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Effect of Potassium Humate on Vegetative Growth, Flowering and Corms Yield of *Gladiolus Hybrida cv.* "Sancerre" Plants under Different Concentrations of Gibberellic Acid (GA_3)

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ABSTRACT: A field experiment was carried out to determine the best rate of potassium humate and optimum concentration of GA_3 in a sandy soil to optimize the growth, biomass, and chemical composition of gladiolus plant (*Gladiolus hybrida cv.* Sancerre). Four different rates of K-humate 0.00, 2.0, 4.0 and 6.0 g plant^{-1} was added K- humate was applied at 15 days intervals (first one after 15 days from planting) with four levels of gibberellic acid (GA_3) at 0.00, 50, 100 and 150 ppm as foliar spray. Treatments were implemented in a split-plot design with three replications, in both seasons.

The main results of this study can be summarized in the following points:

I- The results showed that using the different rate of K-humate had a significant effect on all the vegetative growth characteristics. Potassium humate at 5g gave the highest reduction for the time required to flowering stage (day), the maximum of florets number, and inflorescence weight (g). The highest significant increase in the chlorophylls in fresh leaves and potassium content (%) in the leaves were obtained by using 3 and /or 5g plant $^{-1}$.

II- Plant height, leaf length, leaves area and dry weight of leaves/plant (g) significantly increased with increasing levels of GA_3, with not significant differences among concentration 100 and high level at 150 ppm compared with control treatment in most cases. The highest values of plant height, leaf length, leaves area and leaf weight were obtained by adding 150 ppm. All levels of gibberellic acid were significantly advanced the time flowering, and the highest concentration produced the maximum increase in flower quality and quantity. Chemical analysis showed with increasing GA_3 led to a significant increase in the chlorophylls content and K percentage in the leaves.

III- Using K-humate with gibberellic acid at 150 ppm gave the maximum beneficial effect on growth characters. The best characters of flowers production were recorded by adding the high level of potassium humate 6g /plant combined with 100 and/or150 ppm GA_3, it produced the highest reduction for the time required to flowering stage and the highest number of florets, and heaviest dry weight of inflorescence for both seasons. Chlorophylls and K content of leaves showed that there was significant effect for K-humate with gibberellic acid on the chemical composition.

IV- The results of chemical analysis showed an improvement in the leaf content of chlorophyll (31.98 to 58.76 SPAD), potassium percentage (2.13 to 3.98%). and total carbohydrates (14.86 to 23.37 %) as well as the content of new corms (total carbohydrates 36.91 to 47.54 %), as a result of treatment with both K-humate and gibberellic acid compared to the control treatment plants.The best value was recorded by using 6 g/plant of K-humate with 150 ppm GA_3.

Keywords: *Gladiolus hybrida* ,Flowering bulbs, Potassium humate, gibberellic acid (GA_3)
Abbreviations: Potassium humate = (KH)= K-humate , gibberellic acid= (GA_3)

INTRODUCTION

Gladiolus holds a significant place in the floriculture industry as one of the most significant and high quality flowers for hand picking. Gladiolus is produced in large quantities in Germany, The United States, England, France, and Italy. In Egypt, it is the most popular flower to cultivate outside. In addition to the flowers' many colors, shapes, and superior quality of keeping, the short growth time till flowering may be the reason for its extensive production. There are 180 species of Gladiolus in the Iridaceae family **(Lewis, *et al.* 1972 and Wilfert and Raulston, 1974).**
Gibberellins are crucial endogenous regulators of plant growth and development, including trichome formation, flower induction, stem and leaf

elongation, pollen production following anthesis, fruit and seed development, and seed germination . Gibberellins are essential for plant growth and development. Gibberellins have a major role in growth by controlling cell division and elongation, which affects the production, components, and quality of plants. Numerous studies have been conducted to examine how Gibberellic Acid (GA_3) affects vegetative growth i.e., When **El-Naggar and Sharaf (2002)** studied tuberose plants (*Polyanthus tubrosa* C.V. "double"), they discovered that the greatest results for the leaves' total chlorophyll content came from foliar application of gibberellic acid (200 mg/l). On the other hand, potassium is a crucial nutrient for the meristematic growth of plants as well as their physiological processes, which include the control of gas and water exchange, protein synthesis, enzyme activation, photosynthesis **(Devlin, 1975 and Wang et al., 2013).** A required natural substance, potassium humate (KH) can improve the physio-biochemical characteristics of soils, their functionality, and plant productivity. High fertilizer levels are necessary for the intensive production of cut flowers. Pollution of the soil, water, and ecosystem can result from improper fertilizing. Organic fertilizers containing various compounds, like as humic acid, have recently been introduced as a fertilization strategy. There is no detrimental risk to the environment from these organic materials. **Arancon *et al*., (2003)** shown that humic acid promoted growth of marigold plants. Moreover, **Iftikhar *et al*., (2013)** According to Gladiolus, the best results were obtained with applications of Humic Acid and NPK at the planting and 3-leaf stages. These included early and uniform sprouting, more foliage growth per plant, greater leaf area, and total leaf chlorophyll contents; earlier spike emergence, more florets per spike, longer stems and spikes, and a larger spike diameter; higher flower quality, longer vase life; more cormels per clump; and a larger cormel diameter and weight. **Abdolrahman et al. (2014)** investigate how applying humic acid affects the micronutrient status and qualitative traits of *Petunia hybrid* L. The findings showed that, in comparison to the control, a rise in humic acid boosted all assessed growth and flowering features and increased the absorption of micronutrients.

This study's primary goal was to evaluate the effectiveness of applying KH at the ideal GA_3 level to enhance gladiolus (*Gladiolus hybrida cv.*"Sancerre") plant growth and flower production.

MATERIALS AND METHODS

Experimental location and corms plantation:

During the 2023 and 2024 seasons, this experiment was set up in the newly reclaimed lands of Nubaria region,Alexandria , Egypt. Uniforms corms of (*Gladiolus hybrida cv.*"Sancerre") 8 – 10 cm in circumference, were planted in a full sunny place on 10th March 2023 and 13th March, 2024 in the first and second seasons, using seven cm depth and inter and intra row spacing (20× 50 cm) **Potti and Arora, 1986 & Al-Humaid, 2001.**

Expermimental layout& Treatments

Three replicates with a split-plot design were used and ten corms made up each experimental unit as as a plot on the open field. K-humate four levels: 0.00, 2.00, 4.00 and 6.00 g plant^{-1} represented the main plot. While the subplot represented of gibberellic acid (GA_3), 0.00, 50.00, 100.00 and 150.00 ppm. K-humate was added two times at 15 days intervals (first one after 15 days from corms planting). The First addition of Gibberellic acid was sprayed three times till run off during each growing season at two -three leaf stage, the second one was applied 15 days after the first application (4-5 leaf stage), and the third application (6-7 leaf stage) was administered 15 days following the second. plants received 3 g/ plant at one-month intervals of 19:19:19: (N: P_2O_5: K_2O), as a dressing application, which began a month after the corms were planted. Fe-EDTA (14% Fe) and magnesium sulfate hexahydrate (MgSO4.7H2O-) were sprayed on the foliage three times at three-week intervals until the run-off point at 150 and 75 ppm for Mg and Fe,
, respectively. **(El-Deeb, 2016).**

Soil analysis:

Analysis of some chemical and physical properties of the used medium at the beginning of the experimental sites are presented in table (1 and 2).

Table (1): Organic matter and physical properties

Criterion	OM%	Particles %			Soil Texture
		Sand	Silt	Clay	
Sandy soil	0.28	70.1	18.2	11.7	Sandy

Table (2). chemical properties.

Criterion	T.S.S	Cat. (meq/l)				Ani. (meq/l)				SRA
	meq/l	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Co_3^{-}	Hco_3^{-}	Cl^{-}	So_4^{-}	
Sandy soil	22.1	9.8	2.2	7.3	1.6	zero	2	9.7	10.4	3.32

Recorded data:

1. **Vegetative growth, flower and corms yield:**

Plant height (cm), leaf length (cm), leaves area/plant (cm^2), dry weight of leaves/spike.

The leaf area (cm^2) was measured by taking a constant number of 20 discs for each. Then the relationship between the fresh weight of these discs and their area was calculated. The following equation was developed to measure the leaf area:

$$\text{Leaf area } (cm^2) = \frac{x}{Y} \times M$$

Where x and y are the area (cm^2) and weight (g) of the leaf segment, respectively. where M is the amount of weight (g) of the total leaf **(Priya et al., 2021).** While, the flowering data were; time of showing color, florets number /spike and dry weights of florets spike, Furthermore, the corms yield recorded data were; corms size and weight of new corms.

Plant analyses and chemical composition:

1- Chlorophyll content (SPAD units): The SPAD-502 meter according to method described by **Yadava (1986)**.

2- Potassium %: according to **Westerman (1990).**

3- The amount of total carbohydrate in leaves and young corms were determined according to **Herbert et al., (1971**).

Analyzing statistics :

A computer software was used to statistically examine the data. and using the statistical analysis system (SAS Institute, 2001), and means, as explained by Snedecor and Cochran (1990), were compared using the "Least Significant Difference (L.S.D)" test at the 5% level.

RESULTS AND DISCUSSION

I- Impact of potassium humate and GA_3 concentration on growth of Gladiolus plants: -

1- Plant height

The data in Table (3) showed that potassium humate (KH) addition (2.00, 4.00 and 6.00 g $plant^{-1}$) caused significant increases in height of *Gladiolus hybrida cv.*"Sancerre" plants. Generally, there were significant increases in plant height by adding the rate of potassium humate up to 6 g $plant^{-1}$. The highest values of gladiolus height were obtained by addition potassium humate (KH) at a rate 6 g $plant^{-1}$. This dose gave the highest values of that trait in the two seasons 105.00 and 106.58 cm , compared with the control which was given the lowest plant height 84.29 and 86.11 cm for both the growing season, respectively. This increase in plant height might be ascribed to modifications in the physical and chemical characteristics of the soil through the addition of potassium humate (KH) and an increase in organic matter. Additionally, potassium humate (KH) improves the structure, chemical characteristics. These results are consistent with those of **El-Naggar et al., (2020)** with *Gazania splendens* plants and **Ibrahim et al., (2016)** with *Limonium sinuatum*, **Hamza and Sefan (2020)** on *Vitis vinifera* and **Lolo (2022)** on *Calendula officinalis.*

Data in Table (3) clear that gladiolus height increased with GA_3 levels. The lowest ones, however, came from control. Additionally, Gibberellic acid's ability to promote cell division and elongation of newly produced growth cells in pot marigold (*Calendula officinalis*) plants may be the cause of these increases in plant height.

It was evident from the data in Table (3) that plant height was significantly increased with increasing potassium humate (KH) rate 2.0, 4.0 and 6.0 g $plant^{-1}$ combined with concentration of gibberellic acid (GA_3) 50, 100 and 150 ppm, as compared with the untreated plant in the two growing seasons. Potassium humate yielded the highest plant height results at rate 6 g/plant and GA_3 at 150 ppm concentration as compared with the other treatments in the two seasons. The highest values reached 116.80 and 117.38 cm against 78.87and 84.18 cm resulted from the control treatment in 1st and 2nd seasons. The findings discussed the impact of adding k-humate with increased GA3 levels (150 ppm), which enhanced nutrient element absorption and increased plant development.Plant height increased as a result of the synergistic action of GA_3 and potassium humate (KH) in their appropriate and optimal combinations, which promoted growth and dry matter accumulation. **Schmidt et al., (2003)** found that when GA_3 was administered at 300 mgl1, chrysanthemum plant height increased by 16.78%. Similar patterns in carnations and tuberose were seen by **Padaganur et al., (2005) and Kumar et al., (2015),** respectively. These results are somewhat like that obtained **El-Naggar and Sharaf (2002)** with gladioli and **Harhash, et al., (2003)** on dahlia (*Dahlia variabilis* L.)**.**

leaf length / spike (cm):

Data in Table (3) demonstrated that during the two study seasons, K-humate had a substantial impact on that attribute, whereas GA3 treatments and the combination of K-humate and GA3 treatments had a significant impact on leaf length and width/plant.

Regarding different levels of K-humate, the results presented in Table (3) showed that potassium humate (KH) rate at 6g $plant^{-1}$ gave higher leaf length and width/spike than other treatment in both seasons. The values reached leaf length to 38.95and 39.96 cm compared with the control in the two growing season, respectively. Table (3). These results may be related to the accumulation of minerals and carbohydrates in the leaves and their relationship with plant height, and the rate of potassium humate (KH) as an organic matter in the sandy soil. Similar results are observed by **Iftikhar *et al.*, (2013) and Bashir *et al.* (2016)** on *Gladiolus grandiflorus* L.

It is clear from the statistics in Table (2) that all GA_3 treatments significantly increased these parameters (leaf length and width/ plant) The largest leaf length detected with plants received GA_3 with 150 ppm giving values of 38.24 cm and 39.72 cm respectively, in both experimental trials. These findings may stem from foliar applications of GA_3 at an appropriate quantity, which increased the size of the photosynthetic surface and the development of the leaves in the plant's growing areas. Similar results are observed **El-Deeb (2023)** with *Dahlia variabilis* L.

Applying all rates of potassium humate (KH) with gibberellic acid (GA3) treatments had a substantial impact on leaf length and spike, according to the findings in Table (3).The great influence of receiving the plants KH at 4 and/or 6 g plant^{-1} combined with 150 ppm gibberellic acid (GA_3) gave significant increase in leaf length / spike compared with the other treatments for both experimental seasons. The best results were found by using 6 g plant^{-1} potassium humate (KH) plus GA_3 at 150 ppm during the 1st and 2nd seasons. Such treatment significantly increased the values compared with that recorded from the other treatments giving values of 42.20 cm and 43.95 cm, respectively. The results could be attributed to stimulating effects of both potassium humate (KH) and/or GA_3 may be due to activating apical meristems beside the protoplasm formation, division and elongation of meristems cells **Kumar et al., 2011** on *Tagetas erecta* .

4- Leaves area & dry weight / spike

Results presented in Table (3) and revealed that adding potassium humate (KH) at the studied rates (2, 4 and 6 g/plant) caused significant increases in leaves area and dry weight/plant in the two seasons as compared with untreated plants. The best results were obtained with treating plants with potassium humate (KH) at the rate of 6 g plant^{-1} with values of (681.80 cm^2, 4.11 g and 700.73 cm^2, 4.08 g) for both seasons. However, the control treatment showed the lowest values for leaves area & dry weight of leaves/plant (504.67 cm^2 2.46 g and 508.00 m^2, 2.54 g), respectively for both seasons.

Furthermore, the treated gladiolus plants with gibberellic acid (GA_3) showed significant increase in leaves area and dry weight in the two seasons compared with untreated plants. The most effective treatment of gibberellic acid (GA_3) was 150 ppm with values of (687.00 cm^2, 4.34 g and 701.94 cm^2, 4.27 g) respectively. The least results were obtained by using 0.0 ppm GA_3 with values of (525.31 cm^2, 2.59 g and 526.32 cm^2, 2.97g), respectively.

The interaction between potassium humate (KH) and gibberellic acid (GA_3) treatments for leaves dry weight were significant as clearly indicated in tables (3). The most effective treatment was 6 g (KH) plus 150 ppm GA_3 in the both seasons with values of (759.93 cm^2, 4.96 g and 794.76 cm^2 , 4.65 g, respectively. While the contrary action was observed resulting from untreated plants as the values decreased to only433.94 cm^2, 1.67 g and 430.89 cm^2, 1.88 g in the first and second seasons, respectively. This increase in leaves dry weight may be attributed to potassium humate (KH) and gibberellic acid (GA_3) stimulated the growth by encouraging cell division and stimulated more growth mechanism in tissue cells of plant**.** Similar conclusion was also reported by **Fan et al., (2014)** on Chrysanthemum plants**.**

Table (3): Average of potassium humate (KH), GA_3 and their interaction treatments on growth characteristics such as plant height, leaf length, leaves area and dry weights of leaves of *Gladiolus hybrida cv.*"Sancerre"plants during the two seasons of 2023 and 2024.

K Humate g plant^{-1}	GA$_3$ concentrations (ppm)									
	plant height (cm)									
	(1st) season					(2nd) season				
	0.00	50	100	150	mean	0.00	50	100	150	mean
0.00	78.87	83.14	86.00	89.12	84.29	78.94	84.18	88.78	92.52	86.11
200	82.63	88.40	94.69	96.99	90.68	83.55	89.35	93.85	97.94	91.17
4.00	89.30	94.94	108.30	111.49	101.00	88.92	96.36	109.50	112.64	101.86
6.00	92.70	97.75	112.92	116.80	105.00	95.94	99.85	113.15	117.38	106.58
mean	85.88	91.10	100.48	103.60		86.84	92.44	101.32	105.12	
LSD$_{0.05}$	KH = 4.16	GA$_3$=2.23	Intr.=4.44			KH =3.55	GA$_3$=2.15	Intr.= 5.30		
	Leaf length / spike (cm)									
	0.00	50	100	150	mean	0.00	50	100	150	mean
0.00	20.75	24.50	29.15	32.10	26.63	21.00	26.47	31.38	34.88	28.43
2.00	23.47	28.75	34.17	37.92	31.10	26.77	29.30	38.45	38.85	33.34
4.00	32.25	37.00	39.58	40.75	37.40	34.55	37.30	39.22	41.18	38.10

6.00	**33.50**	**38.25**	**41.83**	**42.20**	**38.95**	**34.78**	**38.85**	**42.47**	**43.95**	**39.96**
mean	**27.49**	**32.13**	**36.18**	**38.24**		**29.28**	**32.98**	**37.88**	**39.72**	
$LSD_{0.05}$	**KH =1.43 GA_3=1.12 Intr.= 2.36**					**KH =1.55 GA_3=1.34 Intr.=2.50**				
leaves area / spike (cm^2)										
	0.00	**50**	**100**	**150**	**mean**	**0.00**	**50**	**100**	**150**	**mean**
0.00	**433.94**	**459.22**	**534.67**	**590.85**	**504.67**	**430.89**	**465.15**	**536.43**	**599.53**	**508.00**
2.00	**474.41**	**528.60**	**578.23**	**647.51**	**557.20**	**477.21**	**526.91**	**579.93**	**665.89**	**562.49**
4.00	**583.86**	**597.88**	**664.12**	**749.72**	**648.90**	**584.36**	**598.47**	**664.57**	**747.57**	**648.74**
6.00	**609.00**	**645.80**	**712.46**	**759.93**	**681.80**	**612.83**	**669.34**	**726.00**	**794.76**	**700.73**
mean	**525.31**	**557.88**	**622.37**	**687.00**		**526.32**	**627.72**	**626.74**	**701.94**	
$LSD_{0.05}$	**KH =36 GA_3=27 Intr.= 42**					**KH =27 GA_3=34 Intr.=51**				
leaves dry weight / spike (g)										
	0.00	**50**	**100**	**150**	**mean**	**0.00**	**50**	**100**	**150**	**mean**
0.00	**1.67**	**2.02**	**2.95**	**3.20**	**2.46**	**1.88**	**2.15**	**2.98**	**3.16**	**2.54**
2.00	**2.11**	**3.56**	**3.87**	**4.54**	**3.52**	**2.21**	**3.58**	**3.92**	**4.68**	**3.68**
4.00	**3.21**	**3.41**	**4.21**	**4.67**	**3.86**	**3.32**	**3.67**	**4.19**	**4.57**	**3.94**
6.00	**3.39**	**3.69**	**4.40**	**4.96**	**4.11**	**3.47**	**3.81**	**4.39**	**4.65**	**4.08**
mean	**2.59**	**3.17**	**3.86**	**4.34**		**2.97**	**3.31**	**3.87**	**4.27**	
$LSD_{0.05}$	**KH =0.05 GA_3=0.03 Intr.= 0.05**					**KH =0.06 GA_3=0.04 Intr.=0.08**				

II- Impact of potassium humate and GA_3 concentration on floral products of Gladiolus plant:-

1-Number of days to flowering (showing color):

The number of days till flowering was significantly impacted by fertilizer rates of potassium humate (KH). The plants that received potassium humate (KH) of 4 and 6 g plant^{-1} showed the earliest flowering, while those that received a fertilizer rate of 0.0 and 2 g showed the later flowering (Table 4). The findings could be explained by the medium or high fertilizer treatment rate's beneficial effects on vegetative development and the production of adequate hormones to start flower buds earlier than unfertilized plants and plants treated with low fertilizer application rates. These results agree with those of **El-Khateeb *et al*., (1991)** on freesia. Results in table (4) indicated that the time taken to showing color in the two growing seasons were significantly decreased with the spraying of GA_3. The earliest reduction in the period from planting date until appearance of color, was obtained by using 150 ppm GA_3, as compared with the control in 1st and 2nd seasons. This may be due to that using gibberellic acid (GA_3) at suitable concentration led to the increase and activation the formed roots. This stimulates absorption of the essential elements for flowers initiation and development. These results are in general agreement with those obtained by **El-Naggar (1999)** on gladiolus**, El-Naggar (2002)** on tuberose**.**

Referring to the interaction, flowering time for the two growing seasons is considerably reduced when the gibberellic acid (GA_3) and potassium humate (KH) interact. In contrast to the control in seasons one and two, the addition of 6g potassium humate (KH) coupled with 150 ppm of GA_3 produced the earliest reduction in the time from planting until color appearance. These results are similar to those obtained by **Mazrou et al., (1991)** on rose **Starck et al., (1991)** and **Ramesh et al., (2002)** on carnation**.**

2- Number of florets /spikes:

Evidently data in Table (4), reveal the increment on the number of florets per spike resulting from using 6 g of potassium humate (KH) in plantation in both experimental fields (12.58 and 12.38) florets in both seasons, However, receiving the plants 4 g also showed a favorable effect in this concern on the values reached to 12.66 and 12.22 inflorescences in in 1st and 2nd seasons , The results are consistent with those on gladiolus plants found by **Iftikhar et al. (2013).**

A great influence on the number of inflorescences was observed in both plantations as a result of receiving the plants with the highest concentration of GA_3. Whereas the other GA_3 treatment gave about the same effect on the obtained values in both experimental seasons, as indicated in Table (4). These results are in harmony with those of **El-Naggar and Sharaf (2002)** on tuberose and **EL-Deeb (2023)** with *Dahlia variabilis* L.

The interaction between the different potassium humate (KH) and gibberellic acid (GA_3) treatment revealed the superiority of adding the plants 6g/plant and combined with GA_3 at 150 ppm treatment for increasing number of florets per spike in both experimental fields (14.78 and 14.77 inflorescences, respectively). The figures obtained from the untreated plants (control) showed the opposite effect, declining to just 7.14 and 7.56 florets in the first and second seasons, respectively. The findings are in harmony with those obtained by **EL-Shafie (1980)** on Queen *Elizabeth* and *Baccara rose* varieties and **Iftikhar et al., (2013)** on gladiolus.

3- Dry weight of florets / spike:

The data in Table (5) clearly show that the dry weight of florets per spike was dramatically impacted by potassium humate treatments. In both seasons, plants that received 6 g/plant showed superior dry weight of florets per spike, with increases of 52.21% and 51.43% in comparison to control. It was evident from the obtained data in table 4 that dry weight of florets increased with GA_3 at 100 and/or 150 ppm. Table 4's results for the interaction made it abundantly evident that the dry weight of the florets increased dramatically when the potassium humate rate added. (2, 4 and 6 g plant^{-1}) in combined with any concentration of GA_3 as compared with control. The highest values of dry weight of florets were obtained by using KH fertilizer at level of 6 g plus GA_3 at concentration of 150 ppm as compared with the other treatments in the two seasons. The values reached 2.37 and 1.13 against 4.94 and 1.17 g plant^{-1} that resulted from the control. These results are in parallel line with those of **Koriesh (1990)** on rose, **El-Naggar and Sharaf (2002)** on *Polianthus tuberose* and **Lolo (2022)** on *Calendula officinalis*.

Table (4): Average of potassium humate (KH), GA_3 and their interaction treatments on number of days to showing color, florets number and dry weights of florets / spike of *Gladiolus hybrida cv.*"Sancerre" plants during the two seasons of 2023 and 2024.

K Humate g plant^{-1}	GA_3 concentrations (ppm)									
	Number of days to showing color									
	(1st) season					(2nd) season				
	0.00	50	100	150	mean	0.00	50	100	150	mean
0.00	98.63	95.35	87.93	85.15	91.77	99.24	94.20	89.15	87.28	92.47
2.00	94.32	86.25	84.19	79.00	85.94	96.18	86.93	86.07	81.00	87.55
4.00	90.72	84.37	81.96	78.13	83.80	90.27	85.53	82.16	78.19	84.04
6.00	87.38	83.78	82.05	79.20	83.10	88.67	81.90	80.55	77.43	82.14
mean	92.76	87.69	84.03	80.37		93.59	87.14	84.48	80.98	
$LSD_{0.05}$	KH =1.86	GA_3=1.56	Intr.= 2.79			KH =1.42	GA_3=1.28	Intr.=2.37		
	Number of florets / spike									
	0.00	50	100	150	mean	0.00	50	100	150	mean
0.00	7.14	7.92	8.51	8.80	8.10	7.65	8.18	9.25	9.97	8.76
2.00	8.24	8.66	10.26	10.75	9.49	8.39	8.61	10.22	10.80	9.51
4.00	9.08	9.82	12.46	13.93	11.32	9.17	9.79	12.51	13.87	11.34
6.00	9.86	11.81	13.87	14.78	12.58	9.88	11.90	12.95	14.77	12.38
mean	8.58	9.55	11.28	12.07		8.77	8.91	10.58	11.85	
$LSD_{0.05}$	KH =0.59	GA_3=0.52	Intr.= 0. 74			KH =0.48	GA_3=0.42	Intr.=0.69		
	dry weights of florets / spike									
	0.00	50	100	150	mean	0.00	50	100	150	mean
0.00	1.13	1.20	1.56	1.69	1.36	1.17	1.22	1.54	1.67	1.40
2.00	1.42	1.51	1.80	1.93	1.67	1.52	1.62	1.85	1.98	1.73
4.00	1.57	1.63	1.99	2.26	1.86	1.58	1.66	1.96	2.29	1.87
6.00	1.72	1.92	2.25	2.37	2.07	1.75	1.98	2. 31	2.44	2.12
mean	1.46	1.57	1.91	2.06		1.51	1.62	1.96	2.10	
$LSD_{0.05}$	KH =0.04	GA_3=0.03	Intr.= 0.06			KH =0.03	GA_3=0.02	Intr.=0.05		

III – Impact of potassium humate acid and GA_3 concentration on corms yield of *Gladiolus* plants: -

1- Corms size and weight :

Data in Table (5) demonstrates a significant effect on new corms characteristics because of using all potassium humate. Application of potassium humate at 6.0 g produced the greatest values for corms diameter and corms fresh weight providing values for the aforementioned parameters of 3.82cm and 4.88 g, respectively, in the in 1st season and 3.84 cm, and 4.94 g in 2nd season.) This outcome may be explained by the high rate fertilization's effective use of available potassium. The data presented in Table (5) indicates that the application of gibberellic acid (GA_3) has a considerable impact on the corm diameter and fresh weight. When compared to the other treatments in 1st and 2nd season, the maximum values of corm diameter and fresh weight were obtained with high concentration of GA_3 (150 ppm).

The data in Table (5) showed that the interaction between potassium humate (KH) and gibberellic acid (GA_3) were significant increase in the corms diameter and fresh weight in the two seasons. The greatest corms diameter (4.75 and 4.78 cm) and corms fresh weight (5.26and 5.31 g) were observed on the plants treated with potassium humate (KH) at 6 g combined with 150 ppm of gibberellic acid (GA_3) in the two seasons. Nevertheless, the control treatment produced the lowest corm diameter (1.95 and 2.02 cm) and fresh weight values (2.15 and 2.17g) in 1st and 2nd season. The findings may be explained by the enhanced availability and absorption of the vital nutrient components, particularly potassium, which leads to better corm production, when k-fertilizers are mixed with the right amounts of gibberellic acid (GA_3). These findings could be explained by the roles that GA_3 and KH play in division and elongation of cell, activation of the enzymes, translocation, and accumulation of assimilated substances like glucose, fructose, sucrose, and carbohydrates in storage plant sections that encourage the initiation and growth of new corms. Similar outcomes were achieved by **EL-Naggar and Sharaf (2002)** on tuberose**.**

IV - Impact of potassium humate acid and GA_3 concentration on chemical analysis of Gladiolus plants:-

1. Photosynthetic pigments:

The addition of potassium humate (KH) significantly impacted the amount of photosynthetic pigments (chlorophyll -SPAD), according to measurements of leaves.

The average amount of chlorophyll of untreated (control) plants was lower in both seasons than that of plants treated with any amount of potassium humate (KH) fertilizer (Table 5). The plants treated with potassium humate (KH) at 4 and 6 g showed the greatest significant increase in total chlorophyll content when compared to the control.

Regarding gibberellic acid (GA_3) treatments, total chlorophyll content increased incrementally as GA_3 concentration increased from low (50 ppm) to high (150 ppm) of GA_3. Potassium humate (KH) combined with gibberellic acid (GA_3) resulted in the highest amount of chlorophyll in contrast to the control in 1st and 2nd seasons. Furthermore, employing 6g/plant of potassium humate with GA3 at 150 ppm produced the most notable increase in the overall chlorophyll content, with values of 58.30 and 59.21 in 1st and 2nd seasons as compared with the control. The capacity of potassium humate with GA_3 to retard the aging of leaves by reducing the degradation of chlorophyll and improving the absorption of essential elements, specifically NH4, P, Fe^{2+}, and Mg^{2+} cations, which are essential for enzyme activation and the development of chloroplasts and chlorophyll and are present in a variety of physiologically active substances, including chlorophylls, may be the cause of this increase in the formation of photosynthetic pigments. These results were agreement with **El-Naggar and Hedia (2005)** on Narcissus and **EL-Deeb (2023)** with Dahlia.

Table (5): Average of potassium humate (KH), GA_3 and their interaction treatments on corms size (diameter) and corms fresh weight of *Gladiolus hybrida cv.*"Sancerre"plants during the two seasons of 2022 and 2023.

K Humate (g plant^{-1})	GA3 concentrations (ppm)									
	corms size (diameter)									
	(1st) season					(2nd) season				
	0.00	**50**	**100**	**150**	**mean**	**0.00**	**50**	**100**	**150**	**mean**
0.00	1.95	2.25	2.38	2. 71	2.32	2.02	2.27	2.35	3.69	2.58
200	2.31	2.54	2.79	3.15	2.70	2.32	2.57	2.69	3.17	2.69
4.00	2.68	3.16	3.28	3.57	3.22	2.70	3.18	3.27	3.59	3.19
6.00	3.24	3.59	3.68	4.75	3.82	3.27	3.61	3.70	4.78	3.84
mean	2.55	2.86	3.03	3.55		2.58	2.91	3.00	3.81	
$LSD_{0.05}$	KH= 0.24	GA_3 =0.19	Intr.=0.35			KH =0.22	GA_3=0.13	Intr.= 0.34		
	Fresh weight of corms (g)									
	0.00	**50**	**100**	**150**	**mean**	**0.00**	**50**	**100**	**150**	**mean**
0.00	2.15	2.56	3.34	3.59	2.91	2.17	2.50	3.32	3.58	2.89
2.00	3.16	3.68	4.24	4.78	3.96	3.18	3.68	4.23	4.81	3.98
4.00	4.31	4. 37	4.64	4.95	4.57	4.40	4. 31	4.64	4.97	4.58
6.00	4.44	4.82	5.00	5.26	4.88	4.52	4.83	5.09	5.31	4.94
mean	3.52	3.86	4.31	4.65		3.57	3.83	4.32	4.67	
$LSD_{0.05}$	KH =0.06	GA_3=0.05	Intr.= 0.08			KH =0.06	GA_3=0.05	Intr.= 0.08		

2. Potassium %

Data in table 5 demonstrated that the potassium content was significantly impacted by the potassium humate treatment. The potassium concentration of 4 or 6 g plant^{-1} produced the greatest results.Also, gibberellic acid had a notable impact.on potassium content in leaves. There was a significant effect between50, 100 and 150 ppm of potassium content and control. The interaction between potassium humate and gibberellic acid showed significant differences in leaves potassium content. For 1st and 2nd season, the highest values were obtained when 6 g of potassium humate was coupled with 150 ppm of GA3. However, 4g of potassium humate combined with 150 ppm of GA3 produced the following results for 1st and 2nd season (3.98and 3.97%). Nonetheless, the control treatment produced the lowest potassium % readings 2.12 and 2.14 % 1st and 2nd season. Similar outcomes were observed by **Ibrahim et al., (2016)** with *Limonium sinuatum*, **Sherif and Ali (2018)** on Maize (*Zea mayes* L.) plants, and **El-Deeb (2016)** on gladiolus and **Harhash et al., (2023)** on *Dahlia variabilis* L.

Table (5): Average of potassium humate (KH), GA_3 and their interaction treatments on chlorophyll and K content of *Gladiolus hybrida cv.*"Sancerre"plants during the two seasons of 2022 and 2023.

K Humate (g plant^{-1})	GA_3 concentrations (ppm)									
	Chlorophyll content of leaves (SPAD)									
	(1st) season					(2nd) season				
	0.00	50	100	150	mean	0.00	50	100	150	mean
0.00	31.02	35.40	36.54	38.54	35.38	32.93	34.86	37.10	39.50	36.10
200	35.19	37.54	39.41	43.50	38.91	36.75	38.56	39.12	46.79	40.31
4.00	43.23	45.19	45.59	49.08	45.77	42.64	44.75	46.20	49.98	45.90
6.00	49.52	52.39	55.98	58.30	54.05	48.68	54.60	57.37	59.21	54.99
mean	39.74	42.63	44.88	47.36		40.25	43.19	44.95	48.87	
$LSD_{0.05}$	KH = 3.27	GA_3=1.38	Intr.= 3.82			KH =4.19	GA_3= 1.89	Intr.=4.52		
	K content of leaves (%)									
	0.00	50	100	150	mean	0.00	50	100	150	mean
0.00	2.12	2.27	2.39	2.43	2.30	2.14	2.29	2.35	2.45	2.31
2.00	2.42	2.62	2.86	3.08	2.75	2.38	2.63	2.84	3.13	2.75
4.00	3.24	3.45	3.69	3.95	3.58	3.26	3.48	3.70	3.97	3.60
6.00	3.51	3.65	3.90	3.98	3.76	3.58	3.67	3.74	3.97	3.74
mean	2.82	3.00	3.21	3.36		2.84	3.02	3.16	3.38	
$LSD_{0.05}$	KH = 0.07	GA_3=0.05	Intr.= 0.09			KH =0.09	GA_3= 0.05	Intr.=0.09		

3.The total carbohydrates percentage of aerial parts and corms:

Data in Table (6) showed that potassium humate, gibberellic acid (GA_3) had significant effect on total carbohydrates percentage of aerial parts and corms in both seasons of study.

The results presented in Table (6) showed that the highest of total carbohydrates percentage of aerial parts and corms were obtained by using potassium humate at 6g/plant. The values reached to 21.98 and 22.44 % for aerial parts and 44.52and 44.89% for new corms in 1st and 2nd season, respectively.

Data of the two seasons in Table (6) indicated that the carbohydrates percentage of aerial parts and corms were significantly increasing by using gibberellic acid (GA_3) at 50 , 100 and 150 ppm.

Whereas gibberellic acid (GA_3) at 150 ppm provided the most notable increases in the proportion of carbohydrates percentage in corms and aerial parts,with the mean of 20.66 and 21.36 % of aerial parts and 43.75 and 43.92 % of new corm in 1st and 2nd seasons.

The highest rate of potassium humate (KH) with gibberellic acid (GA_3) at 150 ppm was the best treatment for increasing the carbohydrates percentage of aerial parts and corms for both seasons. These treatment increased the carbohydrates percentage of aerial parts (22. 95 and 23.78) and corms (47.77 and 47.30) against to 14.93 , 14.78 and 36.01 , 37.80 % emerged as a result of the control in 1st and 2nd seasons. However, 6 g plant^{-1} k-humate and 100 ppm gibberellic acid(GA_3) produced the following resultsThis increase in total carbohydrate content brought about by k-humate and gibberellic acid may be explained by the physiological function of K in promoting vegetative development. (Table 3), It most likely had leaves with a higher chlorophyll concentration, increasing photosynthetic activity and generating more carbohydrates. These results agree with those reported by **Haikal, M. (1992).** on gladiolus and **El- Naggar and El- Naggar (2004) with** *Dianthus caryophyllus* .

Table (6): Average of potassium humate (KH), GA_3 and their interaction treatments on Total carbohydrate percentage of aerial parts and new corms of *Gladiolus hybrida cv.*"Sancerre"plants during the two seasons of 2022 and 2023.

K Humate (g plant^{-1})	GA3 concentrations (ppm)									
	Total carbohydrate percentage of aerial parts									
	(1st) season					(2nd) season				
	0.00	50	100	150	mean	0.00	50	100	150	mean
0.00	14.93	16.02	16. 65	17.35	16.24	14.78	15.92	17.12	17.39	16.30
200	15.33	17.35	18.17	20.20	17.76	16.22	18.37	19.66	21.74	18.99
4.00	18.78	19.42	21.28	22.13	20.40	19.10	20.13	21.78	22.53	20.89
6.00	20.43	21.85	22.68	22. 95	21.98	21.15	21.85	22.98	23.78	22.44
mean	17.37	18.66	19.70	20.66		17.81	18.89	20.39	21.36	
LSD0.05	KH= 1.33	GA_3 =1.09	Intr.=1.75			KH =1.29	GA_3=1.05	Intr.= 1.64		
	Total carbohydrate percentage of new corms									
	0.00	50	100	150	mean	0.00	50	100	150	mean
0.00	36.01	38.23	38.59	39.10	37.98	37.80	38.02	39.34	39.79	38.74
2.00	39.09	40.75	43.19	43.92	41.74	39.14	40.23	43.41	43.50	41.57
4.00	39.23	41.64	43.98	44.20	42.26	40.88	43.20	44.59	45.08	43.44
6.00	41.44	43.68	45.21	47.77	44.52	42.46	43.82	45.98	47.30	44.89
mean	38.94	41.10	42.74	43.75		40.07	41.32	43.33	43.92	
LSD0.05	KH =1.62	GA_3=1.00	Intr.= 1.83			KH =1.51	GA_3=1.07	Intr.= 1.42		

Therefore, it is recommended to apply 6 g/plant of k-humate and foliar spray with a 150 ppm of GA_3 for the cultivation of *Gladiolus hybrida cv.*"Sancerre" in sandy soil. This regimen is suggested to achieve optimal growth, flowering, as well as maximize productivity in terms of corms.

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