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# EFFECT OF IRRIGATION AND POLYACRYLAMIDE ON THE PRODUCTION OF GLADIOLUS PLANTS IN SANDY SOILS

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## ABSTRACT

This investigation was carried out during 2012/2013 and 2013/2014 seasons on *Gladiolus hybrida* cv. "White Prosperity" grown in plastic pots of 20 cm diameter at Antoniades Research Branch, Horticulture Institute, Ministry of Agriculture, Alexandria, Egypt. The study was a trial to investigate the effect of different levels of irrigation (20 %, 40 %, 60 %, 80 % and 100 % of the field capacity) and different ratios of polyacrylamide as a synthetic soil conditioner (0.0, 0.1, 0.2 and 0.4 %) and their combinations (20 treatments) on the vegetative growth, flowering characteristics, corms production and some chemical constituents of gladiolus plants grown in sandy soils.

Results revealed that the irrigation level was more effective than polyacrylamide ratios on all the studied characteristics of gladiolus plants. Also, using the highest level of the available moisture (100 % of field capacity) combined with polyacrylamide at 0.2 % gave the highest significant values on the plant height, leaf number, floret number, rachis length, corm diameter, cormlet number per plant, carbohydrate content of the new corms and the shortest period needed from planting to showing colour. The maximum values of the leaf area, leaf fresh and dry weights, flowering duration, florets dry weight, leaf chlorophyll and the minimum leaf proline contents were found by the highest irrigation level (100 % of field capacity) alone.

Generally, the results obtained suggest that irrigating the cultivated gladiolus in the sandy soil daily with using irrigation level not less than 80 % of field capacity combined with polyacrylamide at the rate of 0.2 % provided improvements in the vegetative growth, flowering characteristics, corm production and the quantity of some products of gladiolus plants grown in sandy soil.

***Key words:*** *Gladiolus hybrida – irrigation – polyacrylamide.*

## 1. INTRODUCTION

Gladiolus is one of the most important cut flower crops in the floricultural industry and it is the most widely grown outdoor cut flower in Egypt. The name gladiolus is derived from the Latin word "Gladius" meaning sword (Clarence, 1945).

Gladiolus is represented by 180 species (Lewis *et al.,* 1972). The species of the genus gladiolus are chiefly found in south and central Africa and around the Mediterranean area. The species of gladiolus belong to Iridaceae family.

Gladiolus flowers can be all colours, except true blue, although some of the violet shades appear to be very near to blue in subdued light.

The modern gladiolus cultivars offer a diversity of colours, shapes and sizes. Therefore, they can be used as landscape plants in the home garden as specimens for exhibition, and as cut flowers.

Water is becoming an economical scarce resource in many areas of the world, especially in the arid and semi-arid regions. So, increasing water use efficiency and saving irrigation water are important tasks. Nevertheless, even under adequate soil moisture, water stress might develop causing a great variations in most, if not all, the physiological and biochemical processes. Misra and Srivastava (2000) reported that water stress resulted in a significant reduction in chlorophyll content of leaves and in essential oil yield of *Mentha arvensis*. Mohamed (2002) studying *Rosmarinus officinalis* and *pelargonium graveolens*, found that a gradual increase in the fresh and dry weights/plant with increasing irrigation level. The maximum fresh and dry weights/plant and per feddan were obtained by drip irrigation at the rate of 8 l/h.

Generally, cultivation on arid sandy soils requires large quantities of water. The low water holding capacity of this soil causes rapid infiltration and deep percolation below the root zone. The uses of gel-forming hydrophilic polymers have been tested for some years to solve such problem. Polyacrylamide (PAM) is a polymer composed of many subunits of acrylamide molecules, which are linked to identical copies of itself to form long chain-link molecules. PAM is synthesized from natural gas and was originally developed in the 1940s and 1950s for use as a soil conditioner. There is in fact thousands kinds of PAM which vary with the length and ionicity of the polymer chain. Gel-forming or superabsorbant polymers are soil conditioners developed to aid plant establishment in drought prone soils. The polymers commonly available come mainly from three chemical families, Johnson (1984). Mostafa (2002) reported that adding polyacrylamide at 0.1 – 0.2% to the sandy soil under the irrigation frequencies regime of once/2 day enhanced most of plant growth indices of *Dendranthema grandiflorum* cv. Hawaii. Sivapalan (2006) demonstrated that the excess amount of water stored in the soil by polyacrylamide was available to plants and resulted in higher water use. Consequently, there were 12 and 18 fold increases in water use efficiency of soybean plants grown in soils treated with 0.03 and 0.07% polyacrylamide, respectively.

The objective of this investigation was to study the effects of using different percentages of field capacity (irrigation levels), ratios of polyacrylamide and their combinations on the vegetative growth, flowering characteristics, corms and cormlets production and some chemical analysis of *Gladiolus hybrida* cv. "White Prosperity" grown in sandy soils under the prevailing conditions of Alexandria, Egypt.

## 2. MATERIALS AND METHODS

The present study was carried-out during the two successive seasons of (2012/2013) and (2013/2014) at Antoniades Research Branch, Horticulture Research Institute, A.R.C. Alexandria, Egypt.

Corms of *Gladiolus hybrida* cultivar "White Prosperity" were chosen for their popularity and adaptability to the Egyptian environment and for the possibility to export. Corms were imported from Holland for both seasons of the study. The circumferences of the used corms ranged between 8-10 cm. Corms were planted in plastic pots of 20 cm at a depth of 5 cm on October 9$^{th}$, 2012 and October 7$^{th}$, 2013 for the first and second seasons, respectively. The pots were filled with a sandy soil (6 Kg per pot). The analysis of the used sandy soil as described by Jackson (1958) in Table (1).

**Table (1): Chemical analysis of the used sandy soil for the two successive seasons (2012/2013) and (2013/2014).**

| Season | pH | EC | Soluble cations (mg/l) | | | | Soluble anions (mg/l) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | (mmohs/cm) | $Ca^{++}$ | $Mg^{++}$ | $Na^{+}$ | $K^{+}$ | $HCO_3^-$ | $Cl^-$ | $SO_2^{--}$ |
| **2012/2013** | 8.10 | 1.30 | 3.0 | 4.4 | 6.5 | 1.1 | 3.5 | 6.5 | 2.5 |
| **2013/2014** | 8.02 | 1.06 | 3.4 | 2.8 | 6.0 | 0.6 | 3.0 | 6.0 | 2.0 |

Five irrigation levels were used to keep the soil moisture at the field capacity of the used sandy soil at 20%, 40%, 60%, 80% and 100%. The reduction in the moisture level of each treatment was determined daily using Moisture Tester Model KS-DI (Gypsum Block) during the growing seasons.

The amounts of water for the different treatments were added daily to each pot to keep the soil moisture of each treatment at the corresponding percentage using tap water as a source of irrigation. At the end of the experiment the total amount of irrigation water used for each treatment was calculated and presented in Table (2).

The "Flowrowger" is a commercial name of a synthetic polymer with white granular substrate that contains 97 % polyacrylamide (PAM) and has water retention capacity of 600 times on its weight basis, was used as a source of polyacrylamide (PAM). Four concentrations from this polymer were used, i.e. 0.0 (control), 0.1, 0.2 and 0.4% on the basis of soil weight (w/w). Each level from this polymer was completely mixed with the used soil directly

**Table (2): Total amount of the water used for each plant (l/pot) in each treatment during the growing of the two seasons (2012/2013) and (2013/2014).**

| Field Capacity | First season (2012/2013) | | | | | Second season (2013/2014) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Polyacrylamide concentration | | | | | Polyacrylamide concentration | | | | |
| | 0.0% | 0.1% | 0.2% | 0.4% | Mean | 0.0% | 0.1% | 0.2% | 0.4% | Mean |
| **100** | 63.00 | 62.25 | 61.80 | 61.00 | **62.00** | 63.80 | 63.00 | 62.65 | 61.85 | **62.82** |
| **80** | 53.00 | 52.25 | 51.80 | 51.00 | **52.00** | 53.80 | 53.00 | 52.65 | 51.85 | **52.82** |
| **60** | 43.00 | 42.25 | 41.80 | 41.00 | **42.00** | 43.80 | 43.00 | 42.65 | 41.85 | **42.82** |
| **40** | 33.00 | 32.25 | 31.80 | 31.00 | **32.00** | 33.80 | 33.00 | 32.65 | 31.85 | **32.82** |
| **20** | 23.00 | 22.25 | 21.80 | 21.00 | **22.00** | 23.80 | 23.00 | 22.65 | 21.85 | **22.82** |

before planting, Devitt *et al.* (1991).

Five levels of field capacity and four concentrations of polyacrylamide were used, 20 treatments for each season. The design was a split plot with three replicates, each replicate contain 3 plants. The main plots were the irrigation levels while the subplots were the concentrations of polyacrylamide. The means of individual factors and their interactions were compared using L.S.D. test at 5% level of probability, Snedecor and Cochran (1974).

Fertilization of the plants was started three weeks after sprouting of the corms. Two types of compound fertilizers (N: $P_2O_5$: $K_2O$) were used for accelerating the vegetative growth and enhanced the quality of the produced flowers and corms. These fertilizers were 19:19:19 for the vegetative growth followed by 12:12:36 for flowering and corm developing (Yadav and Maity, 1989). Each plant under the experiment was fertilized with 16g. This amount was divided into four equal doses, from each fertilizer type. Each dose was added to the soil surface as a top dressing at biweekly intervals. It was added for the first time after twenty one days of sprouting (November 13, in the first season and November 11, in the second season).

Plants requirement of magnesium (Mg) and iron (Fe) were added as $MgSO_4$. $7H_2O$ (Magnesium Sulphate = 9.5 % Mg) and Fe-EDTA (Disodium Fe of chelate ethylene diamine tetraacetic acid = 18% Fe), which were sprayed four times at three weekly intervals on the plant foliage until the run -off point at 150 and 75 ppm for Mg and Fe, respectively ( Matt and Muhar, 1990 ). The first dose was sprayed on October 13, 2012 and October 11, 2013 for the first and second seasons, respectively.

The following data were recorded: plant height, leaf number, leaf area, leaf fresh and dry weights per plant, number of days to showing color, floret diameter per spike, flowering duration on the plant, floret number, rachis length, floret dry weight, corm diameter, corm dry weight, number of cormlets per plant, total chlorophyll content according to Moran and Porath (1980), leaf proline content as a water stress indicator according to Bates *et al.* (1973) and carbohydrate content according to Dubios *et al.* (1956) of the new corms.

## 3. RISULTS AND DISCUSSION

### 3.1.vegetative g rowth

Generally, data of the two seasons indicated that the irrigation levels were more effective than that of the polyacrylamide rates on all the studied characteristics of gladiolus plants. This result may be due to the poor ability of sandy soil to hold enough water to supply the gladiolus plants. with their needs of water and essential elements to grow well, thus any application of water led to improving the growth rate of gladiolus plants. The data of the two seasons in Table (3) showed that the tallest plants were obtained by using available moisture at 100% of field capacity combined with polyacrylamide at 0.2 % 91.50 and 92.83 cm in 2012/2013 and 2013/2014 seasons, respectively, as compared with the other treatments. These results were probably due to the fact that sprouting the gladiolus corms requires a suitable level of available moisture in the medium to encourage the initiation and development of the roots and buds, besides that using the proper concentration of the polyacrylamide led to improve the water holding capacity and reduced the infiltration rate of the sandy soil. Thus the soil can reserve an enough amount of water needed to give the tallest plant.

**Table (3): Means of vegetative growth characteristics of *Gladiolus hybrida* cv. White Prosperity plants as influenced by field capacity percentage (F.C.), polyacrylamide (PAM) percentage (%) and their combinations (F.C.×PAM) in the two seasons of (2012/2013) and (2013/2014).**

| Treatments | | Plant height (cm) | | Leaves number per plant | | Leaf area (cm$^2$) | | Leaves fresh weight per plant (g) | | Leaves dry weight per plant (g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Field capacity (%) | Polyacrylamide (%) | **2012 /2013** | **2013 /2014** | **2012 /2013** | **2013 /2014** | **2012 /2013** | **2013 /2014** | **2012 /2013** | **2013 /2014** | **2012 /2013** | **2013 /2014** |
| 20% | 0.0 % | 74.00 | 75.66 | 6.00 | 6.00 | 305.86 | 311.41 | 24.53 | 24.76 | 4.01 | 3.92 |
| | 0.1 % | 76.50 | 78.16 | 6.00 | 6.00 | 316.27 | 320.14 | 25.43 | 25.87 | 4.16 | 4.10 |
| | 0.2 % | 77.00 | 78.66 | 6.00 | 6.00 | 318.34 | 323.89 | 25.53 | 26.69 | 4.18 | 4.23 |
| | 0.4 % | 72.83 | 74.50 | 6.00 | 6.00 | 301.09 | 307.12 | 24.14 | 24.97 | 3.95 | 3.95 |
| **Mean** | | **75.08** | **76.74** | **6.00** | **6.00** | **310.39** | **315.64** | **24.90** | **25.57** | **4.07** | **4.05** |
| 40% | 0.0 % | 75.83 | 77.50 | 6.00 | 6.00 | 313.52 | 317.41 | 25.13 | 25.67 | 4.11 | 4.07 |
| | 0.1 % | 77.16 | 78.33 | 6.33 | 6.33 | 319.02 | 324.16 | 25.74 | 26.59 | 4.21 | 4.22 |
| | 0.2 % | 80.83 | 82.66 | 6.50 | 6.66 | 334.33 | 340.35 | 26.81 | 27.79 | 4.39 | 4.40 |
| | 0.4 % | 81.16 | 82.33 | 6.16 | 6.16 | 335.58 | 331.48 | 26.89 | 26.33 | 4.40 | 4.18 |
| **Mean** | | **78.74** | **80.20** | **6.25** | **6.29** | **325.61** | **328.35** | **26.14** | **26.59** | **4.27** | **4.21** |
| 60% | 0.0 % | 77.83 | 79.50 | 6.00 | 6.00 | 321.75 | 327.57 | 25.88 | 26.45 | 4.23 | 4.19 |
| | 0.1 % | 81.16 | 82.00 | 6.33 | 6.50 | 335.61 | 337.59 | 26.89 | 27.59 | 4.40 | 4.37 |
| | 0.2 % | 83.16 | 84.33 | 6.66 | 6.83 | 343.81 | 347.20 | 28.28 | 28.64 | 4.63 | 4.54 |
| | 0.4 % | 80.66 | 82.33 | 6.33 | 6.50 | 333.54 | 333.15 | 26.74 | 27.16 | 4.38 | 4.31 |
| **Mean** | | **80.70** | **82.04** | **6.33** | **6.45** | **333.67** | **336.37** | **26.94** | **27.46** | **4.41** | **4.35** |
| 80% | 0.0 % | 82.50 | 83.66 | 6.00 | 6.00 | 340.98 | 344.44 | 37.38 | 34.71 | 6.12 | 5.51 |
| | 0.1 % | 86.50 | 87.83 | 6.66 | 6.66 | 357.61 | 359.96 | 38.75 | 36.34 | 6.34 | 5.77 |
| | 0.2 % | 86.16 | 87.50 | 7.50 | 7.33 | 359.56 | 360.23 | 38.68 | 37.78 | 6.33 | 5.99 |
| | 0.4 % | 82.33 | 83.33 | 7.16 | 7.00 | 340.31 | 340.91 | 37.29 | 35.13 | 6.11 | 5.57 |
| **Mean** | | **84.37** | **85.58** | **6.83** | **6.75** | **349.61** | **351.38** | **38.02** | **35.98** | **6.22** | **5.71** |
| 100% | 0.0 % | 89.00 | 90.16 | 6.00 | 6.00 | 369.76 | 370.41 | 40.68 | 41.15 | 6.66 | 6.53 |
| | 0.1 % | 90.50 | 91.50 | 7.33 | 7.33 | 380.86 | 380.05 | 41.86 | 44.11 | 6.85 | 6.94 |
| | 0.2 % | 91.50 | 92.83 | 7.83 | 8.00 | 388.27 | 388.90 | 43.51 | 44.57 | 7.14 | 7.07 |
| | 0.4 % | 87.83 | 88.83 | 7.16 | 7.16 | 364.74 | 365.75 | 40.95 | 41.41 | 6.71 | 6.57 |
| **Mean** | | **89.70** | **90.83** | **7.08** | **7.12** | **375.90** | **376.27** | **41.75** | **42.81** | **6.84** | **6.77** |
| Mean (PAM) | 0.0 % | 79.83 | 81.29 | 6.00 | 6.00 | 330.37 | 334.24 | 30.72 | 30.54 | 5.02 | 4.84 |
| | 0.1 % | 82.36 | 83.56 | 6.53 | 6.56 | 341.87 | 344.38 | 31.73 | 32.10 | 5.19 | 5.08 |
| | 0.2 % | 83.73 | 85.19 | 6.89 | 6.96 | 348.86 | 352.11 | 32.56 | 33.09 | 5.33 | 5.24 |
| | 0.4 % | 80.96 | 82.26 | 6.56 | 6.56 | 335.05 | 335.68 | 31.20 | 31.00 | 5.11 | 4.91 |
| L.S.D. at 0.05 | **F.C.** | **0.55** | **0.83** | **0.18** | **0.25** | **1.99** | **2.34** | **0.58** | **2.53** | **0.11** | **0.40** |
| | **PAM** | **0.41** | **0.49** | **0.16** | **0.14** | **1.82** | **2.74** | **0.22** | **0.26** | **0.03** | **0.04** |
| | **F.C.×PAM** | **0.98** | **1.26** | **0.37** | **0.37** | **4.05** | **5.79** | **0.72** | **2.57** | **0.12** | **0.41** |

Also, the data of the two seasons in Table (3) generally, indicated that using the highest level of the available moisture (100 % of field capacity) combined with polyacrylamide at 0.2% gave the highest values of the leaves number/plant (7.83 and 8.00), leaf area (388.27 and 388.90 cm$^2$), leaves fresh weight (43.51 and 44.57 gm) and leaves dry weight (7.14 and 7.07 gm) in first and second seasons, respectively), as compared with the other treatments. These results may be due to the fact that using a suitable level of moisture (100 % of field capacity) at a proper concentration of polyacrylamide activated the root system to grow better and it can absorb the adequate amount of water and fertilizer needed for good plant growth. Besides, increasing the rate of accumulation of the biosynthesates materials in the leaves, thus the leaf number, area, fresh and dry weights could be increased. Similar trend of results was found by Tripepi *et al.* (1991) with *Betula pendula* plant, Halepyati *et al.* (2002) with tuberose and Khattab *et al.* (2002) with *Salvia splendens*. Furthermore, in this investigation, it is also clear that, in general, using polyacrylamide alone at a concentration of 0.2% gave significant increases in all studied leaf characters (number, area, fresh and dry weights), compared with the other concentrations.

These results were probably due to the role of polyacrylamide at a suitable concentration on increasing the availability of water and nutrients, thus the rate of food biosynthesis could be increased. Consequently, the plants can produce many large leaves, thus fresh and dry weight increase. Similar trend was found by Al-Harbi *et al.* (1999) with cucumber and Klock–Moore (2000) with *Salvia splendens*.

Generally, the average increase of the plant height at 100% filed capacity and 0.2% PAM was 91.50 and 92.83 cm in first and second seasons, respectively. The extent of any fall in the second grade (Class II) of was export (which is how far along spike length was between 90 - 120 cm), GOEIC (1988). The increase of the plant height at 80% field capacity and 0.1% PAM was 86.50 and 87.83 cm in first and second seasons, respectively. The extent of any fall in the third grade (Class III) for export (which is how far along was spike length was between 80 – 90 cm), GOEIC (1988).

### 3.2. Flowering characteristics

The results of the two seasons in Table (4-a) indicated that the minimum time taken to showing color stage was obtained by using the highest level of the available moisture, which led to decrease the time to 64.00 and 64.33 days under the treatment of 0.2% PAM in the first and second seasons, respectively, as compared with

**Table (4-a): Means of flowering characteristics of *Gladiolus hybrida* cv. White Prosperity plants as influenced by field capacity percentage (F.C.), polyacrylamide (PAM) percentage (%) and their combinations (F.C.×PAM) in the two seasons of (2012/2013) and (2013/2014).**

| Treatments | | Time to showing colour (day) | | Floret diameter per spike (cm) | | Flowering duration (day) | |
|---|---|---|---|---|---|---|---|
| **Field capacity (%)** | **Polyacrylamide (%)** | **2012 /2013** | **2013 /2014** | **2012 /2013** | **2013 /2014** | **2012 /2013** | **2013 /2014** |
| 20% | 0.0 % | 88.66 | 89.00 | 6.16 | 6.30 | 11.16 | 10.83 |
| | 0.1 % | 86.66 | 87.00 | 6.37 | 6.54 | 12.33 | 12.83 |
| | 0.2 % | 85.83 | 86.16 | 6.45 | 6.65 | 12.83 | 13.00 |
| | 0.4 % | 88.00 | 88.33 | 6.11 | 6.41 | 11.66 | 11.83 |
| **Mean** | | **87.28** | **87.62** | **6.27** | **6.47** | **11.99** | **12.12** |
| 40% | 0.0 % | 83.33 | 83.66 | 6.26 | 6.53 | 11.50 | 11.50 |
| | 0.1 % | 80.83 | 81.16 | 6.52 | 6.78 | 12.50 | 12.83 |
| | 0.2 % | 79.50 | 79.83 | 6.72 | 6.99 | 13.16 | 13.50 |
| | 0.4 % | 83.00 | 83.33 | 6.39 | 6.63 | 12.33 | 12.16 |
| **Mean** | | **81.66** | **81.99** | **6.47** | **6.73** | **12.37** | **12.49** |
| 60% | 0.0 % | 76.50 | 76.83 | 7.47 | 7.72 | 12.16 | 12.16 |
| | 0.1 % | 73.50 | 73.83 | 7.73 | 7.99 | 13.00 | 13.33 |
| | 0.2 % | 72.00 | 72.33 | 7.94 | 8.14 | 13.66 | 14.00 |
| | 0.4 % | 75.83 | 76.16 | 7.58 | 7.92 | 12.83 | 13.16 |
| **Mean** | | **74.45** | **74.78** | **7.68** | **7.94** | **12.91** | **13.16** |
| 80% | 0.0 % | 67.50 | 67.83 | 7.82 | 8.08 | 12.83 | 12.16 |
| | 0.1 % | 65.50 | 65.83 | 8.18 | 8.35 | 14.00 | 14.16 |
| | 0.2 % | 65.16 | 65.50 | 8.29 | 8.50 | 14.33 | 14.66 |
| | 0.4 % | 67.50 | 67.83 | 7.94 | 8.13 | 13.16 | 13.33 |
| **Mean** | | **66.41** | **66.74** | **8.05** | **8.26** | **13.58** | **13.57** |
| 100% | 0.0 % | 66.66 | 67.00 | 9.29 | 9.38 | 13.16 | 13.16 |
| | 0.1 % | 64.16 | 64.50 | 9.52 | 9.71 | 14.66 | 15.00 |
| | 0.2 % | 64.00 | 64.33 | 9.63 | 9.87 | 15.16 | 15.33 |
| | 0.4 % | 66.66 | 67.00 | 9.38 | 9.55 | 14.00 | 14.00 |
| **Mean** | | **65.37** | **65.70** | **9.45** | **9.62** | **14.24** | **14.37** |
| Mean (PAM) | 0.0 % | 76.53 | 76.86 | 7.40 | 7.60 | 12.16 | 11.96 |
| | 0.1 % | 74.13 | 74.46 | 7.66 | 7.87 | 13.29 | 13.63 |
| | 0.2 % | 73.29 | 73.63 | 7.80 | 8.03 | 13.82 | 14.09 |
| | 0.4 % | 76.19 | 76.53 | 7.48 | 7.72 | 12.79 | 12.89 |
| L.S.D. at 0.05 | **F.C.** | **1.36** | **1.27** | **0.09** | **0.08** | **0.39** | **0.39** |
| | **PAM** | **0.35** | **0.32** | **0.03** | **0.05** | **0.23** | **0.24** |
| | **F.C.×PAM** | **1.52** | **1.42** | **0.10** | **0.13** | **0.59** | **0.12** |

the lowest level. These results may be due to using a suitable level of the available moisture which activates the root system to grow early on the planted corms and sprout early and absorbs an adequate amount of the nutrients needed for the biosynthesis process, which led to produce and accumulate the flowering materials that accelerate the initiation and formation of the flowers. As a result, the time needed for showing color stage could be decreased. Similar trend was found by Mostafa and Asker (1997) with *Dianthus barbatus* and *Senecio cruentus*.

In addition, the data presented in Table (4-a) showed that the addition of polyacrylamide at 0.2 % gave the shortest time taken to showing color in both seasons, compared with the other rates. These results may be due to the influence of the added polyacrylamide at a suitable ratio on increasing the efficiency of the soil water and fertilizer. Consequently, the plants reach showing color stage early. Similar trend was found by Mostafa *et al.* (1997) on Chrysanthemum.

Generally, the data on the flower diameter showed that the maximum floret diameter per spike was found at the highest level of the available moisture of the sandy soil combined with 0.2 % polyacrylamide in both seasons, 9.63 and 9.87 cm, respectively (Table (4-a). These results may be related to the effect of polyacrylamide at a suitable concentration on improving the physical properties of the sandy soil, especially when the soil contains the suitable amount of water, consequently the plants could produce good spikes with many florets. Similar trend was found by Devitt *et al.* (1991) on *Catharanthus roseus*.

Generally, the data of the two seasons in Table (4-a) indicated that using the highest level of the available moisture (100 % of field capacity) gave the longest significant flowering duration of gladiolus flowers (15.16 and 15.33 days,) respectively, as compared with all the other treatments. The previous results may be due to using a suitable amount of the available moisture in the sandy soil which led to increase the absorption of the necessary nutrient elements for growth. Thus the growth rate of gladiolus plants could be increased, consequently producing vigorous plants with a long spike with more flowers, and as a result the period of the flowering duration could be increased. Similar trend was reported by Mostafa and Asker (1997) with *Dianthus barbatus* and *Senecio cruentus*.

Generally, the data on the number of florets per spike showed that the maximum number was found at the highest level of the available moisture of the sandy soil combined with 0.2 % polyacrylamide in both seasons (Table 4-b). These results may be related to the effect of polyacrylamide at a suitable concentration on improving the physical properties of the sandy soil, especially when the soil contains the suitable amount of water, consequently the plants could produce good spikes with many flowers. Similar trend was found by Devitt *et al.* (1991) with *Catharanthus roseus*.

Also, the means of rachis length per plant in the two seasons in Table (4-b) indicated that reducing the level of the available moisture of the sandy soil less than 100 % of field capacity decreased the rachis length per plant. The shortest rachis length per plant was found by using 20 % of the available moisture of the soil, which was 36.91 and 37.25 cm using 0.4% PAM in both seasons, respectively. While the highest rachis length was 49.25 and 50.08 cm using 0.2% PAM in both seasons, respectively. These results were probably due to the role of water at a suitable level in plant, which is necessary for nutrient element absorption, chemical combinations that result in the formation of plant food, as a medium through which food and nutrient elements are moved from cell to cell, and to fill the vacuoles in the cells necessary to keep the tissues turgid. As a result, the size of the cells and the division rate of the apical meristem could be increased, consequently the spike length will increase. Similar trend was reported by Mousa and El-Keltawi (1983) with *Strelitzia reginae*.

The data of both seasons in Table (4-b) showed that the longest rachis per flowering spike was obtained by adding the highest level of the available water (100 % of field capacity) combined with polyacrylamide at 0.2 %. These results may be related to the effect of polyacrylamide at a suitable rate on improving the physical properties of the sandy soil especially when the soil contains enough amount of the available moisture, accordingly the plants could absorb the needed water and nutrient elements for improving the whole growth of the plants. As a result, the length of the rachis will increase. Similar trend was reported by Devitt *et al.* (1991) with *Catharanthus roseus* and Mostafa and Asker (1997) with *Dianthus barbatus* and *Senecio cruentus*.

Table (4-b): Means of flowering characteristics of *Gladiolus hybrida* cv. White Prosperity plants as influenced by field capacity percentage (F.C.), polyacrylamide (PAM) percentage (%) and their combinations (F.C.×PAM) in the two seasons of (2012/2013) and (2013/2014).

| Treatments | | Florets number per spike | | Rachis length (cm) | | Florets dry weight (g) | |
|---|---|---|---|---|---|---|---|
| Field capacity (%) | Polyacrylamide (%) | 2012 /2013 | 2013 /2014 | 2012 /2013 | 2013 /2014 | 2012 /2013 | 2013 /2014 |
| 20% | 0.0 % | 8.50 | 9.16 | 37.00 | 37.41 | 0.84 | 0.85 |
| | 0.1 % | 8.83 | 8.66 | 38.08 | 38.58 | 0.90 | 0.92 |
| | 0.2 % | 9.66 | 9.83 | 38.83 | 39.50 | 0.94 | 0.96 |
| | 0.4 % | 9.00 | 9.50 | 36.91 | 37.25 | 0.84 | 0.87 |
| **Mean** | | **8.99** | **9.28** | **37.70** | **38.18** | **0.88** | **0.90** |
| 40% | 0.0 % | 8.83 | 8.33 | 37.91 | 38.41 | 1.89 | 1.90 |
| | 0.1 % | 9.16 | 9.33 | 38.75 | 39.16 | 1.93 | 1.97 |
| | 0.2 % | 10.33 | 10.50 | 41.58 | 42.33 | 2.08 | 2.11 |
| | 0.4 % | 8.66 | 9.33 | 39.41 | 39.16 | 1.94 | 1.95 |
| **Mean** | | **9.24** | **9.37** | **39.41** | **39.76** | **1.96** | **1.98** |
| 60% | 0.0 % | 9.83 | 9.33 | 38.91 | 39.58 | 1.94 | 1.97 |
| | 0.1 % | 11.16 | 11.33 | 40.58 | 41.00 | 2.04 | 2.05 |
| | 0.2 % | 12.33 | 12.50 | 42.41 | 43.33 | 2.11 | 2.16 |
| | 0.4 % | 10.66 | 11.33 | 40.33 | 41.16 | 2.01 | 2.05 |
| **Mean** | | **10.99** | **11.12** | **40.55** | **41.26** | **2.02** | **2.05** |
| 80% | 0.0 % | 11.83 | 11.33 | 41.75 | 42.00 | 2.08 | 2.09 |
| | 0.1 % | 13.16 | 13.33 | 45.41 | 45.58 | 2.25 | 2.24 |
| | 0.2 % | 14.16 | 14.16 | 46.08 | 46.08 | 2.31 | 2.29 |
| | 0.4 % | 12.33 | 12.83 | 44.00 | 43.50 | 2.20 | 2.17 |
| **Mean** | | **12.87** | **12.91** | **44.31** | **44.29** | **2.21** | **2.19** |
| 100% | 0.0 % | 12.66 | 12.16 | 44.66 | 45.41 | 2.23 | 2.24 |
| | 0.1 % | 14.16 | 14.33 | 46.41 | 46.91 | 2.31 | 2.33 |
| | 0.2 % | 15.33 | 15.50 | 49.25 | 50.08 | 2.47 | 2.50 |
| | 0.4 % | 13.33 | 13.83 | 45.58 | 45.41 | 2.28 | 2.27 |
| **Mean** | | **13.87** | **13.95** | **46.47** | **46.95** | **2.32** | **2.33** |
| Mean (PAM) | 0.0 % | 10.33 | 10.06 | 40.04 | 40.56 | 1.79 | 1.81 |
| | 0.1 % | 11.30 | 11.40 | 41.84 | 42.24 | 1.88 | 1.90 |
| | 0.2 % | 12.36 | 12.50 | 43.63 | 44.26 | 1.98 | 2.00 |
| | 0.4 % | 10.80 | 11.36 | 41.24 | 41.29 | 1.85 | 1.86 |
| L.S.D. at 0.05 | **F.C.** | **0.65** | **0.36** | **0.54** | **0.38** | **0.03** | **0.02** |
| | **PAM** | **0.29** | **0.34** | **0.33** | **0.35** | **0.01** | **0.01** |
| | **F.C.×PAM** | **0.86** | **0.74** | **0.84** | **0.76** | **0.03** | **0.04** |

The same trend was found in floret dry weight. It was found that using 100% of water field capacity in combination of 0.2% PAM gave the highest dry weight (2.47 and 2.50 g) in the two seasons, respectively.

Generally, the average of the florets number per spike at 100% field capacity and 0.2% PAM was 15.33 and 15.50 in the first and second seasons, respectively. The extent of any fall in the first grade (Class I) of export (which is how far along florets number greater than 9 florets), GOEIC (1988). We found that the increase of the floret number per spike at 80% field capacity and 0.2% PAM was 14.16 in the both seasons.The extent of any fall in the first grade (Class I) for export (which is how far along florets number between 8–9 florets), GOEIC (1988).

### 3.3. Corm production

Generally, the data of the two seasons in Table (5) showed that the largest corm diameter was 5.02 and 5.28 cm in the first and second seasons, respectively. The corm dry weight was 3.19 and 3.34 g, respectively, and the highest number of the new cormlets per plant were (17.16 and 17.83 cormlets) found by adding the highest level of water content (100 % of field capacity) combined with polyacrylamide at 0.2

Table (5): Means of corm production of *Gladiolus hybrida* cv. White Prosperity plants as influenced by field capacity percentage (F.C.), polyacrylamide (PAM) percentage (%) and their combinations (F.C.×PAM) in the two seasons of (2012/2013) and (2013/2014).

| Treatments | | Corm diameter (cm) | | Corm dry weight (g) | | Cormlet number per plant | |
|---|---|---|---|---|---|---|---|
| Field capacity (%) | Polyacrylamide (%) | **2012 /2013** | **2013 /2014** | **2012 /2013** | **2013 /2014** | **2012 /2013** | **2013 /2014** |
| 20% | 0.0 % | 2.85 | 2.99 | 1.67 | 1.84 | 9.83 | 10.16 |
| | 0.1 % | 3.23 | 3.34 | 1.98 | 2.11 | 11.00 | 11.33 |
| | 0.2 % | 3.74 | 3.71 | 2.22 | 2.38 | 12.16 | 12.50 |
| | 0.4 % | 2.83 | 3.05 | 1.74 | 1.90 | 9.66 | 10.16 |
| **Mean** | | **3.16** | **3.27** | **1.90** | **2.05** | **10.66** | **11.03** |
| 40% | 0.0 % | 3.03 | 3.20 | 1.83 | 2.02 | 10.33 | 10.83 |
| | 0.1 % | 3.99 | 4.14 | 2.41 | 2.60 | 13.33 | 13.83 |
| | 0.2 % | 4.22 | 4.44 | 2.58 | 2.80 | 14.33 | 14.83 |
| | 0.4 % | 3.25 | 3.58 | 2.00 | 2.24 | 11.00 | 12.00 |
| **Mean** | | **3.62** | **3.84** | **2.20** | **2.41** | **12.24** | **12.87** |
| 60% | 0.0 % | 3.20 | 3.58 | 1.98 | 2.26 | 11.00 | 12.00 |
| | 0.1 % | 3.80 | 4.11 | 2.35 | 2.59 | 13.00 | 13.66 |
| | 0.2 % | 4.42 | 4.64 | 2.71 | 2.88 | 15.00 | 15.66 |
| | 0.4 % | 3.30 | 3.54 | 1.98 | 2.25 | 11.00 | 11.66 |
| **Mean** | | **3.68** | **3.96** | **2.25** | **2.49** | **12.50** | **13.24** |
| 80% | 0.0 % | 3.55 | 3.75 | 2.15 | 2.32 | 12.16 | 12.50 |
| | 0.1 % | 4.31 | 4.54 | 2.64 | 2.87 | 14.66 | 15.33 |
| | 0.2 % | 4.83 | 5.05 | 2.98 | 3.18 | 16.50 | 17.00 |
| | 0.4 % | 3.73 | 4.02 | 2.29 | 2.53 | 12.66 | 13.33 |
| **Mean** | | **4.10** | **4.34** | **2.51** | **2.72** | **13.99** | **14.54** |
| 100% | 0.0 % | 3.56 | 3.81 | 2.16 | 2.35 | 12.16 | 12.83 |
| | 0.1 % | 4.36 | 4.54 | 2.65 | 2.87 | 14.66 | 15.33 |
| | 0.2 % | 5.02 | 5.28 | 3.19 | 3.34 | 17.16 | 17.83 |
| | 0.4 % | 3.78 | 4.03 | 2.36 | 2.52 | 12.83 | 13.33 |
| **Mean** | | **4.18** | **4.41** | **2.59** | **2.77** | **14.20** | **14.83** |
| Mean (PAM) | 0.0 % | 3.23 | 3.46 | 1.95 | 2.15 | 11.09 | 11.66 |
| | 0.1 % | 3.93 | 4.13 | 2.40 | 2.60 | 13.33 | 13.89 |
| | 0.2 % | 4.44 | 4.62 | 2.73 | 2.91 | 15.03 | 15.56 |
| | 0.4 % | 3.37 | 3.64 | 2.07 | 2.28 | 11.43 | 12.09 |
| L.S.D. at 0.05 | **F.C.** | **0.18** | **0.25** | **0.08** | **0.14** | **0.48** | **0.70** |
| | **PAM** | **0.08** | **0.09** | **0.03** | **0.05** | **0.19** | **0.28** |
| | **F.C.×PAM** | **2.05** | **2.27** | **1.35** | **1.42** | **7.19** | **7.56** |

%. These results may be due to the role of polyacrylamide at a suitable concentration, on improving the physical properties of the sandy soil, especially when the soil contains the proper level of the available moisture, consequently producing vigorous plants, and accordingly resulted in more back translocation and accumulation of organic matter, which led to the production of large and many cormes per plant. Similar results were found by El-Naggar and Nassar (1994) with *Narcissus tazetta* and Al-Humaid and Al-Moftah (2005) with *Polianthes tuberosa*.

### 3.4. Chemical constituents

The data of the two seasons (Table 6) showed that the maximum total chlorophyll content of gladiolus leaves was found by using the highest level of the available moisture (100 % of field capacity) combined with polyacrylamide at 0.2 %, which was 1.34 and 1.32 mg/g fresh weight, respectively, compared with the other treatments. These results were probably due to using a suitable level of available moisture that led to increasing the absorption of water and nutrient elements, especially nitrogen and magnesium needed for chlorophyll formation. In addition to the presence of polyacrylamide at a proper concentration increases the availability of nitrogen and leaf water potential, thus, the synthesis of the green pigment could be increased. Similar results were obtained by Al-Moftah and Al-Humaid (2004) with *Polianthes tuberosa*.

Furthermore, the data of the Table (6) showed that using the lowest level of the available moisture (20 % of field capacity) combined with polyacrylamide at 0.4% gave the highest value of proline in gladiolus leaves, (2.52 and 2.65 mg/g), for both seasons respectively, as compared with the other treatments. This result was probably due to the fact that protein formation requires a suitable level of water inside the plant tissues, consequently the free amino acids especially proline could be increased in the gladiolus leaves. Similar results were found by Khalil (2003), Kim *et al.* (2004) and Kohler *et al.* (2008) on other plants.

Also, the data of the Table (6) cleared that the

**Table (6): Means of chemical constituents of *Gladiolus hybrida* cv. White Prosperity plants as influenced by field capacity percentage (F.C.), polyacrylamide (PAM) percentage (%) and their combinations (F.C.×PAM) in the two seasons of (2012/2013) and (2013/2014).**

| Treatments | | Total chlorophyll content (mg/ g fresh weight ) | | Proline content (mg/g) | | Total carbohydrates content New corms (%) | |
|---|---|---|---|---|---|---|---|
| **Field capacity (%)** | **Polyacrylamide (%)** | **2012 /2013** | **2013 /2014** | **2012 /2013** | **2013 /2014** | **2012 /2013** | **2013 /2014** |
| 20% | 0.0 % | 0.87 | 0.85 | 2.51 | 2.64 | 32.06 | 33.24 |
| | 0.1 % | 0.94 | 0.92 | 2.44 | 2.56 | 35.70 | 36.30 |
| | 0.2 % | 1.00 | 0.98 | 2.45 | 2.57 | 37.30 | 37.63 |
| | 0.4 % | 0.92 | 0.90 | 2.52 | 2.65 | 32.75 | 33.89 |
| **Mean** | | **0.93** | **0.91** | **2.48** | **2.60** | **34.45** | **35.26** |
| 40% | 0.0 % | 0.90 | 0.88 | 2.34 | 2.46 | 43.09 | 44.15 |
| | 0.1 % | 0.97 | 0.95 | 2.26 | 2.38 | 46.28 | 47.79 |
| | 0.2 % | 1.02 | 1.00 | 2.25 | 2.37 | 47.43 | 49.03 |
| | 0.4 % | 0.92 | 0.91 | 2.36 | 2.48 | 44.25 | 45.73 |
| **Mean** | | **0.95** | **0.93** | **2.30** | **2.42** | **45.26** | **46.67** |
| 60% | 0.0 % | 0.98 | 0.96 | 1.93 | 2.03 | 53.04 | 53.75 |
| | 0.1 % | 1.05 | 1.03 | 1.86 | 1.95 | 55.56 | 56.39 |
| | 0.2 % | 1.09 | 1.06 | 1.83 | 1.93 | 57.55 | 57.84 |
| | 0.4 % | 1.01 | 0.99 | 1.96 | 2.06 | 53.24 | 53.29 |
| **Mean** | | **1.03** | **1.01** | **1.89** | **1.99** | **54.84** | **55.31** |
| 80% | 0.0 % | 1.11 | 1.09 | 1.62 | 1.70 | 62.17 | 64.26 |
| | 0.1 % | 1.26 | 1.24 | 1.55 | 1.63 | 65.14 | 67.00 |
| | 0.2 % | 1.29 | 1.27 | 1.56 | 1.64 | 66.20 | 68.45 |
| | 0.4 % | 1.17 | 1.15 | 1.64 | 1.72 | 63.73 | 65.24 |
| **Mean** | | **1.20** | **1.18** | **1.59** | **1.67** | **64.31** | **66.23** |
| 100% | 0.0 % | 1.23 | 1.21 | 1.34 | 1.41 | 72.37 | 74.82 |
| | 0.1 % | 1.31 | 1.29 | 1.24 | 1.31 | 74.33 | 76.84 |
| | 0.2 % | 1.34 | 1.32 | 1.25 | 1.31 | 76.19 | 78.45 |
| | 0.4 % | 1.26 | 1.24 | 1.33 | 1.40 | 71.45 | 73.86 |
| **Mean** | | **1.28** | **1.26** | **1.29** | **1.35** | **73.58** | **75.99** |
| Mean (PAM) | 0.0 % | 1.01 | 0.99 | 1.94 | 2.04 | 52.54 | 54.04 |
| | 0.1 % | 1.10 | 1.08 | 1.87 | 1.96 | 55.40 | 56.86 |
| | 0.2 % | 1.14 | 1.12 | 1.86 | 1.96 | 56.93 | 58.28 |
| | 0.4 % | 1.05 | 1.03 | 1.96 | 2.06 | 53.08 | 54.39 |
| L.S.D. at 0.05 | **F.C.** | **0.01** | **0.01** | **0.01** | **0.01** | **2.10** | **3.09** |
| | **PAM** | **0.01** | **0.01** | **0.01** | **0.01** | **0.55** | **0.51** |
| | **F.C.×PAM** | **0.01** | **0.16** | **0.02** | **0.02** | **3.50** | **3.24** |

highest rate of carbohydrate content (76.19 and 78.45%) of the new gladiolus corms was found by adding the highest level of the available moisture (100 % of field capacity) combined with polyacrylamide at 0.2%, for both seasons respectively respectively. This result may be related to the effect of polyacrylamide at a proper concentration on improving the physical properties of the sandy soil and decreased the leached amount of organic and inorganic solutes, especially when the soil contains the suitable amount of the available moisture. Consequently producing vigorous plants with many large leaves, and as a result, a large amount of carbohydrates could be formed and translocated to the new corms.

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## تأثير الري والبولي أكريلميد على إنتاج نباتات الجلاديولس في الأراضي الرملية

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فرع بحوث الحدائق النباتية و* فرع بحوث نباتات الزينة بأنطونيادس – معهد بحوث البساتين–
مركز البحوث الزراعية – الاسكندرية – مصر

ملخص

أجرى هذا البحث فى مزرعة البحوث بأنطونيادس – معهد بحوث البساتين بالإسكندرية خلال عامي 2013/2012 و 2014/2013 علـى نباتـات الجلاديـولس صـنف "White Prosperity" المنـزرع فـي أصـص بلاسـتيك مقـاس 20 سـم مملوءة بتربة رملية بهدف دراسة خمسة مستويات من المحتوى المائي للتربـة: هـي 20%, 40 %, 60 %, 80 %, 100 % من السعة الحقلية للتربة الرملية وأربعة تركيزات من البولي أكريلميد هـي صـفر, 0.1 % , 0.2 %, 0.4 % منفرده أو فـي جميـع التباديـل الممكنـة بينهمـا لتعطـى 20 معاملـة وتأثيرهـا علـى بعـض صـفات النمـو الخضـري والزهـري والتحليـل الكيماوي لنباتات الجلاديولس النامية فى التربة الرملية.

أظهرت النتائج المتحصل عليها أن مستويات الري كانت أكثر فاعلية في التأثير علـى جميـع الصـفات المدروسـة لنبـات الجلاديولس بمقارنتها بتركيزات البولي أكريلميد. وعموما أعطي استخدام أعلـى مستوى مـن الرطوبـة الأرضـية ( 100 % سعة حقلية) في وجود محسن التربة عند تركيز 0.2 % أعطى أعلى زيادة معنوية في كل من أرتفـاع النبـات, عدد الأوراق, وزن الأزهار الجاف, عدد الأزهار, طـول الجـزء المزهـر مـن النـورة, قطـر الكورمـة, عـدد الكريمـات لكـل نبـات, محتـوى الكورمة من الكربوهيدرات وأقصر فترة للإزهار.

على الجانب الآخر فقد أعطى أعلى مستوى من الرطوبة الأرضية ( 100% من السعة الحقلية عند الرى ) منفردا أعلى قيم لكل من المساحة الورقية والوزن الطازج والجـاف لأوراق كـل نبـات, قطـر الزهيـرات ومـدة بقـاء الأزهـار علـى الحامـل الزهري, وزن الأزهار الجاف, محتوى الأوراق من الكلوروفيل الكلى وأقل محتوى من البرولين.

وعموما توصى النتائج المتحصل عليها برى نباتات الجلاديولس المنزرعة في الأرض الرملية شتاءا بمستوى رطوبى لا يقل عن 80 % من السعة الحقلية مع استخدام البولي أكريلميد بتركيز 0.2 % حيث يؤدى ذلك للحصول على معدلات جيدة للنمو الخضري والزهري تتمشى مع المواصفات العالمية وإنتاج الكورمات وكمية الكلوروفيل والبرولين والكربوهيدرات لنبتات الجلاديولس النامية في التربة الرملية.

**المجلة العلمية لكلية الزراعة – جامعة القاهرة – المجلد (65) العدد الثالث (يوليو 2014):283-294.**