.97^{h}**	**15.16^{g}**	**18.03^{d}**	**13.47^{i}**	**14.66^{b}**
	Fertilizer types mean		**14.31^{d}**	**19.24^{b}**	**17.59^{c}**	**19.83^{a}**	**15.25^{bc}**	
	Saruchawa	**Velko**	**17.44^{g}**	**20.19^{d}**	**22.25^{c}**	**24.25^{a}**	**18.41^{f}**	**20.50^{a}**
		Baroloro	**14.63^{i}**	**18.65^{e}**	**20.31^{d}**	**22.56^{b}**	**16.97^{h}**	**18.62^{b}**
	Fertilizer types mean		**16.03^{e}**	**19.42^{c}**	**21.28^{b}**	**23.40^{a}**	**17.69^{d}**	

Values with different letters within columns indicate significant differences at 5% according to Duncan's multiple range test.

5. CONCLUSIONS

Sunflower growth, yield and quality are impacted by genotypes, Velko genotype surprise Baroloro in most of the studied traits, additionally Super Nano-fertilizer were superior in their role in increasing growth, yield and quality of sunflower. The highest values for the studied sunflower characters were recorded at the Saruchawa location in comparison with Ranya, this may be due to the difference between soil fertility and the environmental condition of the studied locations.

Acknowledgements:

I would like to thank University of Raparin staff for their help in preparing the field, and equipment during the research period. Then, I would like to thank my academic supervisor, Assist. Prof. Bahar Jalal Mahmood, for her prudent guidance, encouragement, understanding, and advice during my studies. Moreover , I would like to thank my husband, for his continued help and support. Also, special thanks to Dr. Abdul Munem for providing the Nano fertilizers.

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