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Effect of intercropping with leafy vegetables on mainly growth, yield and quality of gladiolus under agro-climatic conditions of Prayagraj

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Abstract
The present investigation entitled "Effect of intercropping with leafy vegetables on mainly growth, yield and quality of gladiolus (*Gladiolus* spp.)" was carried out at Horticulture Research Field, Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, during *rabi* season of October 2023 - March 2024. The experiment was conducted in Randomized Block Design with ten treatment combination. It concluded that cultivation of fenugreek as intercrop with gladiolus as main crop was found as best option among the intercropping thus best result was obtained in T6- Gladiolus + Fenugreek was found higher result of plant height (98.34 cm), Days to spike emergence (62.14 days) Rachis length (55.10 cm), Spike length (82.81 cm), Floret diameter (9.88 cm), Number of florets per spike (18.47) Among the different treatments the highest gross return is 1776960 Rs/ha, net return is 1522657 Rs/ha, benefit cost ratio was obtained from the treatment, that is T10- Gladiolus + Fenugreek + Spinach + Bathua + Sowa crop. Sole cropping of fenugreek, Spinach, Bathua, Sowa leading to higher herbage yield. Gladiolus yield was improved under intercropping as compare to sole cropping system.

Keywords: Gladiolus, Fenugreek, Spinach, Bathua, Sowa, Intercropping

1. Introduction
The word gladiolus was coined from the Latin word gladiolus meaning sword lily on account of its shape of its foliage. Corn flag is it's another name in Europe *G. Illiricus* was found wild as weed in corn fields. Water fall Lilly is another name given to it as *G. primulinis* was found growing near the Victoria Falls in the tropical forests of Africa. It was introduced into cultivation towards end of 16th century. In India cultivation dates back to 19th century, as Firmingers manual of gardening in India published in 1863 mentions that Charles Grey of coonoor grew some gladiolus from corms and seeds in his garden. Gladiolus botanically known as *Gladiolus grandiflorus* L. belonging to the family lridaceae. It is known to be a native of tropical South Africa, Mediterranean region. Europe and Mascardene Islands. The herbaceous plant sprouts from axillary buds of an underground structure, the corm, which is a condensed vertical rootstock, covered with dried leaves base. The inflorescence is a spike, with florets arranged alternately on the floral axis. The fibrous root system in gladiolus develops from the concave base of the corm. Gladiolus is a flower of glamour and perfection which is known as the queen of bulbous flowers due to its flower spikes with florets of massive form, brilliant colours, attractive shapes, varying size and excellent shelf life. Gladiolus is grown as flower bed in gardens and used in floral arrangements for interior decoration as well as making high quality bouquet Gladiolus is considered as a main cut flower and garden plant. It is cultivated in almost all countries of the world, with USA producing 80% of the world gladiolus. In India, gladiolus has become an important commercial cut flower with greater demand in indigenous market for its majestic spikes, which contain attractive, elegant and delicate florets. Gladiolus cultivation under Northern Indian plains (that includes whole of U.P), coastal areas of Tamil Nadu and Pondicherry has a potential to change the economic scenario of farmers of these areas. For generating both money as well as employment in rural areas gladiolus is such a crop suitable for establishing

floriculture industry by progressive farmers and entrepreneurs and undoubtly the best bulbous flower in India. Its magnificent spikes in dazzling colours remain fresh for 10 to 22 days. Its cultivation in Jammu region has become an important sector as consumption of flowers is rising associated with economic development

2. Materials and Methods

The experiment was carried out at Horticulture Research Field, Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, during *rabi* season of October 2023 - March 2024. situated at an elevation of 78 meters above mean sea level at 25.87 degree North latitude and 81.15 degree E longitude. This region has a sub-tropical climate prevailing in the south-east part of Uttar Pradesh with both the extremes in temperature, i.e. the winter and the summer The area of Allahabad district comes under subtropical belt in the South east of Uttar Pradesh, which experiences extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46 ^{0}C – 48 ^{0}C and seldom falls as low as 4 ^{0}C – 5 ^{0}C. The relative humidity ranges between 20 to 94 per cent. The average rainfalls in this area is around 1013.4 mm annually. The experiment was laid out in Randomized Block Design with tenth treatments having three replications. This experiment includes intercropping of Gladiolus with Fenugreek, Spinach, Bathua and Sowa. The details of treatments are T_1Gladiolus sole, T_2Fenugreek sole, T_3Spinach Sole, T_4Bathua Sole, T_5Sowa Sole, T_6Gladiolus sole+ Fenugreek, T_7Gladiolus sole+ Spinach, T_8Gladiolus sole+ Bathua, T_9Gladiolus sole+ Sowa and T_{10} Gladiolus sole+ Fenugreek+ Spinach+ Bathua+ Sowa. Data were statistically analysed by the method suggested.

3. Results and Discussion

The present experiment entitled "Effect of intercropping with leafy vegetables on mainly growth, yield and quality of gladiolus under agro-climatic conditions of Prayagraj" was carried out during the rabi season October 2023 to January 2024 at Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj. The results obtained during the course of investigation are presented with the help of tables, plates and illustrated graphically. Data on various parameters studied were subjected to statistical analysis in order to draw the valid conclusion of results, which have been presented in the succeeding pages. The plant growth and yield of Gladiolus (*Gladiolus grandiflorus*) as influenced by intercropping system with Fenugreek, Spinach, Bathua and Sowa, under different treatments are presented in table 1 and 2. Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on plant height of gladiolus was significant. The maximum plant height of gladiolus (98.34) was recorded with Gladiolus +Fenugreek. Followed by Gladiolus +Bathuaand Gladiolus +Sowa.Where as the minimum plant height (84.04) was recorded in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. To increase their competitive power, plants display adaptive response, such as rapid shoot elongation to consolidate light capture Keuskamp *et al*., (2010) [10]. These findings are in conformity with Singh and Singh (2014) [11] and Singh and Datta (2006) [2] while working with tobacco based intercropping system at Pusa Bihar and Bose *et al.,* (2024) [12]. Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on Number of shoots per corm of Gladiolus was significant. Where as the maximum Number of shoots per corm (2.17) was recorded with treatment Gladiolus + Fenugreek. Followed by Gladiolus +Sowa, Gladiolus + Spinach and Gladiolus Sole. The minimum Number of shoots per corm (1.33) was found in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on Days to spike initiation of Gladiolus was significant. Where as the minimum Days to spike initiation (62.14) was recorded with treatment Gladiolus +Fenugreek. Followed by Gladiolus +Sowa, Gladiolus +Spinach and Gladiolus Sole. The maximum Days to spike initiation (69.94) was found in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on Days to opening of first floret of Gladiolus was significant. Where as the minimum Days to opening of first floret (73.041) was recorded with treatment Gladiolus +Fenugreek. Followed by Gladiolus +Sowa, Gladiolus +Spinach and Gladiolus Sole. The maximum Days to opening of first floret (83.64) was found in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on First floret durability (days) of Gladiolus was significant. Where as the maximum First floret durability (days) (1.71) was recorded with treatment Gladiolus +Fenugreek. Followed by Gladiolus +Sowa, Gladiolus +Spinach and Gladiolus Sole. The minimum First floret durability (days) (8.27) was found in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. The microclimate within intercrop systems could potentially benefit flower size improvement by providing shade and altering air movement. These changes in microclimate can have a significant impact on flowering size Devdhara *et al*., (2018) [11]. These findings align with those reported in reference Singh and Singh (2014) [11] and Bose *et al.,* (2024) [12]. Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on Spike length (cm) of Gladiolus was significant. Where as the maximum Spike length (cm) (82.81) was recorded with treatment Gladiolus +Fenugreek. Followed by Gladiolus +Sowa, Gladiolus +Spinach and Gladiolus Sole. The minimum Spike length (cm) (74.22) was found in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. Competition for growth resources among intercrops accelerates the vegetative growth of the main crop, enhancing overall resource utilization efficiency. Consequently, this results in the production of maximum rachis length and spike length in gladiolus Soniya *et al*., (2021) [4]. These findings are consistent with references Singh and Datta (2006) [2], l Kumar *et al*., (2017) [3] and Bose *et al.,* (2024) [12]. Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on Rachis length (cm) of Gladiolus was significant. Where as the maximum Rachis length (cm) (55.10) was recorded with treatment Gladiolus +Fenugreek. Followed by Gladiolus +Sowa, Gladiolus +Spinach and Gladiolus Sole. The minimum Rachis length (cm) (45.66) was found in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. The competition for growth resources with intercrops facilitates the rapid vegetative growth of the main crop, thereby enhancing the efficiency of resource utilization. This ultimately results in the production of maximum rachis length and spike length in gladiolus Soniya *et al*., (2021) [4].

It may be due to the optimization of resource use, enhances the microclimate, manages pests, and boosts soil health, all of which contribute to an increased number of rachis. These findings align with those reported in reference Singh and Singh (2014) **[11]** and Bose *et al.,* (2024) [12]. Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on Number of florets per spike of Gladiolus was significant. Where as the maximum Number of florets per spike (18.47) was recorded with treatment Gladiolus +Fenugreek. Followed by Gladiolus +Sowa, Gladiolus +Spinach and Gladiolus Sole. The minimum Number of florets per spike (15.39) was found in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. Competition among crops arises from the growth habit of gladiolus, which capitalizes on peak resources, leading to the promotion of a higher number of florets per spike. By intercropping, it optimizes the use of light, water, and nutrients, allowing plants to access these resources more effectively, which promotes better growth and more florets. These results are consistent with the findings reported in references Singh and Singh (2014) [11] and Singh and Datta (2006) [2] and Bose *et al.,* (2024) [12]. Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on Number of opened florets per spike of Gladiolus was significant. Where as the maximum Number of opened florets per spike (16.30) was recorded with treatment Gladiolus +Fenugreek. Followed by Gladiolus +Sowa, Gladiolus +Spinach and Gladiolus Sole. The minimum Number of opened florets per spike (11.43) was found in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on Number of partially opened florets per spike of Gladiolus was significant. Where as the maximum Number of partially opened florets per spike (2.47) was recorded with treatment Gladiolus +Fenugreek. Followed by Gladiolus +Sowa, Gladiolus +Spinach and Gladiolus +Bathua. The minimum Number of partially opened florets per spike (1.91) was found in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on Floret size (cm) of Gladiolus was significant. Where as the maximum Floret size (cm) (9.88) was recorded with treatment Gladiolus +Fenugreek. Followed by Gladiolus +Sowa, Gladiolus +Spinach and Gladiolus sole. The minimum Floret size (cm) (8.10) was found in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on Durability of spike (days) of Gladiolus was significant. Where as the maximum Durability of spike (days) (12.37) was recorded with treatment Gladiolus +Fenugreek. Followed by Gladiolus +Sowa, Gladiolus +Spinach and Gladiolus sole. The minimum Durability of spike (days) (8.54) was found in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on Number of spikes per hectare (lakh) of Gladiolus was significant. Where as the maximum Number of spikes per hectare (lakh) (1.50) was recorded with treatment Gladiolus sole. Followed by Gladiolus +Fenugreek, Gladiolus +Sowa and Gladiolus +Spinach. The minimum Number of spikes per hectare (1.08) was found in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on Number of corms per planted corm of Gladiolus was significant. Where as the maximum Number of corms per planted corm (2.50) was recorded with treatment Gladiolus sole. Followed by Gladiolus +Fenugreek, Gladiolus +Sowa and Gladiolus +Spinach. The minimum Number of corms per planted corm (1.50) was found in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on Number of corms per hectare (lakh) of Gladiolus was significant. Where as the maximum Number of corms per hectare (lakh) (1.88) was recorded with treatment Gladiolus sole. Followed by Gladiolus +Fenugreek, Gladiolus +Sowa and Gladiolus +Spinach. The minimum Number of corms per hectare (lakh) (1.28) was found in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on Number of cormlets per plant of Gladiolus was significant. Where as the maximum Number of cormlets per plant (23.99) was recorded with treatment Gladiolus sole. Followed by Gladiolus +Fenugreek, Gladiolus +Sowa and Gladiolus +Spinach. The minimum Number of cormlets per plant (15.20) was found in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. In a sole crop system, plants may receive all the avourable environmental conditions such as solar radiation, nutrients, moisture, and space, which enhance the conversion of solar energy into biological yield. This favourable environment leads to the production of a greater number of cormlets per plant in the sole cropping system Atal *et al*., (2021) [5]. It may be due to the influence of various growth factors such as competition for resources (light, water, and nutrients), microclimate modification, and pest and disease control by which it enhanced the growth and yield of corms by improving resource use efficiency, planting density and reduced pest pressure. These findings are consistent with references Singh and Singh (2014) [11] and Singh and Datta (2006) [2] and Bose *et al.,* (2024) [12].

Effect of intercropping system with Fenugreek, Spinach, Bathua and Sowa on Number of cormlets per hectare (lakh) of Gladiolus was significant. Where as the maximum Number of cormlets per hectare (lakh) (18.51) was recorded with treatment Gladiolus sole. Followed by Gladiolus +Fenugreek, Gladiolus +Sowa and Gladiolus +Spinach. The minimum Number of cormlets per hectare (lakh) (12.86) was found in treatment Gladiolus +Fenugreek + Spinach + Bathua + Sowa. Cultivars of species that are compatible in this manner can be planted at higher densities, which is a significant factor contributing to the ability of intercrops to yield more than sole crops Davis and Woolley (1993) [9]. Similar results were reported by Singh and Singh (2014) [11] and Singh and Datta (2006) [2] and Bose *et al.,* (2024) [12]. According to Vasava *et al*. 2024, the ratio between the base crop and the intercrop can significantly impact system productivity. It may be due to resource competition, microclimate changes, and pest control, which improve resource use efficiency and reduce pest pressure. However, the extent of this impact may depend on the nature of the produce and market demand Nikam *et al*., (1988) [6] and Bose *et al.,* (2024) [12]. The economics of different treatments is depicted in Table 3. The gross return is 1776960 Rs/ha, net return is 1522657 Rs/ha, benefit cost ratio (5.99) was obtained from the treatment T10- Gladiolus + Fenugreek Spinach + Bathua + Sowa.

Table 1: Intercropping in Fenugreek, Spinach, Bathua and Sowa with gladiolus on plant growth and yield parameter of Gladiolus

Treatment No.	Treatment	Plant height (cm)	Number of shoots per corm	Days to spike initiation	Days to opening of first floret	First floret durability (days)	Spike length (cm)	Rachis length (cm)	Number of florets per spike	Number of opened florets per spike	Number of partially opened florets per spike	Floret size (cm)	Durability of spike (days)
T1	Gladiolus Sole	87.43	1.71	67.43	78.67	9.45	76.76	49.50	17.09	14.29	2.06	9.36	11.74
T2	Fenugreek Sole	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T3	Spinach Sole	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T4	Bathua Sole	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T5	Sowa Sole	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T6	Gladiolus +Fenugreek	98.34	2.17	62.14	73.04	10.71	82.81	55.10	18.47	16.30	2.47	9.88	12.37
T7	Gladiolus +Spinach	92.47	1.84	66.74	76.06	10.18	77.04	51.14	17.43	14.64	2.15	9.73	12.17
T8	Gladiolus +Bathua	93.40	1.48	68.30	81.04	9.10	75.36	47.85	16.50	13.33	2.11	8.47	10.40
T9	Gladiolus +Sowa	94.06	1.93	65.03	74.83	10.46	81.36	52.37	18.17	14.83	2.33	9.67	12.30
T10	Gladiolus +Fenugreek + Spinach + Bathua + Sowa	84.04	1.33	69.94	83.64	8.27	74.22	45.66	15.39	11.43	1.91	8.10	8.54
	F- test	S	S	S	S	S	S	S	S	S	S	S	S
	S. Ed. (±)	0.725	0.23	0.294	0.389	0.108	0.716	0.543	0.068	0.068	0.022	0.035	0.055
	C. D. (P = 0.05)	0.1523	0.048	0.617	0.818	0.227	1.503	1.142	0.142	0.143	0.046	0.073	0.117

Table 2: Intercropping in Fenugreek, Spinach, Bathua and Sowa with gladiolus on plant growth and yield parameter of Gladiolus

Treatment No.	Treatment	Number of spikes per hectare (lakh)	Number of corms per planted corm	Number of corms per hectare (lakh)	Number of cormlets per plant	Number of cormlets per hectare (lakh)
T1	Gladiolus Sole	1.50	2.50	1.88	23.99	18.51
T2	Fenugreek Sole	0.00	0.00	0.00	0.00	0.00
T3	Spinach Sole	0.00	0.00	0.00	0.00	0.00
T4	Bathua Sole	0.00	0.00	0.00	0.00	0.00
T5	Sowa Sole	0.00	0.00	0.00	0.00	0.00
T6	Gladiolus +Fenugreek	1.41	2.30	1.79	22.27	17.06
T7	Gladiolus +Spinach	1.22	2.12	1.53	20.28	15.07
T8	Gladiolus +Bathua	1.17	2.05	1.43	19.77	14.12
T9	Gladiolus +Sowa	1.29	2.19	1.65	21.16	15.40
T10	Gladiolus +Fenugreek + Spinach + Bathua + Sowa	1.08	1.50	1.28	15.20	12.86
	F- test	S	S	S	S	S
	S. Ed. (±)	0.022	0.033	0.027	0.348	0.225
	C. D. (P = 0.05)	0.046	0.069	0.056	0.731	0.472

Table 3: Economics for cultivation and benefit cost ratio of Gladiolus (*Gladiolus grandiflorus*) intercropped with Fenugreek, Spinach, Bathua and Sowa under different treatments

Treatment No.	Treatment	Cost of cultivation Rs ha^{-1}	Gross returnRs ha^{-1}	Net Return	Benefit Cost Ratio
T1	Gladiolus Sole	540968	1494750	953782	1.76
T2	Fenugreek Sole	94928	342000	247072	2.60
T3	Spinach Sole	92793	217000	124207	1.34
T4	Bathua Sole	110968	404640	293672	2.65
T5	Sowa Sole	91618	251200	159582	1.74
T6	Gladiolus +Fenugreek	393938	1668500	1274562	3.24
T7	Gladiolus +Spinach	392428	1386050	993622	2.53
T8	Gladiolus +Bathua	405968	1450100	1044132	2.57
T9	Gladiolus +Sowa	391488	1471100	1079612	2.76
T10	Gladiolus +Fenugreek Spinach+Bathua+Sowa	254303	1776960	1522657	5.99

4. Conclusion

From the present investigation, it concluded that treatment T6- performed best in terms of growth, with maximum height recorded (98.34 cm) when intercropped with fenugreek, Days to spike emergence (62.14 days) Rachis length (55.10 cm), Spike length (82.81 cm), Floret diameter (9.88 cm), Number of florets per spike (18.47) obtained in treatment T6. Notably, the treatment combining Gladiolus with fenugreek, spinach, bathua, sowa (T_{10}) yielded the highest net return of (1522657 Rs/ha) and a benefit-cost ratio of (5.99). However, it is noteworthy that in terms of vegetative growth, sole cropping of fenugreek, spinach, bathua and sowa produced taller plants with more leaves and branches per plant, resulting in higher herbage yield compared to intercropping. These findings underscore the complexity of crop interactions and the potential economic benefits of intercropping strategies in enhancing overall agricultural productivity and profitability.

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