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***Original Research Paper***

# Genotypic variations in biomass production and nutrient removal pattern in gladiolus raised from cormels

**Sujatha S.*, Rao T.M., Rajiv Kumar and Rupa T.R.**
ICAR- Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru-560089, India
*Corresponding author email: s_sujatha68@rediffmail.com

## ABSTRACT

**The present study was conducted at ICAR-IIHR, Bengaluru, India during 2018-2019 to quantify resource use efficiency in 11 genotypes of gladiolus propagated through cormels based on growth, biomass partitioning and nutrient removal pattern. Growth and yield parameters differed significantly among genotypes. The leaf number was significantly higher in Arka Shobha (9.67) and Arka Manorama (9.00) than other genotypes (6.33-8.67). The spike length was higher in Arka Naveen (102.9 cm) and lesser in Arka Kumkum (66.2 cm). The pattern of biomass partitioning indicated that below ground biomass (corm) accounted for 71.5% of total biomass (3990 kg ha$^{-1}$), while above ground biomass (leaf and spike) was 28.5% of total biomass (1137 kg ha$^{-1}$). In gladiolus genotypes, the nutrient profile indicated that the accumulation of N was higher in corms followed by leaves and spikes. The accumulation of P (0.13-0.14%), Mn (29.8-43.5 mg kg$^{-1}$), Zn (15.3-23.4 mg kg$^{-1}$) and Cu (5.2-6.0 mg kg$^{-1}$) was similar. Spikes accumulated higher K and Mg than leaves and corms. The accumulation of Ca was more in leaves (2.39%) followed by flower stalks (1.95 %). The average Fe concentration (mg kg$^{-1}$) was more in corms (293) followed by leaves (269) and flower stalks (160). The average nutrient removal in genotypes was quantified at 122 kg N, 10.8 kg P and 71.7 kg K per ha per crop. The nutrient demand (g ha$^{-1}$) of Fe was more (1062.4) than Mn (152.5), Zn (23.8) and Cu (23.0). The data implies that gladiolus is a heavy feeder of N and K. Nutrient removal of K and Fe influenced the biomass production with high degree of variability ($Y = -541.858 + 24.097\ K_{uptake} + 1.405\ Fe_{uptake}$ $R^2$=0.995). The present study gives scope for precision nutrient use by avoiding blanket recommendations.**

**Keywords: B**iomass partitioning, cormels, genotypes, gladiolus and nutrient removal

## INTRODUCTION

Gladiolus (*Gladiolus hybrida*) is a popular cut flower crop and innumerable cultivars with attractive colors are available for cultivation. It belongs to the family *Iridaceae*. However, the area increase under gladiolus cultivation was negligible during the last decade despite huge demand for this flower crop both at national and international levels. The area under gladiolus cultivation was 11, 660 ha during 2011-12 and increased to 11,850 ha during 2017-18 (NHB, 2018). Commercial production of gladiolus depends largely on the availability of propagating material especially corms. Large size corm helps in better plant growth and development by supplying storage nutrients in the corm. The slow multiplication rate of quality planting material either corms or cormels is a recurring problem and is hindering the area expansion of this flower crop. Due to slow multiplication rate, dormancy of corms/cormels and high percentage of spoilage of corms during storage, there is an insufficient supply of planting material (Memon et al., 2009; Priyakumari and Sheela, 2005; Swapnil et al., 2017). As cormel production in terms of number per plant is more than corm number and the resource use efficiency of cormels as propagating material needs to be assessed either for corm/cormel production or for production of flower spikes in gladiolus to address the problems of short supply of planting material and huge domestic demand.

Balanced nutrition is required for getting optimum yields of both spikes and corms/cormels in gladiolus cultivation. Though several reports highlighted the importance of major and micronutrients especially boron and zinc for increased weight and number of corms and cormels per hill in gladiolus, present nutrient recommendations are highly variable (Afify, 1983, Shah et al.,1984; Mukherjee et al., 1998; Singh, 1996 and Das, 1998; Shankar and Dubey, 2005; Singh et al., 2013; Satpathy et al., 2016). No data exist on nutrient requirement of gladiolus varieties based on biomass production and nutrient removal pattern. Soil health is another crucial factor for obtaining higher production of below ground biomass (Baldotto and Baldotto, 2013). Thus, precision farming approach with adequate nutrient supply is essential by assessing the nutrient demand of gladiolus genotypes through biomass and nutrient partitioning, and nutrient removal pattern. With this background, the present study was carried out to precisely assess the demand of various nutrients for different plant components especially corms and cormels in various gladiolus genotypes.

## MATERIALS AND METHODS

### Description of study site

The present study was carried out in experimental field at ICAR-Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru, Karnataka, India (13°7'N latitude and 77° 29'E longitude, 890 m above MSL). The climate of the experimental site is semi-arid. The soil of the experimental site is red sandy loam.

### Experimental details

The study was carried out in the ongoing breeding experiment comprising of identified genotypes and advanced breeding lines at ICAR-IIHR during 2018-2019. Uniform cormels of different genotypes were planted in fourth week of January, 2018 at a spacing of 30 cm x 20 cm on raised soil beds. Recommended plant protection measures were followed for control of major pests and diseases. Nutrients were applied @ 200:200:200 kg NPK $ha^{-1}$ in two splits in addition to application 10 t of FYM per hectare before planting. The trait specific genotypes identified at ICAR-IIHR were used to find out overall picture of resource use in gladiolus raised from cormels as propagating material. About eleven IIHR identified genotypes were selected and were evaluated in randomized block design (RBD) with three replications. The desirable traits of genotypes are given in Table S1.

### Growth parameters and biomass estimation

Growth observations such as plant height, leaf number, tiller number and spike length were recorded in three plants in each replication of all genotypes. For estimation of both above ground and below ground biomass, destructive sampling method was adopted. Three plants from each genotype were collected in 2018 just before initiation of flowering and at harvestable stage of spikes. Fresh weight was recorded separately for leaves and spikes/flower stems. Similarly, the fresh biomass of corm/cormels was estimated by collecting all corms/cormels from each plant separately. Samples were cleaned with distilled water, air dried, packed in brown paper bags, oven dried at $60^0$C to a constant weight and dry weight was recorded after drying. After recording oven dry weight, same samples were ground and kept in labeled butter paper bags for nutrient analysis to find out nutrient accumulation and removal pattern. The average biomass of each part was multiplied with total number of leaves and flower stems/spikes to arrive at total above ground biomass. The below ground biomass was also estimated in a similar manner by multiplying corm/cormel number per plant with biomass per plant. The biomass of leaf, flower stem and corms/cormels was considered to arrive at total biomass production.

### Collection and analysis of soil and plant samples

Soil samples were collected at 0-25 cm depth in the root zone at 15 cm distance from the base after harvesting of corms. The air-dried soil samples were ground to pass through a 2.0-mm sieve and kept in labelled plastic bags for further analysis. Soil chemical/fertility parameters like pH, organic carbon, available P and K were analysed for using standard procedures (Jackson 1973). Soil organic carbon was measured by titration method (Walkley and Black, 1934). Soil test P was estimated by ascorbic acid reductant method (Watanabe and Olsen 1965) for colour development after extraction with Olsen's reagent. Available K, Ca and Mg were estimated in Flame Photometer using ammonium acetate extract. The concentration of micronutrients was estimated in AAS using diethylene triamine penta acetic acid (DTPA) extract (Lindsay and Novell 1978).

The leaf, flower stem and corm samples were analysed separately for total N using micro-Kjeldahl digestion method (Jackson 1973). The

plant samples were digested using 1:3 perchloric-nitric acid mixture for estimation of total P, K and micronutrients in different plant parts of flower stalk. Total P (vanadomolybdate) was determined following Piper (1966). Estimation of total K, Ca, Mg was done in flame photometer and micronutrients like copper (Cu), zinc (Zn), iron (Fe) and manganese (Mn) was done in AAS. Nutrient removal was computed by multiplying nutrient concentration in each plant part with respective oven-dry biomass and presented per hectare basis.

**Statistical Analysis**

All data were analyzed using SPSS and Microsoft Excel. The significant differences between the two means are indicated by LSD (5%) values in the tables. Correlations and regressions among different biomass parameters and nutrients were worked out for better understanding of results. Differences among genotypes were tested with ANOVA and LSD.

## RESULTS AND DISCUSSION

**Growth parameters in different genotypes**

The growth parameters such as plant height, leaf number and spike length differed significantly among genotypes. The plant height of genotypes varied from 70.5 cm in Arka Kumkum to 107.7 cm in Arka Naveen. The flower stem length also differed significantly among genotypes. The flower stem length was higher in Arka Naveen (102.9 cm) and lesser in Arka Kumkum (66.2 cm). The leaf number was significantly higher in Arka Shobha (9.67) and Arka Manorama (9.00) than other genotypes with medium leaf number (7.50-8.67) and genotypes with less leaf number (6.33-6.67). The corm number was similar in all genotypes (2), but the corm weight varied significantly due to different size corms. Cormel number and weight were significant among genotypes. The average dry weights of all components per plant varied significantly among genotypes and were used for computing total biomass production per hectare (Table 1).

**Biomass partitioning to different components**

With respect to biomass production in different genotypes raised from cormels (Fig. 1), the biomass partitioning to spikes (15.9%) was more than partitioning to leaves (12.6%) except in four genotypes (Arka Amar, Arka Aarathi, Arka Shobha and Arka Gold). The partitioning of total biomass (3990 kg $ha^{-1}$) was maximum to below ground corm biomass (71.5%). In gladiolus genotypes raised from corms, the partitioning to corms is only 46% of the total biomass (Sujatha et al., 2020c). The average partitioning of biomass to both leaves and

**Table 1. Growth and biomass partitioning in gladiolus genotypes propagated from cormels**

| Variety | Plant height (cm) | Flower stem length (cm) | No. of leaves | Above ground biomass (g $plant^{-1}$) | | | Below ground biomass (g $plant^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Leaf | Flower stalk | Total | Corm | Cormel* | Total | Root |
| Arka Aarti | 79.3 | 74.8 | 6.33 | 4.40 | 2.97 | 10.30 | 13.4 | 10.9(14) | 14.3 | 0.07 |
| Arka Aayush | 77.7 | 73.5 | 8.33 | 3.60 | 5.30 | 10.20 | 16.7 | 10.4(17) | 17.4 | 0.30 |
| Arka Amar | 94.3 | 88.9 | 8.67 | 5.70 | 5.17 | 17.90 | 22.2 | 3.6(10) | 24.6 | 0.33 |
| Arka Darshan | 77.0 | 73.1 | 6.33 | 3.73 | 5.70 | 12.17 | 18.3 | 10.3(19) | 19.7 | 0.40 |
| Arka Gold | 94.7 | 89.6 | 6.67 | 4.90 | 3.50 | 18.40 | 29.1 | 3.4(8) | 33.6 | 0.07 |
| Arka Kumkum | 70.5 | 66.2 | 7.50 | 1.83 | 5.07 | 9.27 | 14.3 | 7.4(11) | 15.5 | 0.37 |
| Arka Manorama | 85.3 | 80.7 | 9.00 | 2.53 | 5.37 | 11.10 | 15.6 | 2.4(7) | 17.5 | 0.07 |
| Arka Naveen | 107.7 | 102.9 | 8.33 | 5.40 | 6.03 | 13.07 | 27.2 | 5.5(8) | 27.9 | 0.40 |
| Arka Poonam | 104.3 | 99.5 | 8.33 | 3.23 | 7.20 | 15.67 | 25.9 | 3.6 (8) | 28.9 | 0.27 |
| Arka Shobha | 94.7 | 89.9 | 9.67 | 6.53 | 3.87 | 21.00 | 31.9 | 3.0(7) | 36.4 | 0.20 |
| Arka Tilak | 80.3 | 75.5 | 8.33 | 4.33 | 7.83 | 14.87 | 24.2 | 4.6(5) | 25.8 | 0.13 |
| Mean | 87.8 | 83.2 | 7.95 | 4.20 | 5.27 | 13.99 | 21.73 | 2.06 | 23.8 | 0.236 |
| CD (*p=0.05*) | 15.32 | 14.11 | NS | 0.880 | 0.923 | 2.438 | 4.03 | 0.863 | 4.68 | 0.085 |

*Figures in the parenthesis indicate cormel number

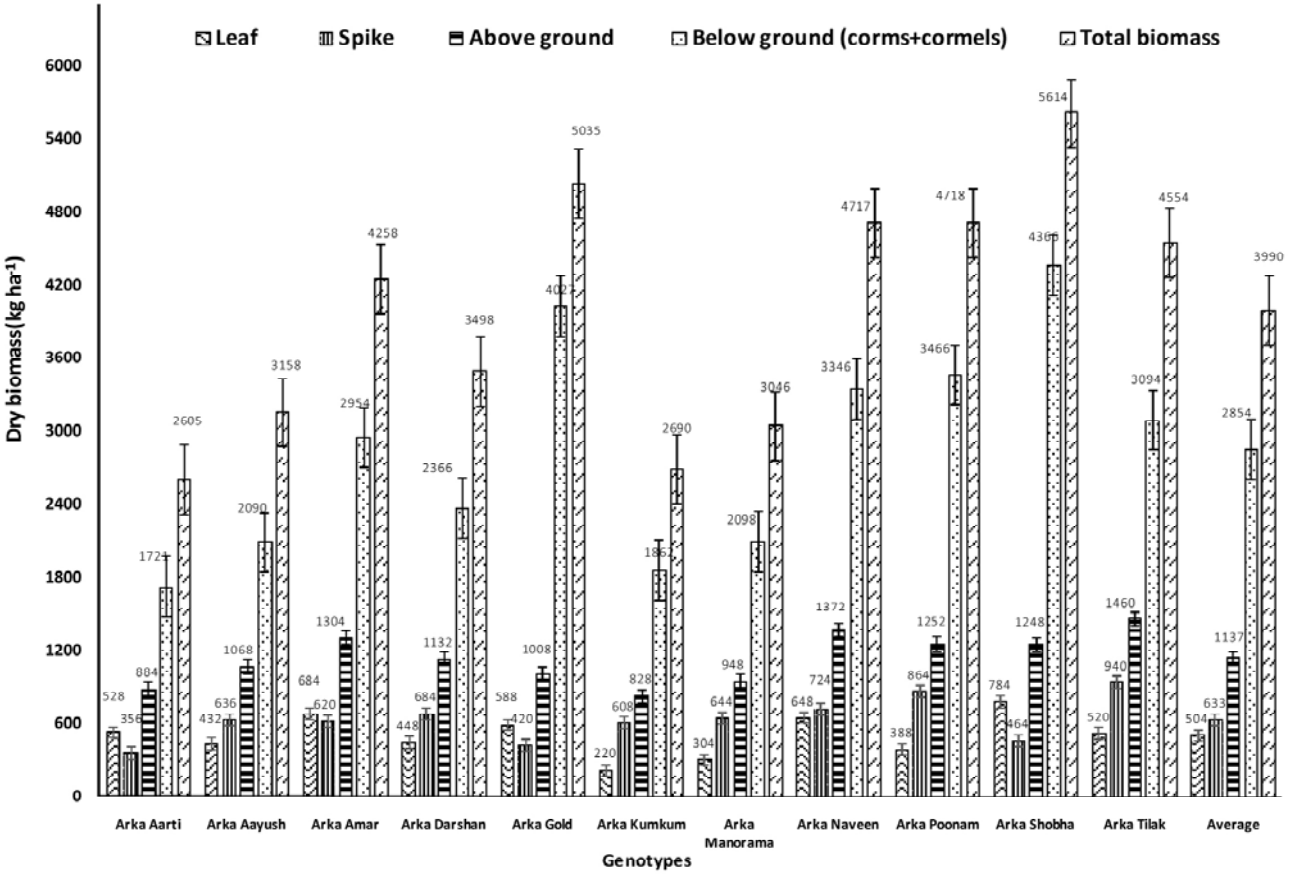


Fig. 1. Biomass partitioning in different genotypes of gladiolus with cormels as planting material (CD (*p=0.05*) for leaf biomass: 112.8; flower stalk biomass: 118.3; aboveground biomass: 139.2; Below ground biomass: 601.1)

spikes was 1137 kg ha$^{-1}$ (28.5% of total). Leaf biomass was significantly higher in Arka Shobha (784 kg ha$^{-1}$), while spike biomass production was significantly higher in Arka Tilak (940 kg ha$^{-1}$). The biomass of corms was higher in Arka Shobha (4366 kg ha$^{-1}$). It is clear that higher biomass partitioning to spikes resulted in reduced corm biomass in genotypes, while higher biomass partitioning to leaves is required for higher corm biomass production. For planting material multiplication, this aspect needs to be considered. The availability of recyclable biomass as leaf and spikes was 28.5% of total biomass in case of recycling after utilization.

**Nutrient accumulation in different plant components**

There were significant variations in nutrient accumulation of major and secondary nutrients in all plant parts such as leaves, spikes and corms among genotypes (Fig. 2 and 3). In gladiolus genotypes, the nutrient profile among different plant parts also showed distinct pattern. The accumulation of N was higher in corms followed by leaves and spikes in all genotypes. The P accumulation was similar in all plant parts (0.13-0.14%). Spikes accumulated higher K than leaves and corms. The accumulation of Ca was more in leaves (2.39%) followed by spikes (1.95 %) and corms (0.39%). The Mg accumulation was higher in flower stalks (0.38%) followed by leaves (0.34%) and corms (0.16%) more Ca and Mg than corms. Among micronutrients, the average Fe concentration (mg kg$^{-1}$) was more in corms (293) followed by leaves (269) and flower stalks (160). The range in concentrations (mg kg$^{-1}$) of Mn, Zn and Cu were 29.8-43.5, 15.3-23.4 and 5.2-6.0, respectively. The previous reports indicated that genotype variability in nutrient content and nutrient uptake is crucial for genetic improvement (Dierig et al., 2003 Feil et al., 2005 Brink et al., 2001).

Biomass production and nutrient removal pattern

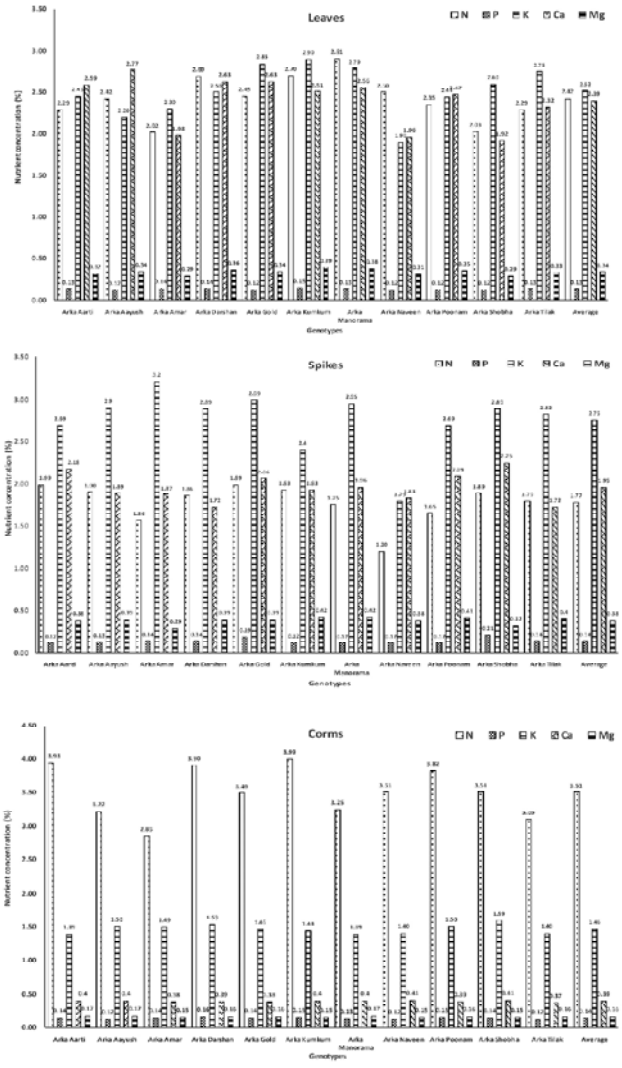


Fig. 2. Nutrient accumulation pattern in gladiolus genotypes raised from cormels

CD (*p=0.05*) for nutrients in leaf (N: 0.172; P: 0.005; K: 0.192;Ca:0.188 Mg: NS), flower stalk (N: 0.147; P: 0.019; K: 0.237;Ca:0.194 Mg:0.06) and corms (N: 0.237; P: 0.008; K: 0.041;Ca: NS Mg: NS)

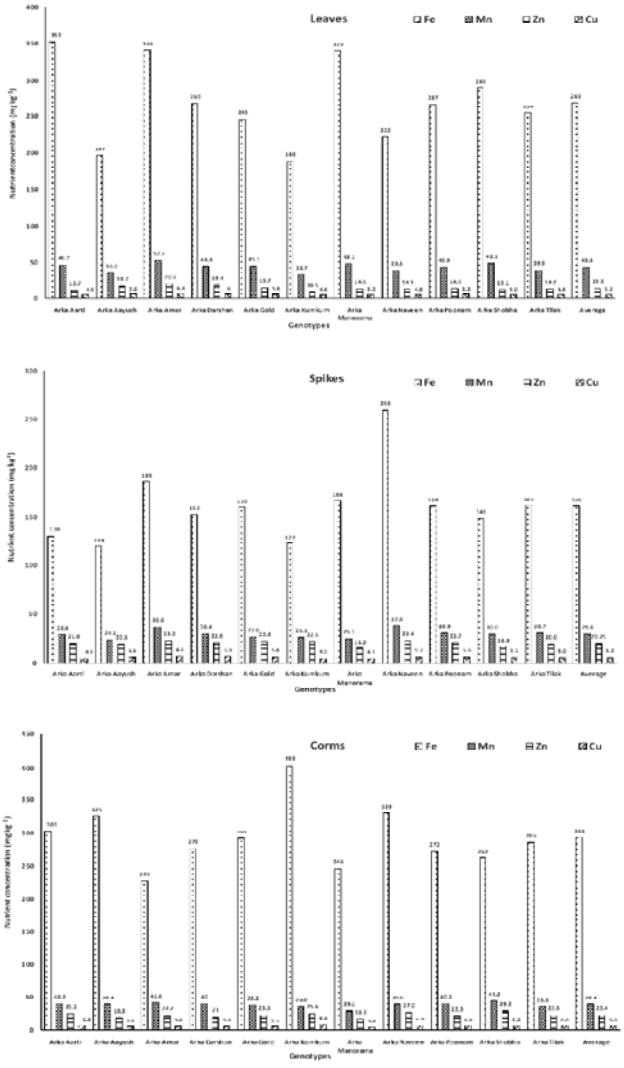


Fig. 3. Micronutrient accumulation pattern in gladiolus genotypes raised from cormels

CD (*p=0.05*) for nutrients in leaf (Fe:38.8, Mn: 6.9, Zn: NS, Cu; NS), flower stalk (Fe:29.9, Mn: NS, Zn:NS, Cu: NS) and corms (Fe:49.5, Mn:5.1, Zn: NS, Cu: NS)

## Nutrient uptake pattern

The uptake of major, secondary and micro nutrients differed significantly among different genotypes of gladiolus (Fig. 4). The total N removal ranged from 87 kg ha$^{-1}$ in Arka Aarti to 178 kg ha$^{-1}$ in Arka Shobha. The removal of P and K ranged between 6.1-15.2 kg ha$^{-1}$ and 46.4-103.2 kg ha$^{-1}$. The average nutrient removal per hectare per year in genotypes raised from cormels was quantified at 122 kg N, 10.8 kg P and 71.7 kg K. The nutrient removal for secondary nutrients ranged between 24.7-43.4 kg for Ca and 6.2-10.8 kg for Mg. Among micronutrients, the demand in terms of grams per hectare for Fe was more (1062.4 g ha$^{-1}$) than Mn (152.5), Zn (23.8) and Cu (23.0). The order of nutrient uptake in gladiolus in all genotypes was N>K>Ca>P>Mg>Fe>Mn>Zn>Cu. The data implies that gladiolus is a heavy feeder of N and K. In comparison to gladiolus raised from corms (Sujatha et al., 2020c), the biomass production and nutrient uptake by gladiolus genotypes raised from cormels are considerably lower. Higher corm biomass production with less nutrient uptake in gladiolus genotypes raised from cormels gives scope for largescale planting material multiplication utilizing cormels.

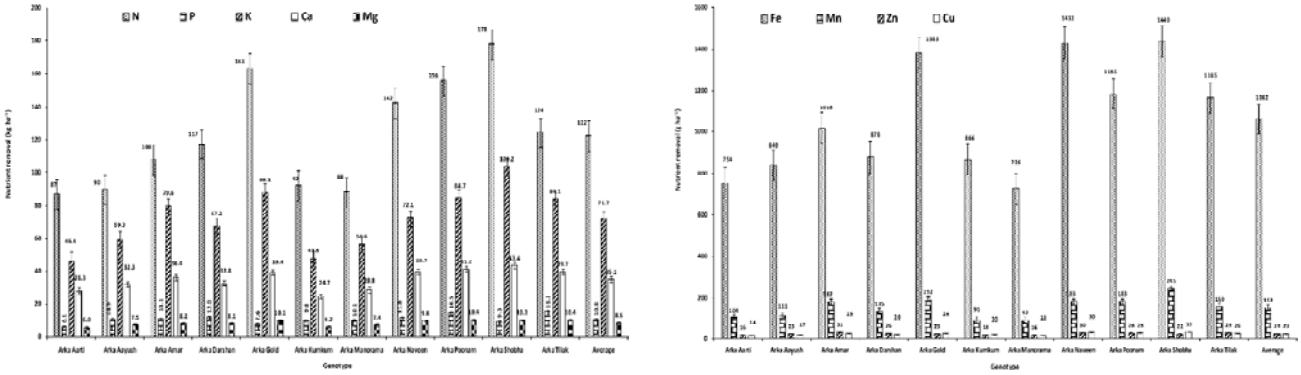


Fig. 4. Nutrient removal pattern in gladiolus genotypes raised from cormels

**Table 2. Correlation matrix for biomass and nutrient uptake**

| Parameter | Total biomass | Leaf biomass | Spike biomass | Above ground biomass | Below ground biomass | N uptake | P uptake | K uptake | Ca uptake | Mg uptake | Fe uptake | Mn uptake | Zn uptake |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Leaf biomass | 0.71** | | | | | | | | | | | | |
| Spike biomass | 0.15 | -0.27 | | | | | | | | | | | |
| Above ground biomass | 0.71** | 0.58* | 0.63** | | | | | | | | | | |
| Below ground biomass | 0.99** | 0.69** | 0.04 | 0.59* | | | | | | | | | |
| N uptake | 0.94** | 0.59* | 0.04 | 0.51* | 0.96** | | | | | | | | |
| P uptake | 0.29 | -0.14 | 0.98** | 0.72** | 0.10 | 0.17 | | | | | | | |
| K uptake | 0.97** | 0.68** | 0.16 | 0.69** | 0.95** | 0.89** | 0.31 | | | | | | |
| Ca uptake | 0.97** | 0.71** | 0.26 | 0.80** | 0.93** | 0.89** | 0.39 | 0.94** | | | | | |
| Mg uptake | 0.94** | 0.52* | 0.41 | 0.77** | 0.90** | 0.88** | 0.52* | 0.91** | 0.96** | | | | |
| Fe uptake | 0.94** | 0.67** | 0.08 | 0.61** | 0.94** | 0.92** | 0.18 | 0.83** | 0.88** | 0.87** | | | |
| Mn uptake | 0.97** | 0.81** | 0.01 | 0.67** | 0.96** | 0.92** | 0.17 | 0.95** | 0.93** | 0.84** | 0.90** | | |
| Zn uptake | 0.62** | 0.47* | 0.61* | 0.89** | 0.50* | 0.43* | 0.70** | 0.59* | 0.69** | 0.66* | 0.54* | 0.59* | |
| Cu uptake | 0.93** | 0.68** | 0.19 | 0.71** | 0.91** | 0.89** | 0.32 | 0.86** | 0.88** | 0.84** | 0.94** | 0.93** | 0.66* |

In gladiolus genotypes, the correlations (Table 2) were highly significant for total biomass production and removal of N (r=0.938), K (r=0.968), Ca (r=0.967) and Mg (r=0.941) and P removal did not influence significantly total biomass production (r=0.292). Application of stepwise regression technique to identify the nutrient variables with a significant influence on the total biomass (Y) resulted in the following equation, where the variables are written in the increasing order of p-level. Multiple regression analysis of removal/ uptake of nutrients with total biomass production showed high degree of relation and nutrient removal of K and Fe influenced the biomass production with high degree of variability.

Y (total biomass) = -541.858 + 24.097 $K_{uptake}$ + 1.405 $Fe_{uptake}$ ($R^2$=0.995)

**Soil fertility status**

The soil fertility status at the end of experimentation was above optimum with soil pH near to neutral (7.07) and the soil organic carbon was 1.32%. The availability of soil nutrients was quantified at 22.3 ppm of P, 335 ppm of K, 4799 ppm of Ca, 1208 ppm of Mg, 11.3 ppm of Fe, 8.5 ppm of Mn, 5.6 ppm of Zn and 4.1 ppm of Cu. The soil fertility status implies that gladiolus system maintains optimum soil fertility despite higher biomass removal in the form of corms/ cormels and the nutrient application can be adjusted based on nutrient uptake pattern to save critical inputs.

## CONCLUSIONS

The present study assessed the pattern of biomass and nutrient partitioning, and nutrient demand of different genotypes in gladiolus when cormels were used as planting material. The major influence of N, K, Ca and Fe on biomass production in gladiolus was evident in this study. The results of the present study can be used as basis for assessing the nutrient requirement of gladiolus when raised through

cormels. The results give scope for precision nutrient application that would reduce the cost of production and avoid soil fertility buildup due to excess nutrient application.

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