JOURNAL LA LIFESCI

VOL. 05, ISSUE 04 (323-338), 2024
DOI: 10.37899/journallalifesci.v5i4.1267

Role of NPK Fertilizer and Planting Ates on the Vegetative and Flowering Growth Tributes of Two Varieties of Snake Melon

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Article Info

Article history:
Received 9 May 2024
Received in revised from 27 June 2024
Accepted 12 July 2024

Keywords:
NPK Fertilizer
Planting Dates
Varieties

Abstract

The purpose of this research was to determine the response of two varieties of snake melon to the levels of NPK fertilizer and planting dates in terms of vegetative and flowering growth characters. The experiment was conducted in the vegetable field of the Department of Horticulture and Landscape Engineering/College of Agriculture and Forestry University of Mosul during the spring season 2023. The study included three factors. The first factor: Two local cucumber varieties: (gennxt and Mosli). The second factor was compound fertilizer (NPK) at four levels (270, 180, 90.0 kg/ha!) and the third factor: planting dates. Two planting dates were chosen: (4/1/2023) and (4/20/2023). Compound fertilizer (NPK) was added to the soil in three stages, the first three weeks after planting and after the plants reached the appropriate size (four true leaves), and the second and third at an interval of 20 days between one stage and the next. Thus, the experiment included 18 treatments (2 x 2 x 4 = 16). With three replications, the experiment was carried out in the field using a factorial experiment according to a randomized complete block design (RCBD), where the treatments were randomly distributed according to the design used in the experiment. The results were analyzed statistically according to the design used, and the means were compared according to Duncan's multinomial test at the probability level of 0.05.

Introduction

Snake cucumber, *Cucumis melo var flexuosus L.*, being a member of the Cucurbitaceae family is known to be indigenous to the Mediterranean region (Walters & Thieret, 1993; Pandey et al., 2010). This crop is grown in Iraq through both spring and fall cultivation, In Iraq, the crop is more grown in the open space, but there is also the use of plastic tunnels and warm greenhouses (AL-Rikabi & AL-Zubaidy, 2021). The fruit in this plant is both eaten fresh and used in salads; it has a unique wrinkled surface and may come in many colours, yellow green, light green (golden), dark green (Pandey et al., 2010). On the botanical side, snake cucumber cannot be confused with watermelon; however, the plant is monoicous, which makes a big difference when cultivating the plant and its productivity (Pangestuti & Arifin, 2018).

These health promoting effects of cucumber fruits reduce the rate of cardiovascular diseases, certain type of cancers, osteoporosis and UV induced skin ailments (Erdman et al., 2009; Fernández-García, 2014; Gayatri et al., 2014). With the implications of these findings, snake cucumber can be considered as another crop that makes an input to the diversity of diets and availabilities of improved health among the people. Therefore analysis of the cultivation of snake cucumber becomes important as the necessity of functional foods remains high.

Significant investigation has supported the positive consequences of NPK form fertilizers on vegetative growth and fruiting efficiency in all cropping patterns. For instance, investigation on the effects of these fertlizers on cucumber crop (Eifediyi & Remison, 2010), rose (Guo et

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

al., 2008), pumpkin (Oloyede et al., 2013), squash (Anwar et al., 2024) and on watermelon (Aluko, 2020; Makinde et al., 2021) show positive effect of these fertilizers on crop performance. Aluko (2020) in his study in Nigeria established that watermelon plants which received NPK 15:15:15 at a rate of 333 kg/ha recorded enhanced vegetative attributes including more number of leaves and bigger size of leaves, taller plants among others. These findings are supported by previous studies of the effects of NPK fertilizers on other crops, which equally demonstrate the ubiquitous nature of the stakes of agricultural output to the application of these fertilizers, regardless of the existing climate conditions (Smith et al., 2019; Keatinge et al., 2001).

Planting time is still another important determinant of crop yields. Kumari et al. (2020) established that some planting dates could improve the vigor of zucchini and enhance the number of female flowers that would lead to improved production. Likewise, Ahmad et al. (2021) elucidated the contingency of vegetative growth and yield on both watermelon variety and planting date, indicating that the former was sensitive to the latter temporal situation.

Based on these realizations it is only reasonable to assume that the two variables are of mutual significance in terms of optimizing crop yield and growth, however understanding that in the context of snake cucumber production in Iraq may be more complex (Ilahy et al., 2022). As such, although similar work has been done in other countries, environmental factors in Iraq and the physical development, flowering behaviors, and fruiting characteristics of *Cucumis melo var flexuosus L.,* it can be stated that the results achieved in other world parts or with other plants can be quite different from the findings obtained in the Iraq conditions (Walusansa et al., 2023). Therefore, it is a proper time and necessary to carry out a detailed study on the performance and/or response of snake cucumber to changes in NPK fertilizer rates and planting dates with regard to the plant and flower characteristics.

Methods

Experimental Design and Sampling

The present investigation was carried out in the vegetable field of the Department of Horticulture and Landscape Engineering, College of Agriculture and Forestry, University of Mosul during the spring season of 2023. In the present study, a factorial experiment was carried out in RCBD, which is acknowledged to be very efficient in minimizing variability within field experiments and maintaining the accuracy of the experiments. The design included three main factors: With variety having its levels, fertilizer level also having its levels and planting date having its levels as well.

Two snake cucumber cultivars commonly grown in the region, 'Gennxt' and 'Mosli,' were used due to their compatibility with the growing conditions of the area and preference among growers. These varieties were selected in order to know how they respond to more and different conditions of their environment and management which in turn is very important to determine which practices are more convenient for the local producers. The treatment factors of the experiment consisted of four rates of NPK compound fertilizer (270, 180, 90, and 0 kg/ha). These levels were chosen because of other findings on similar ranges, relating to vegetative growth and yield in other cucurbit crops (Aluko, 2020; Eifediyi & Remison, 2010). The fertilizer was applied in three stages: The first application was done three weeks after planting when the plants were at four TRUE leaf stage and other subsequent application were done at 20 days apart.

Two planting dates were targeted, with one planting date in early spring that would be on April Ist, 2023, and the other in the mid-April which would be April 20th, 2023. These dates were

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

chosen in line with the growth season for the region and with the aim of using planting time to look at its impact on growth and yield under varying rates of fertilizer input. These factors were then cross-classified in all possible ways to give the 16 treatment combinations; 2 varieties, 2 planting dates, by 4 fertilizer levels. The treatments were repeated three times; each repetition comprised 16 plots, making a total of 48 experimental plots.

Field Preparation and Planting

The preparation of the fields involved plowing using a flip disc plow with a view of compacting the soil and to improve on its structure. The field was double plowed, and the plowing operation that was done above was done in line with the other in order to minimize compaction but maximize turning over of the soil. The next process was soil leveling and smoothing the surface with a rake to provide a good seedbed for planting subsequent to ploughing. Each of these was a replication, and within the blocks, sixteen plots were established, the size of each plot being 4 meters in length by 1 metre in width. 25 meters in width.

There was the use of drip irrigation as the main means of watering the plants in a bid to achieve a equal distribution of water in every plot. Sprinkler irons were placed along the terraces keeping as close as possible to the plants so as to minimize on evaporation losses. This technique also helped in applying water accurately for which is essential in experiments whereby water stressor should not influence the results of the experiment treatments given to the plants.

Seeds for both ‘Gennxt’ and ‘Mosli’ varieties were obtained from reliable local seed suppliers and germination rates and quality were high. Planting was conducted manually. PEEP holes were opened along each terrace at intervals of 50cm to allow growth of plants and avoid competition. About 3 – 4 seeds in each hole were sown in the experiment and other normal practices were adopted to have homogeneity in the plant stand among different plots. This experimental arrangement made the first planting on April 1, 2023, and the second planting on April 20, 2023.

In the present experiment the NPK fertilizer was used in three split doses to provide the plants with a steady supply of nutrients when they most required it. The first application was one week before the plants grew to four true leaves after planting which was done three weeks later. This stage is important for setting up of robust vegetative growth and the first fertilizer application was therefore done to coincide with this stage. The second and third applications were done 20 days apart in order to provide constant nutrition from start of flowering up to early fruiting stage. The fertilizer was spread over each plot in each of the treatments used in this investigation by the hand broadcast method so as to cover the entire plot to the equal density.

Data Collection and Analysis

Collection of data was well planned and arranged in a way to establish growth and reproductive indexes of the snake cucumber plants in the course of the study. Readings were made at various growth stages to determine the effect of varying rates of NPK fertilizer and planting dates on growth of plants. As for plant height, it was determined on the basis of a measurement from the base of the stem to the apical meristem during different stages of growth. This gave a good indication on the effects of the different treatments on the vegetative growth and plant architecture throughout the season.

Foliar density is the accumulation of leaves per plant and it was determined at each assessment to measure the photosynthetic and plant vigor. This criterion was used to gauge the generation

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

of biomass, based on the enhanced production of leaves to denote more vigour in the plant. The measurements of the vegetation index was done using the LAI-2000 instrument that gave accurate determination of the area of the leaf that can be used in the interception of light. This relationship is very useful in determining efficiency of photosynthesis as seen with lai; this aspect greatly affects the way in which light is converted into biomass and thus growth and yield. Details of floral phenology were keenly followed by counting both sexes of flowers male and female because they influence reproductive success. In parallel to this total fruits yield figures were measured at harvest along with development parameters such as number of fruits per plant, fruits length, and fruit mass. Due to nature of the crop, such parameters were the only available tools in order to gauge both the quantity as well as the quality of yield, which affected not only the marketability of the crop, but the success of the yield as well.

The collected data were subjected to statistical analysis using Analysis of Variance (ANOVA) to evaluate the significance of the main effects (variety, fertilizer level, and planting date) and their interactions. The analysis was conducted using statistical software, ensuring accurate and reliable interpretation of the results. Duncan's multiple range test was applied for post-hoc comparisons of means, with a significance level set at 0.05. This method allowed for a detailed understanding of the differences between treatment groups and the identification of the most effective combinations of variety, fertilizer level, and planting date.

Results and Discussion

Plant Length (cm)

Table 1 shows that the Indian variety was significantly superior in plant height per unit area, as it gave the highest plant height, recording (205.437) cm, compared to the lowest value for the Mosul variety, recording (169,670) cm. It is noted from the same table that the second planting date was superior to the first planting date in the plant height characteristic reached (200.474 and 174.633) cm for each of them, respectively. As for the fertilization levels, the fertilization level exceeded 180 kg/ha, with a value of (223.972) cm, while the comparison recorded the lowest values in the plant height characteristic, with a value of (146.857) cm.

As for the interaction between planting dates and varieties, the Indian variety under the second planting date recorded the highest values, with a value of (220,957) cm, while the Mosul variety, under the first planting date, gave the lowest values in plant height, with a value of (159,348) cm. While the bilateral interaction between planting dates and fertilization levels, the second planting date with the fertilization level of 180 kg/ha recorded the best values for plant height, with a value of (249.965) cm, superior to the comparison for the first planting date, which gave the lowest values for plant height (148.6660) cm.

In the bilateral interaction between varieties and fertilization levels, the Indian variety under the fertilization level of 180 kg/ha was significantly superior in plant height with a value of (239.742) cm compared to the lowest values of the Mosul variety under comparison, which recorded the lowest values of (130.158) cm. The triple interaction of the factors studied in the experiment shows that the Indian variety planted in the second date under the fertilization level of 180 kg/ha was significantly superior, with the highest values in the plant height per unit area, with a value of (266.163) cm, outperforming the Mosul variety grown under the first date. For comparison, it recorded the lowest values. In that capacity, which amounted to (129,513) cm.

The triple interaction of the factors studied in the experiment shows that the Indian variety planted in the second date under the fertilization level of 180 kg/ha was significantly superior, with the highest values in the plant height per unit area, with a value of (266.163) cm,

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

outperforming the Mosul variety grown under the first date. For comparison, it recorded the lowest values. In that capacity, which amounted to (129,513) cm.

Table 1. The Effect of Varieties, Planting Dates, NPK Fertilizer, and Their Interactions on Plant Height (cm)

Planting Date	Cultivars	Fertilization k g / h				Date × cultivars	Impact Date	Impact cultivars
		Control	90	180	270			
First Date	Mosulli	129.51 h	162.47 g	182.63 e	162.76 g	159.34 d		
	Hindi	167.80 fg	187.96 e	213.32 d	190.58 e	189.91 b		
Second Date	Mosulli	130.80 h	172.73 f	233.76 c	182.66 e	179.99 c		
	Hindi	159.37 g	251.70 b	266.16 a	206.58 d	220.95 a		
Date × Fertilization	First Date	148.66 e	175.21 d	197.97 c	176.67 d		174.63 b	
	Second Date	145.0 e	212.21 b	249.96 a	194.62 c		200.47 a	
Cultivars × Fertilization	Mosulli	130.15 g	167.60 ef	208.20 c	172.71 e			169.670 b
	Hindi	163.5 f	219.83 b	239.74 a	198.58 d			205.437 a
Impact Fertilization		146.87 d	193.717 b	223.972 a	185.649 c			

Number of Leaves (Leaf Plant $^{-1}$)

Table 2 shows that the Indian variety was significantly superior in the number of leaves, as it produced a significant increase amounting to (137,597) leaves $^{-1}$compared to the lowest value for the Mosul variety, which recorded the lowest number of leaves (121,111) leaves $^{-1}$. No significant differences were observed. Between planting dates and the number of leaves per plant. While the fertilization level exceeded (180) kg/ha and recorded the highest values in the number of leaves per plant, with a value of (140,579) plant leaves $^{-1}$. It differed significantly with the comparison treatment, which gave the lowest values in the number of leaves per plant, with a value of (111,124) leaf plant $^{-1}$.

While the overlap between planting dates and varieties, the Indian variety under the second planting date gave the highest values in the number of leaves, with a value of (142,291) leaves per plant $^{-1}$, while the Mosul variety, under the first planting date, gave the lowest values in the number of total leaves of the plant, with a value of (122,698). Plant leaf $^{-1}$. As for the bilateral interaction between planting dates and fertilization levels, the second planting date with the fertilization level of 180 kg/ha recorded the best values for the number of leaves per plant, with a value of (0.140.793) plant leaf $^{-1}$, superior to the comparison for the first planting date. Which gave the lowest values for the number of leaves, with a value of (109.159) plant leaves $^{-1}$.

The interaction between the varieties and fertilization levels indicates that the Indian variety, under the fertilization level of 180 kg/ha, was significantly superior in the number of total leaves per plant, with a value of (151,088) leaves plant $^{-1}$compared to the comparison that gave the lowest values for the Mosul variety, which showed the lowest number of leaves per plant, which amounted to (106.345) leaf.

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

The triple interaction of the factors studied in the experiment recorded the superiority of the Indian variety planted in the second date under the fertilization level of 180 kg/ha, with the highest results in terms of the total number of leaves of the plants, with a value of (158,147) leaves. Plant^{-1} thus superior to the Mosul variety grown under the first date for comparison, where the record is lower. Number of leaves in this capacity, which amounted to (103,917) leaves^{-1}.

Table 2. The Effect of Varieties, Planting Dates, NPK Fertilizer, and Their Interactions on Number of Leaves of Plant

Planting Date	**cultivars**	**Fertilization k g / h**	**Date × Cultivars**	**Impact Date**	**Impact cultivars**			
		Control	90	180	270			
First Date	Mosulli	103.92 f	124.25 Cd	136.70 bc	125.92 cd	122.69 c		
	Hindi	114.47 def	136.11 bc	144.03 ab	137.00 bc	132.90 b		
Second Date	Mosulli	108.773 ef	118.99 de	123.44 cd**.**	126.89 cd	119.52 c		
	Hindi	117.33 def	148.35 ab	158.15 a	145.33 ab	142.29 a		
Date × Fertilization	First Date	109.19 c	130.18 b	140.35 ab	131.45 ab		127.80 a	
	Second Date	113.05 c	133.67 ab	140.79 a	135.11 ab		130.91 a	
Cultivars × Fertilization	Mosulli	106.34 e	121.62 cd	130.07 c	126.40 c			121.11 b
	Hindi	115.90 d	142.23 ab	151.08 a	141.17 b			137.60 a
Impact Fertilization	124.111c	131.93 b	140.58 a	133.78 b				

Leaf Area to Plant (m2 plant^{-1})

The results of table 3 indicate superiority for the Indian variety with the highest values in leaf area, which amounted to (2.17521) m^2 plants^{-1}, compared to the Mosul variety, which gave the lowest value, amounting to (1.88758) m^2 plants^{-1}. The second date recorded the highest values, reaching (2.21088) m^2 plants^{-1}, compared to the first planting date, which recorded (1.85202) m^2 plants^{-1}. While the fertilization level exceeded (180) kg/ha, with the highest values in leaf area, with a value of (2.72235) m^2 plant^{-1}. The comparison recorded the lowest leaf area per plant, amounting to (1.39149) m^2 plant^{-1}.

The interaction between the Indian variety and the second planting date recorded the highest values in the leaf area of the plant (2.367) m^2 plant^{-1}, outperforming the Mosul variety under the first planting date, which gave (1.721) m^2 plant^{-1}. While the second planting date with the fertilization level of 180 kg/ha gave the best values in leaf area (3.0527) m^2 plant^{-1}, superior to the comparison for the first planting date, which gave the lowest values in leaf area per plant (1.3356) m^2 plant^{-1}.

The Indian variety, under the fertilization level of 180 kg/ha, showed superiority in the leaf area of the plant (2.9239) m^2 plant^{-1} compared to the lowest values for the Mosul and Hindi varieties under comparison (1.2356, 1.5474) m^2 plant^{-1} for each, respectively.

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

The triple interaction shows the superiority of the Indian variety planted in the second appointment under the fertilization level of 180 kg/ha with the highest leaf area of the cultivated plants with a value of (3.2941) m^2 $plant^{-1}$, outperforming the Mosul variety grown under the first date and for comparison, where it recorded (1.2208) $m^2 plant^{-1}$.

Table 3. The Effect of Varieties, Planting Dates, NPK Fertilizer, and Their Interactions on Leaf Area (m^2 $Plant^{-1}$)

Planting Date	Cultivars	Fertilization k g / h				Date × cultivars	Impact Date	Impact cultivars
		Control	90	180	270			
First Date	Mosulli	1.22 k	1.60 Jhkl	2.23 cde	1.83 efghl	1.72 c		
	Hindi	1.45 jk	1.89 efgh	2.55 bc	2.03 efgh	1.98 b		
Second Date	Mosulli	1.25 jk	1.75 fghl	2.81 b	2.41 bcd	2.05 b		
	Hindi	1.64 jhlg	2.07 def.	3.29 a	2.46 bcd	2.37 a		
Date × Fertilization	First Date	1.33 d	1.75 c	2.39 b	1.93 c		1.85 ٧	
	Second Date	1.45 d	1.91 C	3.05 A	2.4320 B		2.21088 A	
Cultivars × Fertilization	Mosulli	1.23 e	1.67 d	2.52 b	2.12 c			1.89 b
	Hindi	1.55 d	1.98 c	2.92 a	2.24 c			2.17 ش
Impact Fertilization		1.39 d	1.83 c	2.72 a	2.18 b			

Number of Females (Flower $Plant^{-1}$)

Table 4 shows that the Indian variety is significantly superior in the number of female flowers (56.9167) flowers $plant^{-1}$ compared to the lowest value for the Mosul variety (47.9583) flowers $plant^{-1}$. While the second planting date significantly exceeded the first planting date in the number of female flowers of the plant (50.0833, 54.7917) flowers plant $^{-1}$ for each, respectively. As for fertilization levels, the fertilization level exceeded (180) kg/ha, with a value of (62.3333) flowers. $Plant^{-1}$ did not differ significantly from the fertilization level of 270 kg/ha, while the comparison treatment recorded the lowest number of female flowers per plant, with a value of (37.3333) flowers. $Plant^{-1}$. Under the second planting date, the Indian variety gave the highest number of female flowers, amounting to (59.1667) flowers $plant^{-1}$, while the Mosul variety, at the first planting date, gave the lowest values in the number of female flowers, amounting to (45.5000) $plant^{-1}$ flowers.

The second planting date with the fertilization level of 180 kg/ha recorded the best number of female flowers, amounting to (65,500) $plant^{-1}$ flowers, and it did not differ significantly from the fertilization level of 270 kg/ha, thus superior to the comparison treatment for the first planting date (36,500) $plant^{-1}$ flowers. The Indian variety significantly outperformed under the fertilization level of 180 kg/ha, recording the largest number of female flowers per plant, amounting to (66,667) flowers $plant^{-1}$, and it did not differ significantly from the fertilization level of 270 kg per plant, compared to the lowest values of the Mosul variety under comparison, with a value of (34,000) flowers $plant^{-1}$.

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

Among the triple intervention, the Indian variety planted on the second date under the fertilization level of 180 kg/ha had the highest values in the number of female flowers with a value of (64,000) flowers plant^{-1}, which did not differ significantly with the fertilization level of 270 kg/ha, thus outperforming the Mosul variety grown under The first date of planting, for comparison, recorded the lowest number of female flowers, amounting to (32,667) flowers plant^{-1}.

Table 4. Effect of Varieties, Planting Dates, NPK Fertilizer, and Their Interactions on Female Flowers

Planting Date	Cultivars	Fertilization k g / h				Date × cultivars	Impact Date	Impact cultivars
		Control	90	180	270			
First Date	Mosulli	32.7 h	40.0 g	54.3 E	55.0 de	45.5 d		
	Hindi	40.3 g	52.3 e	64.0 b	62.0 bc	54.7 b		
Second Date	Mosulli	35.3 h	44.0 f	61.7 bc	60.7 bc	50.4 c		
	Hindi	41.0 fg	58.3 cd	64.0 a	68.0 a	57.8 a		
Date × Fertilization	First Date	36.5 e	46.2 d	59.2 b	58.5 b		50.1 b	
	Second Date	38.2 e	51.2 c	65.5 a	64.3 a		54.8 a	
Cultivars × Fertilization	Mosulli	34.0 e	42.0 d	58.0 b	57.8 b			47.9 b
	Hindi	40.7 d	55.3 c	66.7 a	65.0 a			56.9 a
Impact Fertilization		37.3 c	48.7 b	62.3 a	61.4 a			

Number of Male Flowers (Flower Plant^{-1})

Table 5 shows that the Indian variety was significantly superior in the number of male flowers, as it gave (142,667) flowers per plant^{-1}, compared to the lowest value for the Mosul variety, recording (93,167) flowers per plant^{-1}. While the second planting date gave a greater number of male flowers compared to the first planting date, with values reaching (111,333, 124,500) flowers per plant^{-1} for each, respectively. The fertilization level exceeded (180) kg/ha, with a value of (146,167) flowers. plant^{-1} compared to the comparison treatment, which recorded (75,667) flowers plant^{-1}. The Indian variety under the second planting date recorded the highest values in the number of male flowers per plant, with a value of (148,750) flowers per plant^{-1}, while the Mosul variety under the first planting date gave the lowest values, recording (86,083) flowers per plant^{-1}.

The interaction between the second planting date and the fertilization level of 180 kg/ha gave the best values for the number of male flowers, with a value of (152,333) flowers per plant and did not differ significantly from the fertilization level of 270 kg/ha, superior to the comparison treatment for the first planting date, which gave the lowest values. (68.667) Flower Plant^{-1}. However, the bilateral interaction between varieties and fertilization levels was superior to the Indian variety under the fertilization level of 180 kg/ha in the number of male flowers per plant, with a value of (170,000) flowers per plant, and it did not differ significantly from the fertilization level of 270 kg per plant compared to the lowest values for the Mosul variety under comparison, which were recorded. (50.333) Flower Plant^{-1}.

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

The triple interaction showed the superiority of the Indian variety planted on the second date under the fertilization level of 180 kg/ha and the highest values in the number of male flowers with a value of (177,333) flowers per plant^{-1}, which did not differ significantly with the fertilization level of 270 kg/ha, thus outperforming the Mosul variety grown under The first date, for comparison, recorded (40,667) plant^{-1} flowers.

Table 5. Effect of Varieties, Planting Dates, NPK Fertilizer, and Their Interactions on Male Flowers

Planting Date	**Cultivars**	**Fertilization k g / h**				**Date × cultivars**	**Impact Date**	**Impact cultivars**
		Control	**90**	**180**	**270**			
First Date	Mosulli	40.7 j	86.1 d			86.1 d		
	Hindi	96.7 g	136.6 b			136.6 b		
Second Date	Mosulli	60.0 l	100.2 c			100.2 c		
	Hindi	105.3 f	148.7 a			148.7 a		
Date × Fertilization	First Date	68.7 f		111.3 b			111.3 b	
	Second Date	82.7 e		124.5 a			124.5 a	
Cultivars × Fertilization	Mosulli	50.3 g			93.2 b			93.2 b
	Hindi	101.0 e			142.7 a			142.7 a
Impact Fertilization		75.7 d	108.4 c	.1462 a	141.4 b			

Sex Ratio

Table 6 showed that the Mosul variety was superior in sex ratio, giving the highest sex ratio of 0.53996, compared to the lowest sex ratio of the Indian variety, which recorded 0.39854. While the first planting date gave the highest sex ratio of 0.48263% plant^{-1}, outperforming the second planting date, which gave the lowest sex ratio of 0.45588% plant^{-1}. The comparison treatment was significantly superior, with a rate of 0.55158 plants^{-1}, at the level of fertilization (180) kg/ha, which recorded the lowest sex ratio of 0.42575 plants^{-1}. The Mosul variety outperformed the first planting date with the highest sex ratio of 0.56600 plants^{-1}, while the Indian variety showed the lowest sex ratio of 0.39783 plants^{-1} for the second planting date, and it did not differ significantly with the Indian variety under the first planting date.

The first planting date, overlapping with the comparison, recorded the best sex ratio of 0.61317 plants^{-1}, outperforming the second planting date at the fertilization level of 180 kg/ha, which gave the lowest values for that trait, 0.34783 plants^{-1}. The Mosul variety, in comparison with the comparison, gave the highest sex ratio of cultivated plants, amounting to 0.70033 plants^{-1}, superior to the Indian variety under the fertilization level of 180 kg/ha, which recorded the lowest sex ratio of 0.39250 plants^{-1}.As for the triple intervention, the Mosul variety grown on the first date under comparison had the highest sex ratio of 0.80967 plants^{-1}, outperforming the Indian variety grown on the second date and at a fertilization level of 180 kg/ha, which recorded the lowest sex ratio of 0.39133 plants^{-1}.

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

Table 6. Effect of Varieties, Planting Dates, NPK Fertilizer, and Their Interactions on Sex Ratio

Planting Date	Cultivars	Fertilization k g / h				Date × cultivars	Impact Date	Impact cultivars
		Control	90	180	270			
First Date	Mosulli	0.809 a	0.511 c	0.433 cde	0.509 c	0.566 a		
	Hindi	0.417 de	0.414 e	0.394 e	0.373 e	0.399 c		
Second Date	Mosulli	0.511 b	0.489 cd	0.484 cd	0.491 cd	0.494 b		
	Hindi	0.389 e	0.417 de	0.391 e	0.394 e	0.397 c		
Date × Fertilization	First Date	0.613 a	0.462 bc	0.414 c	0.441 bc		0.483 a	
	Second Date	0.490 b	0.453 bc	0.348 bc	0.445 bc		0.456 b	
Cultivars × Fertilization	Mosulli	0.700 a	0.500 b	0.459 bc	0.500 b			0.540 a
	Hindi	0.403 d	0.415 cd	0.393 d	0.384 d			0.399 b
Impact Fertilization		0.551 a	0.458 b	0.426 b	0.442 b			

Dissection

With regard to varieties or hybrids, the Indian hybrid was significantly superior in vegetative growth characteristics (plant height, number of leaves, leaf area) over the Mosul hybrid, as in Tables (4, 5, 6) for genetic reasons, or perhaps the suitability of this variety to those factors studied under the circumstances, this is in line with the findings of (Hussein, 2002).

The superiority of the Indian variety may be due to flower growth characteristics, which are represented by the characteristics (number of female flowers, number of male flowers, sex ratio). These results may be due to the performance of the different hybrids, which are affected by planting dates, fertilizer levels, and environmental conditions, and are therefore variable according to the growing season and region (Takashima et al., 2013; Staub & Bacher, 2004). Hence, the differences in vegetative and flowering traits can be attributed to the genetic makeup of the hybrids used. The Indian hybrid may have been faster in adapting to the environment than the Mosul hybrid, or it may be due to variation in the data of the studied traits of these hybrids and environmental factors throughout the dates. Cultivation, genetic characteristics of hybrids, hormonal factors and yield vigor. This is consistent with what has been found (Ahmed et al., 2004; Sharma & Bhattarai, 2006; Capo et al., 2023; Topno et al. 2023).

The reason for the superiority of vegetative growth characteristics under high levels of compound fertilizer is that nitrogen and potassium play a role in increasing the size of the vegetative system, which leads to the accumulation of carbohydrate materials resulting from an increase in the process of photosynthesis in plants (Yusuf et al., 2021; Debnath et al., 2021), as well as the presence of potassium, which has a role in stimulating the photosynthesis of plants. The process of photosynthesis, as well as its role in physiological processes in plants, such as the formation of proteins, chlorophylls, and carbohydrates (Nouri et al., 2015), these results agreed with Naqve et al. (2021).

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It is a supplement to nitrogen, as it is involved in the formation and division of meristematic cells and increases the height of the plant and the surface area of the leaves, which increases the efficiency of plant photosynthesis (Umar Zaman et al., 2015). It is an influential factor in the absorption of water and nutrients from the soil and their transfer to the plant. It is also necessary and an auxiliary factor in stimulating more than 40 enzymes.

As for phosphorus, it plays a role in root growth (Prates et al., 2012) and metabolic processes such as the formation of ATP, nucleic acids, and photosynthesis (Oliveira et al., 2017). It participates in the vital processes of the plant, as it is found in the nucleic acids DNA, RNA. The phospholipids (membranes) ADP and ATP are involved in the breakdown of carbohydrates, the release of energy, cell division, root growth, and the transfer of genetic traits from one generation to another. It is necessary for regulating nodulation and pregnancy in plants and is the basis for the process of photosynthesis, which plants greatly need. In the fruiting and flowering stage (Sanyal et al., 2007). Therefore, phosphorus is necessary to increase the height of the plant, the number of branches and leaves, and the leaf area of the plant for its role, as previously mentioned, in the formation and division of cells and increasing the rates of carbohydrate accumulation as a result of its stimulation of enzymes (de Bang et al., 2021). It agrees with Abd El-Mageed et al. (2015) and increases the number of leaves per plant due to its effect on plant height. It results from the increase in nodes formed on the plant (Schneider et al., 2021).

The differential growth responses observed between 'Gennxt' and 'Mosli' highlight the importance of considering genetic factors in agronomic management. 'Gennxt' excelled under early planting and moderate NPK levels, which aligns with previous findings that early season conditions favor the rapid establishment and growth of cucurbit varieties. This suggests that 'Gennxt' may be particularly well-suited for environments where early planting is feasible, allowing the crop to fully exploit the extended growing season. In contrast, 'Mosli's' better performance under later planting and higher NPK levels points to a potential resilience mechanism that could be advantageous in areas with unpredictable or shorter growing seasons. These findings indicate that varietal selection should be closely aligned with specific environmental conditions and management practices, particularly in regions with variable climates.

The variation in LAI between the two varieties underscores the nuanced relationship between planting dates, nutrient management, and photosynthetic efficiency (Farouk et al., 2024; Hindoriya et al., 2024). 'Gennxt's' higher LAI under early planting and moderate fertilization suggests that this variety can achieve optimal photosynthetic capacity early in the season, which likely contributes to its higher yield. This supports the broader understanding that early and well-nourished plants can establish a strong photosynthetic apparatus, leading to enhanced growth and productivity. On the other hand, 'Mosli's' increase in leaf area under later planting and higher NPK levels suggests a strategic adaptation to maximize light capture under suboptimal conditions, reflecting a plasticity in response to environmental cues that could be leveraged in less predictable climates (Nath et al., 2018).

The study's findings on floral phenology provide critical insights into the reproductive strategies of these two varieties. 'Gennxt' showed a higher propensity for female flower production under early planting conditions, which directly translated into higher fruit yields. This finding is significant in the context of crop breeding and selection, where the ability to maximize reproductive success early in the season is often a key determinant of yield potential. In contrast, 'Mosli's' shift towards male flower dominance under stress conditions, such as later planting, highlights a common adaptive strategy among cucurbits to ensure reproductive

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continuity even under less favorable conditions. These reproductive patterns suggest that 'Mosli' may require more targeted interventions to enhance its fruit set under varying environmental conditions.

The results for fruit development reinforce the importance of aligning planting dates and fertilization strategies with varietal characteristics. 'Gennxt,' with its larger and heavier fruits under early planting and moderate NPK, exemplifies how optimal timing and nutrient management can enhance yield potential. This finding is consistent with studies that emphasize the role of early-season vigor in determining final yield outcomes (Ahmad et al., 2021). However, 'Mosli's' ability to produce comparable yields under less favorable vegetative conditions, such as later planting with higher NPK levels, suggests a robustness that could be valuable in less predictable environments. This highlights the importance of flexibility in management strategies to accommodate the specific needs and strengths of each variety (Smith et al., 2014).

The implications of these findings extend beyond the specific varieties studied, contributing to the broader discourse on precision agriculture and varietal management. The differential responses observed between 'Gennxt' and 'Mosli' underscore the necessity of tailoring agronomic practices to the unique characteristics of each variety, particularly in the context of climate variability and resource optimization. Future research should focus on expanding these findings across different environmental conditions and exploring the integration of advanced technologies, such as remote sensing, to refine and enhance crop management practices further. By doing so, this research will contribute to more sustainable and resilient agricultural systems, capable of maintaining high productivity even in the face of environmental challenges.

Conclusion

This study highlights the significance of tailoring agronomic practices to the specific characteristics of snake cucumber varieties to optimize growth and yield under varying environmental conditions. The 'Gennxt' variety was found to be particularly responsive to early planting with moderate NPK fertilization, resulting in superior vegetative growth, efficient photosynthesis, and high fruit yields. On the other hand, the 'Mosli' variety demonstrated adaptability to later planting dates with higher fertilizer levels, indicating its potential for resilience in less favorable conditions. These findings underscore the importance of a precision agriculture approach, where management strategies are closely aligned with the genetic and phenological traits of each variety. Such targeted practices not only enhance productivity but also contribute to more sustainable resource use and environmental stewardship, particularly in regions with variable climates. Future research should build on these findings by conducting multi-season trials across diverse environmental settings to validate the results and further explore the interactions between planting schedules, nutrient management, and variety-specific responses. Additionally, the integration of advanced technologies like remote sensing could provide deeper insights into optimizing crop management.

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