Modeling Growth of Cut-Flower Stock (*Matthiola incana* R. Br.) in Response to Differing in nutrient Level

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Abstract The present research project was aimed to study the effect of foliar application of zinc and NPK on growth of Stock (*Matthiola incana* L.). The study was carried out at Floriculture Research Area, University of Agriculture, Faisalabad, during the year 2011-2012. The experiment was laid out in randomized complete block design (RCBD) with three replications. There were twelve treatment combinations comprising four levels of NPK (0, 0.5%, 1% and 1.5%) and three level of Zn (0%, 0.5% and 1%), which were applied on Stock (*Matthiola incana* L.). The results regarding growth of stock were found significant. The treatments comprising both zinc and NPK as T₁₁ (1% Zn + 1.5% NPK) was ranked first in plant height (91.66 cm), number of leaves per plant (65.33 leaves/plant) and leaf chlorophyll contents (85.53 spade). T₇ (0.5% Zn + 1% NPK) was ranked first in leaf area (36.10 cm²) and minimum days to flowering were recorded in T₁₁ (1% Zn + 1.5% NPK), 42.60 days. T₁₁ (1% Zn + 1.5% NPK) got the first position in stalk length (87.63 cm) and floret diameter (4.93 mm). Foliar application of zinc and NPK increased nutrient accumulation in leaves of stock. The nitrogen contents (6.0 %) phosphorus contents (0.46 ppm) and potassium contents (38.10 ppm) increased in response to treatment comprising both zinc and NPK.

Keywords *Matthiola Incana*, Groth Modling, NPK, Zinc, Cut-Flower

1. Introduction

Matthiola incana (L.) R.Br. is an important ornamental plant native to Mediterranean region and belongs to family Brassicaceae [1,2] It comes in a variety of conspicuous colors which make it an excellent cut flower [3]. Turkey is one of the richest countries in the world where 571 species of Brassicaceae are found followed by United States, with 653 native species in 61 genera [4]. Floriculture had become identified as a potential business due to divergence of

farmers towards high value floral crops and utilization of flowers in social and industrial level in Pakistan. Production of cut flowers e.g. Roses, Gladiolus, Tuberoses, Iris, Narcissus, Lilies, Freesia, Statice and Gerbera in Pakistan is estimated at about 10-12 thousand tons per annum and floriculture is fast emerging as a profitable venture for small farmers [5].

Most of the soil in Pakistan has pH range from 7.8 to 8.3 that does not suit for proper up take of nutrient [6]. Foliar application of nutrition is one of the best methods to reduce this failure of plant to absorb certain nutrients which are necessary for their normal growth. Foliar nutrition is an alternate method when nutrient deficiencies of plant cannot be corrected by applications of nutrients through soil [7]. Genotypic variation and micronutrient application are two key factors which play a vital role in successful production of best quality cut roses. Most of growers are not well aware about micronutrients that are why they are unable to produce economically viable produce due to lack of information about proper concentrations of different micronutrients [8]. Nitrogen plays a key role in the initiation of meristematic activity of the plant resulting in the maximum plant height [9].

Similarly Zinc plays a significant role to enhance the biomass of plants [7]. chlorophyll production, pollen function, fertilization and germination [10]. Zinc act as a metal component of various enzymes or as a functional, structural or regulatory co-factor and also for protein synthesis, photosynthesis, the synthesis of auxin, cell division, the maintenance of membrane structure, and sexual fertilization [11, 12]. Macro and micronutrients are necessary for the various biochemical processes which occur within the plant and are essential for plant normal growth and development. Since sandy soil of desert is characterized by high pH value, foliar feeding is viable under these conditions to avoid the soil fixation of some micronutrients such as Fe, Mn, Zn and Cu [13]. Association and rapid undulation of nutrition compound within plant micronutrients are too much essential due to their immense significance in involvement to straight the enzymes system in metabolism

[14]. For that reason, NPK fertilizers both in course and solution (liquid) form are normally use as transporter of macronutrients as well as micronutrients with varied fertilizer which is a suitable technique of application and allows extra consistent allocation with conservative application apparatus. Micronutrients such as Fe, Cl, Mn, Cu, B, Zn, Ni, Mo and Co are necessary in significantly lesser quantity and needed for plant intensification as compared to those with the primary nutrients [15].

Foliar request of various macro and micro nutrients has been provided evidence of helpful because foliar feeding is a comparatively new and controversial technique of feeding plants by applying liquid fertilizer straightforwardly to their leaves. Nutrients are delivering to the tissues of the plants immediately by foliar application. For instance, equal to 80% of the foliar-added phosphorus is straightforwardly immersed within plants tissues while in soil 80% of the phosphorus useful in the course of conservative fertilizers may get fixed up [16]. A balanced fertilization program with macro and micronutrients in plant nutrition is very important in the production of high yield with high quality products [17, 18]. The optimum concentrations of nutrients are important as they have great influence on growth and quality attributes like stalk length, stalk diameter and vase life of Gladiolus. It has been reported that nitrogen, phosphorus, potassium with micro-nutrients especially boron and zinc remarkably increased weight and number of corms and cormels [19]. Inadequate plant nutrition causes serious disorders and may eventually lead to decline of plant vigor and yield [20]. Foliar application overcomes soil fertilization limitations like leaching, insoluble fertilizer precipitation, antagonism between nutrients and fixation reactions like in the case of phosphorus and potassium. Foliar feeding can also be used to overcome root problems when plants are suffering from limited activity due to low/high temperatures, lack of oxygen in flooded fields, nematode attack damaging the vascular system and a decrease in root activity during the reproductive stages where more of the photosynthetic activity is transferred for reproduction stage [21]. The objective of the study was to estimate the response of stock after micro and macronutrients application on the functioning and structure of plants.

2. Materials and Methods

Present study was carried out during 2011-2012 at floriculture area of Institute of Horticulture, University of Agriculture Faisalabad. The objective of research was to elucidate the response of stock *matthiola incanna* L. at different concentrations of micro and macro nutrients. Seeds were sown in germination tray in September 2011. Seedling attained, 2-3 leave transplant in field was thoroughly tilled and leveled with RCBD design with twelve treatments combinations and three replicate at four levels of NPK (0, 0.5, 1 and 1.5%) and three levels of Zn (0, 0.5 and 1%). Plants were allowed to grow and data

regarding growth and flowering indices were collected using standard procedures: following treatment were applied:

To = control	T6 = 0.5% Zn + 1% NPK
T1 = 0.5% NPK	T7=0.5% Zn + 1.5% NPK
T2 = 1% NPK	T8=1% Zn
T3 = 1.5% NPK	T9=1% Zn + 0.5% NPK
T4 = 0.5% Zn	T10=1% Zn + 1% NPK
T5 = 0.5% Zn + 0.5% NPK	
T11=1% Zn + 1.5% NPK	

2.1. Growth Parameters

Growth parameters such as, plant height (cm), number of leaves plant⁻¹, Leaf area (cm²), Leaf chlorophyll contents (SPAD Value), Days to flowering, Stem diameter (mm), Stalk length (cm), Floret diameter (mm), Fresh weight of plant (g), Dry weight of plant (g), Fresh weight of stalk (g), Dry weight of stalk (g) were recorded.

2.2. Estimation of Nitrogen, Potassium Phosphorus and Zinc Elements

Estimation of Nitrogen, potassium, phosphorus and zinc elements were determined according to the method described by Cottenie [22]. The obtained resulted were subjected to statistical analysis of variance according to the method described by Snedecor and Cochran, 1980 and the combined analysis of the two seasons was calculated according to the method of Steel and Torrie [23].

3. Results

A significant superiority ($p < 0.05$) of T₁₁ (1% Zn + 1.5% NPK) was observed with maximum plant height 91.66 cm followed by the T₁₀ (81.33 cm) and T₉ (76.66 cm). The lowest plant height was observed in T₀ (38.10 cm), T₄ (45.66 cm), and T₈ (50.66 cm) (Fig.1).

Figure 1. Effect of exogenous application of micro and macro nutrients on plant height of *Matthiola incana* L.

The maximum number of leaves were obtained in T_{11} (1% Zn + 1.5% NPK) with 65.33 leaves per plant followed by the T_7 (0.5% Zn + 1% NPK) having 57.60 leaves and T_{10} (1% Zn + 1% NPK) with 57.26 leaves/plant. The lowest number of leaves was obtained in T_0 (38.50) T_1 (41.23) and T_4 (41.66) leaves/plant. The single NPK and zinc treatment as T_3 produce 53 leaves/plant, T_8 (44.70) and T_2 (46.16) leaves/plant (Fig.2).

Figure 2. Effect of exogenous application of micro and macro nutrients on number of leaves of *Matthiola incana* L.

Among all the treatments, T_7 (0.5% Zn + 1% NPK), showed the maximum leaf area 36.10 cm² that has significant superiority over rest of the treatments. It was followed by T_6 (0.5% Zn + 1% NPK), 35 cm² and T_{11} (1% Zn + 1.5% NPK), 34.83 cm². The least leaf area was observed in T_0 (Control), 12.96 cm², T_4 (0.5% Zn), 16.16 and T_8 (1% Zn), 17.86 cm². The single NPK treatments such as, T_1 (0.5% NPK), T_2 (1% NPK) and T_3 (1.5% NPK) produced leaf area with values 22.66 cm² 18.16 cm² 26.03 cm² respectively (Fig.3)

Figure 3. Effect of exogenous application of micro and macro nutrients on leaf area of *Matthiola incana* L.

Comparison of mean indicate the minimum days to flowering was observed in of T_{11} (1% Zn + 1.5% NPK), 42.60 followed by the T_{10} (1% Zn + 1% NPK), 45.66 and T_7 (0.5% Zn + 1% NPK), 45.50. The maximum days to flowering was noticed in T_0 (Control), 56.70, T_4 (0.5% Zn),

54.83 and T_1 (0.5% NPK), 53.80. The other treatments as T_6 (0.5% Zn + 1% NPK), 48.00, T_3 (1.5% NPK) 49.83 and T_9 (1% Zn + 0.5% NPK), 53.20 are ranked in middle order (Fig. 4)

Figure 4. Effect of exogenous application of micro and macro nutrients on days of flowering of *Matthiola incana* L.

A significant superiority of T_{11} (1% Zn + 1.5% NPK), 4.93 mm was observed in floret diameter followed by the T_{10} (1% Zn + 1% NPK), 4.63 mm and T_7 (0.5% Zn + 1% NPK), 4.63 mm. The least floret diameter was observed in T_0 (Control), 3.40 mm, T_4 (0.5% Zn), 3.50 mm and T_1 (0.5% NPK), 3.80 mm. The single zinc and NPK treatments and combined lower dose treatments are ranked in middle as, T_8 (1% Zn) 3.93 mm, T_2 (1% NPK), 3.86 mm and T_9 (1% Zn + 0.5% NPK), 4.36 mm (Fig. 5).

Figure 5. Effect of exogenous application of micro and macro nutrients on floret diameter of *Matthiola incana* L.

Results showed that the maximum availability of chlorophyll contents were present in T_{11} (1% Zn + 1.5% NPK), 85.53 spade followed by the T_{10} (1% Zn + 1% NPK), 72.40 spade and T_7 (0.5% Zn + 1% NPK), 61.73 spade. The least leaf chlorophyll contents was observed in T_4 (0.5% Zn), 47.96 spade, T_0 (Control), 48.60 spade, and T_5 (0.5% Zn + 0.5% NPK), 49.76 spade. The single zinc and NPK treatments and combined lower dose treatments are ranked in middle as T_1 (0.5% NPK), 52.40 spade, T_8 (1% Zn) 50.30 spade and T_6 (0.5% Zn + 1% NPK) 61.10 spade (Fig. 6).

Figure 6. Effect of exogenous application of micro and macro nutrients on leaf chlorophyll contents of *Matthiola incana* L

The maximum number of nitrogen contents were found in T₁₁ (1% Zn + 1.5% NPK), 6.0 % followed by the T₇ (0.5% Zn + 1% NPK), 5.96 % and T₃ (1.5% NPK), 5.66 %. The least leaf nitrogen contents was observed in T₀ (Control), 0.96 %, T₄ (0.5% Zn), 1.0 % and T₈ (1% Zn) 1.033 %. The single zinc and NPK treatments and combined lower dose treatments are ranked in middle as, T₁₀ (1% Zn + 1% NPK), 3.63 %, T₁ (0.5% NPK), 1.30 % and T₅ (0.5% Zn + 0.5% NPK), 1.833 % (Fig.7).

Figure 7. Effect of exogenous application of micro and macro nutrients on nitrogen contents in leaves of *Matthiola incana* L

Figure 8. Effect of exogenous application of micro and macro nutrients on phosphorus contents in leaves of *Matthiola incana* L

The maximum phosphorus contents were found in T₁₁ (1% Zn + 1.5% NPK), 0.46 ppm followed by the T₇ (0.5% Zn + 1% NPK), 0.40 ppm and T₃ (1.5% NPK), 0.38 ppm. The least leaf phosphorus contents was observed in T₀ (Control), 0.09 ppm, T₄ (0.5% Zn), 0.140 ppm and T₈ (1% Zn) 0.173 ppm. The single zinc and NPK treatments and combined lower dose treatments are ranked in middle as, T₁₀ (1% Zn + 1% NPK), 0.37 ppm, T₁ (0.5% NPK), 0.213 ppm and T₅ (0.5% Zn + 0.5% NPK), 0.22 ppm (Fig. 8).

The results showed that the treatments comprising both Zinc and NPK had significant effect on potassium contents. The maximum number of potassium contents were observed in T₁₁ (1% Zn + 1.5% NPK), 38.10 ppm followed by the T₇ (0.5% Zn + 1% NPK), 33.40 ppm and T₃ (1.5% NPK), 30.33 ppm. The least leaf potassium contents was observed in T₀ (Control), 11.96 ppm, T₄ (0.5% Zn), 14.56 ppm and T₈ (1% Zn) 17.067 ppm. The single zinc and NPK treatments and combined lower dose treatments are ranked in middle as, T₁₀ (1% Zn + 1% NPK), 28.53 ppm, T₁ (0.5% NPK), 17.30 ppm and T₅ (0.5% Zn + 0.5% NPK), 19.00 ppm respectively (Fig. 9).

Potassium contents

Figure 9. Effect of exogenous application of micro and macro nutrients on potassium contents in leaves of *Matthiola incana* L

4. Discussion

The cut flower industry has become globally a fast growing industry, which has achieved significant growth during the past few decades. At present, cut flower production focus has moved from traditional growers, such as the Netherlands, Germany and France, to countries where the climates are better and production techniques are different [24]. More than 2000 years ago, the Greeks and Romans used gladioli to brighten up important events [25]. Gladiolus has great demand and is cultivated all over the world for its attractive spikes having florets of huge forms, dazzling colors, varying sizes and long vase life [26].

The plant height significantly increased with increase in the nutrient levels and it was maximum in T₁₁ (1% Zn + 1.5% NPK). Khosa [27] studied the response of micro and macronutrients on gerbera with three levels of macro and micro nutrients. Plant height, number of branches per plant,

length of branches per plant, number of leaves per plant, leaf area, stock length, days to first flower emergence, flower diameter and flower quality increased with increasing nutrient level. Plants sprayed with Zn and NPK might have stored more carbohydrates through effective photosynthesis which caused a reasonable increase in plant height of stock [28]. Stem elongation might be increased due to zinc spray which caused increase in the production of tryptophan as precursor of auxin (IAA) which is responsible for the stem growth [12]. Iron and zinc application on *Nerium oleander* L. at different concentrations i.e @ 0.25%, 0.50% and 0.75%, gave the maximum value on all the growth attributes like plant height, number of secondary branches, number of leaves per plant, plant spread and leaf area [29].

The results showed that the treatments with both NPK and zinc showed the significant effect on number of leaves. The foliar application with higher doses of NPK and zinc enhanced the vegetative growth of the plants by increasing the number of leaves [21]. NPK provided nitrogen which was converted into the organic nitrogen compounds (proteins) in the plants which might be increased vegetative growth [30]. Zinc caused increase in activity of apical meristems, division and elongation of meristems cells which caused increase in vegetative height [13]. The maximum leaf area was found in T_7 (0.5% Zn + 1% NPK), 36.10 cm² that has significant superiority over rest of the treatments and the least leaf area was observed in T_0 (Control), 12.96 cm². Minimum number of leaves in control might be due to absence of N for leaf bud formation (Ram et al. 1997) whereas; the main reason for greater lamina area was the maximum photosynthetic rate of leaves [31].

Micronutrients also enhanced the meristematic activities and increased the leaf length and provided the area for the storage of the products. Plants sprayed with Zn might be stored more carbohydrates through effective photosynthesis. The increase in area of leaves might be due to storage of carbohydrates and nitrogen compounds in the leaves. The carbohydrates and soluble nitrogen compounds were translocated into leaves [32]. These results are conformity with the results of Iersel [33].

The results show that the treatments comprising both zinc and NPK had significant effect on the chlorophyll. The increase in chlorophyll content might be due to improvement in nitrogen assimilation from NPK [34]. Regarding the beneficial effect of nitrogen on photosynthetic pigments, may be due to its role in increasing the rates of photochemical reduction [29]. These results are in agreement with Mahgoub [35] on Iris bulbs who reported that the increasing nitrogen level might be responsible for increase in chlorophyll. The rate of photosynthesis increased in the presence of nitrogen was reported by Rawat and Mathpal [34] on gladiolus.

The decrease in days to first flower emergence is considered as important indices by the reference of growth and this decrease is directly related to the availability of nutrition to the plant. The fact is supported by the above results in which it is evident that as the plant nutrition was

provided in proper combination and ratio, days to first flower emergence was decreased. Days to first flower emergence also related to the fact that micronutrients application to the plant tends to more protein and chlorophyll synthesis

The results showed that the combination of zinc and NPK induced early flowering. Minimum days to flowering was observed in of T_{11} (1% Zn + 1.5% NPK), 42.60 followed by the T_{10} (1% Zn + 1% NPK), 45.66 whereas, (Control), 56.70, took maximum days to flowering. This suggested that combination of above nutrients was the best due to high nutrients concentration. The early flowering is very important. Balanced nutrition is one of the best practices to get early flowering in plants (Kumar and Haripriya [29]. The foliar application of the nutrients increased the root portion of the plants. Improved root portion of the plants uptake more nutrients and cause the early sprouting of the bulbs of the caladium. Root exudates also improved the physical properties which enhanced rooting and growth performance of the stock.

Application of both zinc and NPK had significant effect on diameter of floret. Macronutrients have vital role in growth and development of plant because of their stimulatory and catalytic effect in various physiological and metabolic processes of plants and nitrogen application significantly increased florets diameter [37]. This increase was mainly owing to the increase in number of leaves which might have increased the production of photosynthates needed to enhance reproductive growth [38].

The addition of Zinc and NPK as foliar application significantly increased nitrogen content as compared to the control treatment. The result showed the positive co-relationship between the doses of zinc and NPK and the nitrogen contents of the leaves. This could be attributed to the rapid absorption of these elements by the plant surface and their translocation in the gladiolus plant [29, 30]. Increased nitrogen uptake might be due to easy transformation of macronutrients into available nutrients and also due to synergistic effect of zinc and NPK [40].

Treatments with Zinc and NPK had significant effect on phosphorus and potassium contents in T_{11} (1% Zn + 1.5% NPK), 0.46 ppm. The increased level of Phosphorus may be attributed to higher dose of NPK which might had increased root and shoot growth and increased the availability of phosphorus from the soil [41]. Foliar application of macronutrients on *Salvia farinacea* plants significantly increased the phosphorus level in the leaves [42]. Foliar fertilization of nutrients may increase uptake of nutrients from the soil [47] and is might be responsible for release of more sugars and other exudates from roots into the rhizosphere. These exudates stimulate the activity of beneficial microbial populations and this biological activity increases the availability of potassium to the plant [44].

5. Conclusion

This study concluded that foliar application of zinc and

NPK increased the growth of stock. Soil analysis showed that the soil was alkaline in nature and the nutrients were not in available form so under such conditions the foliar application of zinc and NPK was best method to get maximum crop yield. The results regarding the vegetative growth, flowering growth showed a considerable response to Zinc and NPK foliar application. Foliar application of zinc and NPK increased nutrient accumulation in leaves of stock with higher level of nitrogen, phosphorus and potassium contents in the plant.

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