J Nanostruct 16(1): 938-944, Winter 2026

RESEARCH PAPER

Effect of Organic and Nano Fertilizers on Growth and Yield Attributes of Fenugreek (Trigonella Foenum-Graecum L.)

Marwa Mhaibis Thijee *, Wasan Hamza Al-Shammeryi

Department of Biology, College of Science, Wasit University, Wasit, Iraq

ARTICLE INFO

Article History:
Received 24 August 2025
Accepted 24 December 2025
Published 01 January 2026

Keywords:
Fenugreek
Foliar application
Nano-fertilizer
Organic fertilizer
Trigonella foenum-graecum L

ABSTRACT

A field experiment was conducted at the College of Science, Wasit University, during the growing season from November 2024 to February 2025 to investigate the influence of foliar applications of organic and nano-fertilizers on fenugreek (*Trigonella foenum-graecum* L.). The study followed a design to compare fertilized plants against a non-fertilized control group. The results demonstrated that the application of both fertilizer types significantly enhanced vegetative and physiological characteristics. Notable increases were recorded in average leaf surface area, stem diameter, and total chlorophyll content. Furthermore, the yield quality improved, evidenced by higher percentages of oil and protein. Interestingly, the synergistic effect of combining organic and nano-fertilizers yielded the most superior results, showing statistically significant differences over individual treatments and the control. In conclusion, the foliar application of organic and nano-fertilizers serves as an effective growth promoter, substantially boosting the vegetative growth and yield attributes of fenugreek.

How to cite this article
Thijee M., Al-Shammeryi W. Effect of Organic and Nano Fertilizers on Growth and Yield Attributes of Fenugreek (Trigonella Foenum-Graecum L.). J Nanostruct, 2026; 16(1):938-944. DOI: 10.22052/JNS.2026.01.083

INTRODUCTION

Fenugreek (*Trigonella foenum-graecum* L.) is a significant annual herbaceous plant belonging to the Fabaceae (legume) family. The etymology of its name reflects its botanical features and historical utility; the genus name, *Trigonella*, is derived from the Greek word for ‘little triangle’, referring to the characteristic triangular appearance of its flowers. The species epithet, *foenum-graecum*, translates to ‘Greek hay,’ indicating its long-standing use as a forage and fodder crop since the era of ancient Greek civilization [1].

Globally, fenugreek seeds are extensively used as a spice and condiment to impart a distinctive flavor to various cuisines [2]. Beyond its seeds, the plant is cultivated for its fresh or dried leaves for human consumption and as high-quality livestock fodder. Fenugreek leaves are highly valued for their nutritional profile, being rich in essential nutrients such as iron, calcium, vitamins, proteins, and essential amino acids [3].

Fenugreek holds considerable medicinal value and has been a staple in the traditional medicine of many East Asian countries for centuries. It is traditionally used to treat ailments such as constipation and indigestion, and to stimulate metabolism [3]. The plant’s high nutritional quality

* *Corresponding Author Email: std2023204.mkhfaif@uowasit.edu.iq*

is attributed to its rich composition of proteins, carbohydrates, and fiber. Its mineral content includes key elements like iron, phosphorus, and calcium, along with various vitamins (e.g., Vitamin A, B-complex, C, and E) [4]. Furthermore, the seeds contain fixed and volatile oils, mucilaginous substances, and several bioactive compounds. The medicinal properties are largely attributed to alkaloids such as trigonelline and choline, in addition to saponins and nicotinic acid [5].

Fertilization is a critical factor in modern agricultural management, significantly impacting both crop quality and quantity [6]. However, the excessive and inefficient use of traditional synthetic chemical fertilizers—especially bulk macronutrients (NPK)—has led to environmental degradation, including soil degradation and water pollution [7]. To address these concerns, two advanced and sustainable fertilization approaches have gained prominence:

- Nano-Fertilizers: Utilizing nutrients in their nano-form is an economically and environmentally viable strategy. The ultra-small particle size allows for lower application rates and a slow-release mechanism, thereby increasing Nutrient Use Efficiency (NUE) and ensuring environmental safety [7, 8].
- Organic Fertilizers: In line with the growing interest in organic agriculture and food safety, there is a global shift away from synthetic inputs. Organic fertilizers, particularly soluble formulations containing amino acids, are highly recommended. As protein precursors and organic nitrogen sources, these fertilizers accelerate vegetative growth and productivity by playing a vital role in protein synthesis [9].

The application of nano-fertilizers represents a modern technological innovation aimed at boosting agricultural output while reducing costs. These materials offer flexibility in application, whether applied to the soil or as a foliar spray [10]. Foliar application is often preferred over soil application due to the rapid delivery of nutrients, ease of absorption through leaf stomata, and immediate response to the plant's physiological needs [11].

Given the limitations of traditional fertilization and the potential offered by sustainable systems, this study aims to evaluate the effects of foliar application of organic and nano-fertilizers on the growth and yield attributes of Fenugreek, specifically focusing on leaf surface area, stem diameter, total chlorophyll content, and the percentage of oil and protein.

MATERIALS AND METHODS

The field experiment was conducted during the 2024–2025 agricultural season at the Department of Biology, College of Science, Wasit University, Iraq. The study utilized 75 experimental pots, each containing 10 kg of a standardized soil mixture. The experiment was structured as a Factorial experiment according to a Completely Randomized Design (CRD). This design was selected to evaluate the individual and interactive effects of organic and nano-fertilizer treatments under uniform environmental conditions.

Crop Cultivation

On November 1, 2024, ten seeds of fenugreek (*Trigonella foenum-graecum* L.) were sown per pot at a depth of 3–5 cm in the upper third of the soil mixture. After successful germination (approximately two weeks later), the seedlings were thinned to establish a final stand of three healthy plants per pot. All pots were routinely watered as required.

Treatment Factors and Application

The study involved two main treatment factors, both applied as foliar sprays:

1. Organic Fertilizer (O): Applied at five concentrations (0, 5, 10, 15, and 20 ml/L).
2. Nano-Fertilizer (N): Applied at five concentrations (0, 5, 10, 15, and 20 ml/L). Each treatment combination was replicated three times (3 replicates × 25 treatment combinations = 75 pots

Foliar Application

The foliar spraying process commenced on December 12, 2024. The treatments were applied in the early morning to ensure optimal absorption, continuing until the entire leaf surface of the plants was thoroughly covered. A second, identical foliar application was administered two weeks after the first treatment.

Data Collection and Measured Parameters

Data collection for the growth and yield attributes began two weeks following the second fertilizer application. The following parameters were measured::

1. Leaf Surface Area (cm^2): Measured using

the gravimetric method or by applying the formula based on leaf length and width as described by[12].

2. Stem Diameter (mm): Measured at the second internode from the soil surface using a digital vernier caliper[13].

3. Total Chlorophyll Content (SPAD): Determined using a portable chlorophyll meter (SPAD-502), which provides a non-destructive estimate of leaf chlorophyll concentration [14] [15].

4. Oil Percentage (%): The oil content was extracted from dried seeds using the Soxhlet apparatus with hexane as a solvent, following the official methods of analysis [16].

5. Protein Percentage (%): Total nitrogen content was determined using the Micro-Kjeldahl method. The protein percentage was then calculated by multiplying the nitrogen content by a factor of 6.25[16].

Statistical Analysis

The collected data were analyzed using Analysis of Variance (ANOVA) based on the Completely Randomized Design (CRD). To identify significant differences between the treatment means, the Least Significant Difference (LSD) test was applied at a probability level of 0.05[17].

RESULTS AND DISCUSSION

Determination of Average Leaf Surface Area (cm²/plant⁻¹)

The data in Table 1 showed that both organic fertilizer and nano-fertilizer significantly influenced the average leaf surface area, with a clear trend of increasing leaf area as the concentration of each fertilizer increased.

The mean leaf surface area increased progressively from 7.633 cm² in the control treatment (0% organic fertilizer) to 9.873 cm² at the highest level (20 ml/L organic fertilizer). This represents an increase of 29.3% compared to the control.

Similarly, nano-fertilizer application resulted in a steady increase in leaf surface area, from 7.307 cm² in the control (0 ml/L nano-fertilizer) to 9.700 cm² at the highest concentration (20 ml/L nano-fertilizer). This corresponds to an improvement of 32.7% over the control.

The interaction between organic fertilizer and nano-fertilizer was also significant (LSD at P=0.05 = 0.7310), indicating that the combined application produced effects beyond the sum of their individual impacts. The smallest mean value (7.000 cm²) was observed in the absence of both fertilizers (O_oN_o), while the largest value (10.867 cm²) was recorded when combining the highest organic fertilizer level (20ml/L) with the highest nano-fertilizer concentration (20 ml/L), showing an increase of 55.3% compared to the control.

Determination of Average stem diameter (mm)

The data in Table 2 indicated that both organic fertilizer and nano-fertilizer significantly influenced the average, stem diameter with a clear trend of increasing stem diameter as the concentration of

Table 1. Effect of Nano -fertilizer and Organic fertilizer and the interactions between them on average of the Average Leaf Surface Area.

Organic fertilizer (0)	Nano -fertilizer					Average of organic fertilizer (O)
	0	5 ml/L	10 ml/L	15 ml/L	20 ml/L	
0	7.000	7.267	7.633	7.833	8.433	7.633
5ml/L	7.433	8.167	8.700	8.433	8.867	8.320
10ml/L	7.100	8.600	9.333	9.600	9.700	8.867
15ml/L	7.100	8.833	9.733	10.333	10.633	9.327
20ml/L	7.900	9.300	10.500	10.800	10.867	9.873
Average of Nano -fertilizer	7.307	8.433	9.180	9.400	9.700	Nano -fertilizer
LSD (P=0.05)			0.3269			LSD (P=0.05) 0.3269
Two-way interaction LSD (P=0.05)			0.7310			

each fertilizer increased.

The mean stem diameter increased progressively from 1.820 mm in the control treatment (0ml/L organic fertilizer) to 4.180mm at the highest level (20ml/Lorganic fertilizer). This represents an increase of 129.6% compared to the control.

Similarly, nano-fertilizer application resulted in a steady increase in stem diameter, from 2.100 mm in the control (0 ml/L nano-fertilizer) to 3.687 mm at the highest concentration (20 ml/L nano-fertilizer). This corresponds to an improvement of 75.5% over the control.

The interaction between organic fertilizer and nano-fertilizer was also significant (LSD at P=0.05 = 0.1782), indicating that the combined application produced effects beyond the sum of their individual impacts. The smallest mean value (1.567 mm) was observed in the absence of both fertilizers (O_0N_0), while the largest value (4.687 mm) was recorded when combining the highest organic fertilizer level (20ml/L) with the highest nano-fertilizer concentration (20 ml/L), showing an increase of 210.5% compared to the control.

Determination Average of total chlorophyll (µmol m^{-2})

The data in Table 3 demonstrated that both organic fertilizer and nano-fertilizer significantly influenced the average, total chlorophyll with a

Table 2. Effect of Nano -fertilizer and Organic fertilizer and the interactions between them on average of the stem diameter.

Organic fertilizer (0)	Nano -fertilizer					Average of organic fertilizer (O)
	0	5 ml/L	10 ml/L	15 ml/L	20 ml/L	
0	1.567	1.633	1.833	1.867	2.200	1.820
5 ml/L	1.700	1.767	1.833	2.500	2.767	2.113
10 ml/L	1.800	2.133	3.600	3.733	3.833	3.020
15 ml/L	2.667	3.767	4.267	4.600	4.767	4.013
20 ml/L	2.767	3.676	4.667	4.833	4.867	4.180
Average of Nano -fertilizer	2.100	2.613	3.240	3.507	3.687	Nano -fertilizer
LSD (P=0.05)			0.0797			LSD (P=0.05) 0.0797
Two-way interaction LSD (P=0.05)				0.1782		

Table 3. Effect of Nano -fertilizer and Organic fertilizer and the interactions between them on average of the total chlorophyll.

Organic fertilizer (0)	Nano -fertilizer					Average of organic fertilizer (O)
	0	5 ml/L	10 ml/L	15 ml/L	20 ml/L	
0	11.63	13.33	13.90	15.30	15.53	13.94
5 ml/L	14.07	15.43	17.30	17.67	18.47	16.59
10 ml/L	16.83	17.83	19.17	19.10	20.90	18.77
15 ml/L	18.53	20.60	22.33	22.63	23.53	21.53
20 ml/L	20.03	23.40	23.77	24.27	25.00	23.29
Average of Nano -fertilizer	16.22	18.12	19.29	19.79	20.69	Nano -fertilizer
LSD (P=0.05)			0.714			LSD (P=0.05) 0.714
Two-way interaction LSD (P=0.05)				1.596		

clear trend of increasing total chlorophyll as the concentration of each fertilizer increased.

The mean total chlorophyll increased progressively from 13.94 µmol / m^{-2} in the control treatment (0ml/L organic fertilizer) to 23.29 µmol / m^{-2} at the highest level (20ml/L organic fertilizer). This represents an increase of 67.07% compared to the control.

Similarly, nano-fertilizer application resulted in a steady increase in total chlorophyll, from 16.22 µmol / m^{-2} in the control (0 ml/L nano-fertilizer) to 20.69 µmol / m^{-2} at the highest concentration (20 ml/L nano-fertilizer). This corresponds to an improvement of 27.55% over the control.

The interaction between organic fertilizer and nano-fertilizer was also significant (LSD at P=0.05 = 0.596), indicating that the combined application produced effects beyond the sum of their individual impacts. The smallest mean value (11.63 µmol / m^{-2}) was observed in the absence of both fertilizers (O_0N_0), while the largest value (25.00 µmol / m^{-2}) was recorded when combining the highest organic fertilizer level (20ml/L) with the highest nano-fertilizer concentration (20 ml/L), showing an increase of 114.96% compared to the control.

Determination the percentage of oil(%)

The data in Table 4 demonstrated that both nano-fertilizer and organic fertilizer significantly influenced the percentage of oil. The LSD value at P ≤ 0.05 was 0.0661, which confirms that differences greater than this value are statistically significant.

As the level of nano-fertilizer increased from 0 to 20ml/L, the average number of percentage of oil consistently increased across all levels of organic fertilizer. The highest number of percentage of oil (4.963%) was recorded with the combination of 20 ml/L organic fertilizer and 20 ml/L nano-fertilizer, while the lowest (0.793) was observed in the control treatment (0 organic, 0 nano).

The average values for nano-fertilizer treatments show a clear upward trend:

Similarly, the average number of oil percentage also increased with organic fertilizer application:

The two-way interaction LSD value was 0.1479, and many combinations show differences exceeding this, confirming a significant interaction between the two factors.

Determination percentage of protein (%)

The data in Table 5 presented that both nano-fertilizer and organic fertilizer significantly influenced the percentage of protein. The LSD value at P ≤ 0.05 was 0.0924, which confirms that differences greater than this value are statistically significant.

As the level of nano-fertilizer increased from 0 to 20ml/L, the average number of percentage of protein consistently increased across all levels of organic fertilizer. The highest number of percentage of protein (20.837%) was recorded with the combination of 20 ml/L organic fertilizer and 20 ml/L nano-fertilizer, while the lowest (12.350%) was observed in the control treatment (0 organic, 0 nano).

Table 4. Effect of Nano -fertilizer and Organic fertilizer and the interactions between them on average of the oil percentage.

Organic fertilizer (0)	Nano -fertilizer					Average of organic fertilizer (O)
	0	5 ml/L	10 ml/L	15 ml/L	20 ml/L	
0	0.793	0.970	1.260	1.413	1.780	1.243
5 ml/L	1.900	1.950	2.310	2.573	2.780	2.303
10 ml/L	1.707	1.923	2.970	3.180	3.560	2.668
15 ml/L	1.693	1.950	3.557	3.727	3.950	2.975
20 ml/L	2.610	3.480	4.660	4.947	4.963	4.132
Average of Nano -fertilizer	1.741	2.055	2.951	3.168	3.407	Nano -fertilizer
LSD (P=0.05)			0.0661			LSD (P=0.05) 0.0661
Two-way interaction LSD (P=0.05)				0.1479		

Table 5. Effect of Nano -fertilizer and Organic fertilizer and the interactions between them on average of the protein percentage.

Organic fertilizer (0)	Nano -fertilizer					Average of organic fertilizer (O)
	0 ml/L	5 ml/L	10 ml/L	15 ml/L	20 ml/L	
0	12.350	12.517	13.470	13.817	17.263	13.883
5 ml/L	13.450	15.220	17.410	17.840	17.877	16.359
10 ml/L	13.913	15.643	15.887	16.497	16.850	15.758
15 ml/L	14.850	15.713	15.883	17.760	17.917	16.425
20 ml/L	15.930	17.710	18.813	20.403	20.837	18.739
Average of Nano -fertilizer	14.099	15.361	16.293	17.263	18.149	Nano -fertilizer
LSD (P=0.05)	0.0924					LSD (P=0.05)
						0.0924
Two-way interaction LSD (P=0.05)	0.2067					

The average values for nano-fertilizer treatments show a clear upward trend:

Similarly, the average number of protein percentage also increased with organic fertilizer application:

The two-way interaction LSD value was 0.2067, and many combinations show differences exceeding this, confirming a significant interaction between the two factors.

A study found that the application of nano-fertilizers led to a significant increase in leaf area due to enhanced nutrient absorption and better physiological responses in plants [18]. Similarly,[19] observed that combining organic and nano fertilizers improved photosynthetic activity, leading to increased biomass and leaf expansion.

A study demonstrated that nano-fertilizers enhance the availability and uptake efficiency of nutrients at the cellular level, contributing to better leaf development [20]. The organic matter, on the other hand, improves soil structure and microbial activity, as reported by [21], which may further Improve the efficiency of plant absorption of nutrients.The extract may contain growth regulators that are related and followed in stimulating cell elongation and expansion of plant tissue which leads to an increase in the diameter of the stem and the number of leaves this increase is due to the speed of the photosynthesis process in the plant [22].

According to [23], the reason for the increase the percentage of chlorophyll in the leaves, this may be because foliar spraying quickly adds nutrients through the stomata in the leaves, helping to speed up and maintain the flow of nutrients and elements needed for plant metabolic processes, such as the production of chlorophyll pigments. These findings are consistent with those for fenugreek repoted by [24] they demonstrated that The reason for the increase in the percentage of protein,alkaloids, this may be because conventional fertilizers only last 10 to 12 days, while nanofertilizers provide nutrients to plants for up to 50 days. As a result, plants have the opportunity to grow for an estimated five times longer. Comparable increases in oil percentage under nano fertilizer application were also documented by [25]in crop plants, this may be because nanofertilizers provide the plant with a larger surface area and make nutrients more available, which can help improve certain quality parameters (such as protein, oil, and sugar content) by accelerating the plant's reaction or synthesis.

It was indicated that foliar nutrition is most suitable for plants in arid and semi-arid areas, and is more suitable compared to adding it to the soil when free radicals are unable to provide the necessary elements [26].

CONCLUSION

In conclusion, the study investigated effects of organic and nano-fertilizers on fenugreek growth parameters, including leaf surface area, stem diameter, chlorophyll content, oil percentage, and protein percentage. The factorial experiment utilized a completely randomized design across 75 pots, revealing that both fertilizers, especially when applied in combination at higher concentrations, led to remarkable improvements in all measured attributes. Specifically, the highest combined application (20 ml/L of both fertilizers) resulted in a 55.3% increase in leaf area and a 210.5% increase in stem diameter compared to the control. Additionally, enhancements in total chlorophyll and nutrient content suggest improved photosynthetic activity and nutrient absorption efficiency, attributed to the physical and biological interactions facilitated by the fertilizers. These findings underscore the potential of integrated fertilization strategies to optimize crop yield and quality, particularly in arid regions where traditional fertilization may be less effective.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

REFERENCES

1. Martin E, Akan H, Ekici M, Aytac Z. Karyotype analysis of ten sections of Trigonella (Fabaceae). Comparative Cytogenetics. 2011;5(2):105-121.
2. Das B, Sarkar PK, Dhakar MK, Naik SK, Maurya S, Singh AK, et al. Basin enrichment of bael plants (Aegle marmelos Correa) through alley cropping of biomass producing plants: Effects on plant growth and soil properties. Fruits. 2021;76(2):61-71.
3. Vyas N, Choudhary B, Purohit M. Community Analysis of Plant Parasitic Nematodes in and Around Bilara, Rajasthan. The Scientific Temper. 2022;13(01):51-54.
4. Sarwar S, Hanif MA, Ayub MA, Boakye YD, Agyare C. Fenugreek. Medicinal Plants of South Asia: Elsevier; 2020. p. 257-271.
5. Sulieman AME, Ali AO, Hemavathy J. Lipid content and fatty acid composition of fenugreek (Trigonella foenum-graecum L.) seeds grown in Sudan. International Journal of Food Science and Technology. 2008;43(2):380-382.
6. Lowe SB, Wilson LA. Yield and Yield Components of Six Sweet Potato (Ipomoea batatas) Cultivars I. Contribution of Yield Components to Tuber Yield. Exp Agric. 1975;11(1):39-48.
7. Advances in Nano-Fertilizers and Nano-Pesticides in Agriculture: Elsevier; 2021.
8. Al-Juthery HWA, Lahmod NR, Al-Taee RAHG. Intelligent, Nano-fertilizers: A New Technology for Improvement Nutrient Use Efficiency (Article Review). IOP Conference Series: Earth and Environmental Science. 2021;735(1):012086.
9. Frary A. Plant Physiology and DevelopmentPlant Physiology and Development edited by Lincoln Taiz, Eduardo Zeiger, Ian Max Moller, and Angus Murphy. 2014. . ISBN 978-1-60535-255-8 $123.96 (casebound); $80.58 (looseleaf). Sinauer Associates Inc., Sunderland, MA. Rhodora. 2015;117(971):397-399.
10. Duhan JS, Kumar R, Kumar N, Kaur P, Nehra K, Duhan S. Nanotechnology: The new perspective in precision agriculture. Biotechnology Reports. 2017;15:11-23.
11. Micro/Nanofertilizers for Sustainable Agriculture: A Review. American Chemical Society (ACS).
12. Watson DJ. The Physiological Basis of Variation in Yield. Advances in Agronomy: Elsevier; 1952. p. 101-145. http://dx.doi.org/10.1016/s0065-2113(08)60307-7
13. W. R. Al-Karawi A, M. A. Al-Jumaily J. Study of Some Growth Criteria and Yield of Soybean Crop with the Effect Of Boron And Some Growth Regulators. iraq journal of market research and consumer protection. 2022;14(1):137-145.
14. Arnon DI. Copper Enzymes in Isolated Chloroplasts. Polyphenoloxidase in Beta Vulgaris. Plant Physiol. 1949;24(1):1-15.
15. Yadava UL. A Rapid and Nondestructive Method to Determine Chlorophyll in Intact Leaves. HortScience. 1986;21(6):1449-1450.
16. Official Methods of Analysis. Official Methods of Analysis of AOAC INTERNATIONAL: Oxford University Press; 2023.
17. Robinson HF. Principles and Procedures of Statistics. Agron J. 1961;53(5).
18. Ahmad T, Khan R, Nawaz Khattak T. Effect of humic acid and fulvic acid based liquid and foliar fertilizers on the yield of wheat crop. J Plant Nutr. 2018;41(19):2438-2445.
19. Jjagwe J, Chelimo K, Karungi J, Komakech AJ, Lederer J. Comparative Performance of Organic Fertilizers in Maize (Zea mays L.) Growth, Yield, and Economic Results. Agronomy. 2020;10(1):69.
20. El-Maaty HMAA, El-Khateeb AY, El-Khateeb AY, El-Naggar AS, El-Naggar AS, Sherif SK, et al. Performance of Hybrid Chickens as Influenced by Phytogenic Extracted Meal-Supplemented Diet as Antibiotic Alternatives During Summer. J Agric Sci. 2018;10(7):471.
21. Badu Brempong M, Addo-Danso A. Improving Soil Fertility with Organic Fertilizers. New Generation of Organic Fertilizers: IntechOpen; 2022.
22. Talebi R, Karami E. Morphological and physiological traits associated with seed yield in different chickpea (Cicer arietinum L.) genotypes under irrigated andwaterâ€deficit environments. South Asian Journal of Experimental Biology. 2011;1(6):260-267.
23. D. Udhaya Nandhini MR, Suganthi S. Supplementation of Mineral Nutrients through Foliar Spray-A Review. International Journal of Current Microbiology and Applied Sciences. 2017;6(3):2504-2513.
24. Alaawad NA-HS, Alrubaie SAF. Relationship of Planting Dates and Spraying with Conventional and Nano NPK Fertilizer to some Secondary Metabolite Traits of Fenugreek Plant Trigonella foenum-graecum. IOP Conference Series: Earth and Environmental Science. 2023;1225(1):012024.
25. Qureshi A, Singh DK, Dwivedi S. Nano-fertilizers: A Novel Way for Enhancing Nutrient Use Efficiency and Crop Productivity. International Journal of Current Microbiology and Applied Sciences. 2018;7(2):3325-3335.
26. Ehmke T. WATER management strategies under water-limited conditions. Crops and Soils. 2018;51(3):16-19.