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Stability Analysis of Plant Density and Frequency of Foliar Application of Nitrogen in *Gladiolus hybrida*

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Abstract: An attempt was made to find stable planting density and frequency of foliar nitrogen application using stability models. The data on various flowering and growth characteristics in gladiolus for four foliar nitrogen spray viz., 0, 3, 5 and 7 days and three planting density i.e. 100, 120 and 140 cormels m^{-2} were collected and experiment was repeated in four seasons over two years. Treatment combinations of 3 days + 120 cormels m^{-2} and 5 days + 120 cormels m^{-2} were found to be stable for number of corms per m^2; 3 days + 100 cormels m^{-2}, 3 days + 120 cormels m^{-2}, 3 days + 140 cormels m^{-2}, 5 days + 100 cormels m^{-2}, 5 days + 120 cormels m^{-2}, 5 days + 140 cormels m^{-2}, 7 days + 120 cormels m^{-2} and 7 days + 140 cormels m^{-2} were found to be stable for weight of corms m^{-2}. 3 days + 140 cormels m^{-2} was found to be stable for number of cormels $plant^{-1}$ and 5 days + 100 cormels m^{-2} was found to be stable for weight of cormels $plant^{-1}$.

Keywords: Gladiolus, Eberhart & Russell's model, Plant density, Frequency of foliar nitrogen application

Floriculture is gaining importance as a good source of income apart from giving pleasure and happiness. Particularly, gladiolus (*Gladiolus spp.*) a member of the family Iridaceae, has gained much importance as a cut flower because of its beautiful spikes. In the world, this genus occurs in Asia, Mediterranean Europe, South Africa, and tropical Africa. Moreover, India has suitable agro-climatic conditions for gladiolus cultivation; and is commercially cultivated in West Bengal, Himachal Pradesh, Sikkim, Karnataka, Uttar Pradesh, Tamil Nadu, Punjab and Delhi. Gladiolus responds well to balanced nutrition for better growth and maximum flower production. Inadequate plant nutrition causes serious disorders and may eventually lead to decline of plant vigor and flower yield. Nitrogen is one of the most important nutrient producing growth and yield responses in gladiolus. The quantity of phosphorus required by gladiolus is about one-tenth of the nitrogen expressed in terms of foliar analysis. Foliar nutrition with NPK in addition to soil application significantly affects vegetative growth and floral characters (Roy *et al.* 1995). Nutrition plays an important role in the overall growth performance of the gladiolus crop.

Foliar spray of nitrogen × planting density (N×D) interaction is a universal phenomenon when different frequency of foliar N application and planting density are evaluated across different seasons of different years. Most agronomically and economically important flower traits of Gladiolus species, such as number of days taken for sprouting, per cent sprouting, plant height and number of leaves/plant are quantitative in nature and routinely exhibit N × D interaction. Keeping in view this, an attempt was made to identify stable frequency of foliar spray of nitrogen and planting density in different seasons/years for various growth and flowering characteristics by using Eberhart & Russell's stability (1966).

MATERIAL AND METHODS

Data on various growth and flowering characteristics of Gladiolus cultivar "Solan Mangla" with four treatments of foliar spray of N and three treatments of planting density each replicated three times over two years and two seasons per year were taken from the field of Floriculture and Landscape Architecture, Dr. Y.S. Parmar University of Horticulture & Forestry, Nauni, Himachal Pradesh during year 2016-17. The area has an elevation of about 1250 m above mean sea level, with the coordinates as: latitude 30º50'30" to 30º50'0" N and the longitude $77^0$8'30" and $77^0$11'30" E.

Twelve treatment combinations i.e., control + 100 cormels m^{-2} (N_0D_1), control + 120 cormels m^{-2} (N_0D_2), control + 140 cormels m^{-2} (N_0D_3), 3 days + 100 cormels m^{-2} (N_1D_1), 3 days + 120 cormels m^{-2} (N_1D_2), 3 days + 140 cormels m^{-2} (N_1D_3), 5 days + 100 cormels m^{-2} (N_2D_1), 5 days + 120 cormels m^{-2} (N_2D_2), 5 days + 140 cormels m^{-2}(N_2D_3), 7 days + 100 cormels m^{-2} (N_3D_1), 7 days + 120 cormels m^{-2} (N_3D_2), 7 days + 140 cormels m^{-2}(N_3D_3) were experimented. The data on number of days taken for sprouting, per cent sprouting, plant height (cm), number of leaves $plant^{-1}$, cropping duration (days), number of cormels $plant^{-1}$, weight of cormels $plant^{-1}$, size of cormels(cm), number of corms plant^{-1}, weight of corms m^{-2} (g), size of corms(cm) were taken into consideration to draw the inference.

Eberhart and Russell's model was used to identify stable treatment combinations for various growth and flowering characteristics. Eberhart and Russell's Model (1966) has three parameters of stability and were calculated as

Phenotypic index (P_i)=

$$\frac{\Sigma_j^e xij}{e} - \frac{\Sigma_i^g \Sigma_j^e xij}{ge} and \Sigma_i^g P_i - 0, i = 1,2.....(g)$$

The regression coefficient (b_i)= $\frac{\Sigma_j^e xijI_j}{\Sigma_j^e I_j^2}$

Deviations from linearity (S^2_{di}) =g_iMSS – EMS ;

where, g_i MSS= $\frac{\left[\left(\Sigma_j^e x_{ij}^2 - \frac{T_{gi}^2}{e}\right) - \left(\frac{\Sigma_j^e x_{ij} I_j}{\Sigma_j^e I_j^2}\right)^2\right]}{(e-2)}$

The following inferences can be drawn from the following adaptive specificity for various environments:

Low yield, low sensitivity: Phenotypic index (P_i) less than zero and regression coefficient (b_i) < 1.

Low yield, high sensitivity: Phenotypic index (P_i) less than zero and regression coefficient (b_i) > 1.

High yield, low sensitivity: Phenotypic index (P_i) greater than zero and regression coefficient (b_i) < 1.

High yield, high sensitivity: Phenotypic index (P_i) greater than zero and regression coefficient (b_i) > 1.

A stable genotype is one which confirms to the following condition of three stability parameters i.e. P_i > 0; b_i = 1 and (S^2_{di}) is low.

RESULTS AND DISCUSSION

A single experiment will precisely furnish information about only one location or season or year in which the experiment is conducted. Therefore, it was necessary to repeat the same experiment either at different places or over a number of years to obtain valid recommendations taking into account place to place variation or variation over period. Average response of genotypes thus depends largely upon the absence or presence of genotype × season interaction, coupled with high yield indicated that the genotypes are suitable for general adaptation in the range of environment considered. But this ideal situation is rarely found because the stability of a genotype is inversely proportional to the mean yield. Genotypes with high stability are generally low yielders and vice-versa. Main objective is to identify stable genotype that interact less with the environment in which they are grown.

Treatment×season (T×S) interaction was found to be significant for number of corms per square meter, weight of corms per square meter, number of cormels per plant, weight of cormels per plant. Therefore stability analysis was conducted for these characters. Parameters of Eberhart & Russell's model along with conclusions are presented in Tables 1, 2, 3 and 4 for number of corms per square meter, weight of corms per square meter, number of cormels per plant, and weight of cormels per plant respectively.

Number of corms per square meter: The treatment combination N_1D_2 i.e. foliar spray of nitrogen (3 days) and plant density (120 cormels m^{-2}) and the treatment combination N_2D_2 i.e. foliar spray of nitrogen (5 days) and plant density (120 cormels m^{-2}) satisfied all three conditions i.e. P_i (7.45 and 4.11 respectively) greater than zero, regression coefficient b_i (1.27 and 1.23, respectively) nearly

Table 1. Parameters of Eberhart and Russell's model for number of corms m^{-2}

Treatment combinations	Mean	P_i	(b_i)	(S^2_{di})	Conclusion
T_1 (N_0D_1)	38.00	-16.22	0.24	5.258	Low yield, low sensitivity
T_2 (N_0D_2)	40.25	-13.97	0.28	4.926	Low yield, low sensitivity
T_3 (N_0D_3)	43.58	-10.64	0.26	3.282	Low yield, low sensitivity
T_4 (N_1D_1)	54.00	-0.22	0.64	53.348	Low yield, low sensitivity
T_5 (N_1D_2)	61.67	7.45	1.27	-0.365	Stable treatment combination
T_6 (N_1D_3)	71.75	17.53	2.05	48.201	High yield, high sensitivity
T_7 (N_2D_1)	50.67	-3.55	0.76	19.843	Low yield, low sensitivity
T_8 (N_2D_2)	58.33	4.11	1.23	1.942	Stable treatment combination
T_9 (N_2D_3)	67.58	13.36	1.87	26.006	High yield, high sensitivity
T_{10} (N_3D_1)	47.92	-6.30	0.73	9.835	Low yield, low sensitivity
T_{11} (N_3D_2)	53.667	-0.55	1.02	14.871	Low yield, high sensitivity
T_{12} (N_3D_3)	63.250	9.03	1.64	10.646	High yield, high sensitivity

equal to one and low S^2_{di} (Table 1). Thus, treatment combinations N_1D_2 and N_2D_2 identified as stable treatment combinations with respect to foliar nitrogen application and plant density and were suitable for general adaptations.

Weight of corms per square meter: The treatment combinations N_1D_1 (3 days foliar spray of nitrogen and 100 cormels m^{-2} plant density), N_1D_2 (3 days foliar spray of nitrogen and 120 cormels m^{-2}), N_1D_3 (3 days foliar spray of nitrogen and 140 cormels m^{-2} plant density), N_2D_1 (5 days foliar spray of nitrogen and 100 cormels m^{-2} plant density), N_2D_2 (5 days foliar spray of nitrogen and 120 cormels m^{-2}), N_2D_3 (5 days foliar spray of nitrogen and 140 cormels m^{-2}), N_3D_2 (7 days foliar spray of nitrogen and 120 cormels m^{-2}) and N_3D_3 (7 days foliar spray of nitrogen and 140 cormels m^{-2}) satisfied conditions of Eberhart and Russell's model i.e. P_i (0.03, 0.08, 0.00, 0.05 and 0.01, respectively) greater than zero, regression coefficients b_i's (1.02, 1.03, 1.04, 1.00, 1.01, 1.02, 0.99 and 1.00, respectively) nearly equal to one and low S^2_{di}(Table 2). Thus, these treatment combinations N_1D_1, N_1D_2, N_1D_3, N_2D_1, N_2D_2, N_2D_3, N_3D_2 and N_3D_3 identified as stable treatment combinations with respect to foliar nitrogen application and plant density and were suitable for general adaptations.

Number of cormels per plant: The treatment combination N_1D_3 (3 days foliar spray of nitrogen and 140 cormels m^{-2} plant density) satisfied all three conditions i.e. P_i ($_{0.90}$) greater than zero, regression coefficient b_i (1.03) nearly equal to one and low S^2_{di} (Table 3). The treatment combinations N_1D_3 was identified as stable treatment combinations with respect to number of cormels per plant and plant density and was suitable for general adaptations.

Weight of cormels per plant: The treatment combination

Table 2. Parameters of Eberhart and Russell's model for weight of corms m^{-2}

Treatment combinations	Mean	P_i	(b_i)	(S^2_{di})	Conclusion
T_1 (N_0D_1)	2.39	-0.10	0.96	0.00	Low yield, high sensitivity
T_2 (N_0D_2)	2.40	-0.09	0.96	0.00	Low yield, high sensitivity
T_3 (N_0D_3)	2.42	-0.06	0.97	0.00	Low yield, low sensitivity
T_4 (N_1D_1)	2.52	0.03	1.02	0.00	Stable treatment combination
T_5 (N_1D_2)	2.54	0.06	1.03	0.00	Stable treatment combination
T_6 (N_1D_3)	2.56	0.08	1.04	0.00	Stable treatment combination
T_7 (N_2D_1)	2.48	0.00	1.00	0.00	Stable treatment combination
T_8 (N_2D_2)	2.51	0.02	1.01	0.00	Stable treatment combination
T_9 (N_2D_3)	2.54	0.05	1.02	-0.00	Stable treatment combination
T_{10} (N_3D_1)	2.46	-0.02	0.99	0.001	Low yield, high sensitivity
T_{11} (N_3D_2)	2.48	0.00	0.99	0.00	Stable treatment combination
T_{12} (N_3D_3)	2.50	0.01	1.00	0.00	Stable treatment combination

Table 3. Parameters of Eberhart and Russell's model for number of cormels $plant^{-1}$

Treatment combinations	Mean	P_i	(b_i)	(S^2_{di})	Conclusion
T_1 (N_0D_1)	3.63	-1.56	0.65	0.000	Low yield, low sensitivity
T_2 (N_0D_2)	3.35	-1.84	0.25	0.000	Low yield, low sensitivity
T_3 (N_0D_3)	3.23	-1.96	0.28	0.001	Low yield, low sensitivity
T_4 (N_1D_1)	7.83	2.64	3.26	0.096	High yield, low sensitivity
T_5 (N_1D_2)	6.60	2.22	1.71	0.033	High yield, low sensitivity
T_6 (N_1D_3)	6.09	0.90	1.03	0.012	Stable treatment combination
T_7 (N_2D_1)	6.53	1.33	1.33	0.077	High yield, low sensitivity
T_8 (N_2D_2)	5.45	0.26	0.73	0.007	High yield, low sensitivity
T_9 (N_2D_3)	4.79	-0.40	0.65	0.000	Low yield, low sensitivity
T_{10} (N_3D_1)	5.32	0.13	0.72	0.028	High yield, low sensitivity
T_{11} (N_3D_2)	4.81	-0.38	0.77	0.005	Low yield, low sensitivity
T_{12} (N_3D_3)	4.61	0.58	0.62	0.002	High yield, low sensitivity

Table 4. Parameters of Eberhart and Russell's model for weight of cormels plant^{-1}

Treatment combinations	Mean	P_i	(b_i)	(S^2_{di})	Conclusion
T_1 (N_0D_1)	0.73	-0.34	0.87	-0.000	Low yield, low sensitivity
T_2 (N_0D_2)	0.67	-0.40	0.55	0.000	Low yield, low sensitivity
T_3 (N_0D_3)	0.65	-0.42	0.45	-0.000	Low yield, low sensitivity
T_4 (N_1D_1)	1.56	0.50	3.20	0.001	High yield, low sensitivity
T_5 (N_1D_2)	1.34	0.28	1.92	0.000	High yield, low sensitivity
T_6 (N_1D_3)	1.26	0.19	1.68	-0.000	High yield, low sensitivity
T_7 (N_2D_1)	1.30	0.24	1.32	0.002	Stable treatment combination
T_8 (N_2D_2)	1.11	0.05	0.44	0.000	High yield, low sensitivity
T_9 (N_2D_3)	1.04	-0.03	0.72	-0.000	Low yield, low sensitivity
T_{10} (N_3D_1)	1.09	0.02	0.07	0.000	High yield, low sensitivity
T_{11} (N_3D_2)	1.04	-0.02	0.34	-0.000	Low yield, low sensitivity
T_{12} (N_3D_3)	1.00	-0.07	0.45	-0.000	Low yield, low sensitivity

N_2D_1 (5 days foliar spray of nitrogen and 100 cormels m^{-2}plant density) satisfy conditions P_i (0.24) greater than zero, regression coefficient b_i (1.32) nearly equal to one and low S^2_{di} (Table 4). The treatment combination N_2D_1 was identified as stable treatment combination with respect to weight of cormels plant^{-1} and was suitable for general adaptations.

For all other characters i.e. number of days for sprouting, percent sprouting, plant height, number of leaves per plant, cropping duration, size of corms and size of cormels variances due to treatment×season (T×S) interaction were not found to be significant. Therefore stability analysis was not conducted for these characters. Stability analysis on 22 gladiolus cultivars for 20 characters was conducted by Nazir et al (2005). Raj and Misra (1998); Shamasundaran and Singh (2004) also performed stability analysis on gladiolus, while Naik et al (2005) and Kapil et al (2011) identified a suitable and stable varieties of marigold.

CONCLUSION

Three days foliar spray of nitrogen and 120 cormels m^{-2} and five days foliar spray of nitrogen and 120 cormels m^{-2} were found to be stable for number of corms m^{-2}. Whereas three days foliar spray of nitrogen and 140 cormels m^{-2} was found to be stable for number of cormels plant^{-1} and five days foliar spray of nitrogen & 100 cormels m^{-2} was found to be stable for weight of cormels plant^{-1}.

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