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INFLUENCE OF POTASSIUM LEVELS ON GLADIOLUS CORMS PRODUCTION IN OPEN FIELD AND INTERCROPPING CONDITIONS

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Abstract

The influence of potassium levels on gladiolus corm (Gladiolus grandiflorus) production under two growing conditions were studied at Agriculture Research Institute, Mingora Swat. The two growing conditions (open field and intercropping) and potassium levels (0, 30, 60 and 90) were studied during the experiment. The experiment was planned in randomized complete block design having split plot arrangement with three replications. Light intensity and soil humidity were also recorded in both conditions. Data was recorded on various growth attributes, which showed that both growing conditions and potassium levels had significantly affected most of the attributes. The maximum sprouting percentage (93.7%), diameter of corms (5.3 cm), corms weight (69.9 g), number of cormels plant^{-1} (19.0) and survival percentage (88.8%) were recorded in open field, while maximum plant height (120.2 cm) was observed in intercropping. Moreover, maximum number of leaves plant^{-1} (6.5), plant height (120.4 cm), diameter of corms (4.3 cm), corms weight (47.9 g), number of cormels plant^{-1} (16.9) and survival percentage (88.8%) were recorded in plots applied with 90 kg potassium ha^{-1}. Hence, it was concluded that gladiolus could be grown in open field condition with application of potassium @ 90 kg ha^{-1} for better growth and production of corms under the agro-climatic conditions of Swat valley.

Key words: *Gladiolus, Growing conditions and Potassium levels.*

INTRODUCTION

Gladiolus (*Gladiolus grandiflorus*) belongs to family *iridaceae*. It is indigenous to South Africa, having around one hundred and fifty known species (Negi et al., 1982). Commonly, it is known as "Sword Lily", an ornamental cormelous flower (Memon, 2009). It is cultivated on a wide range of tropical to subtropical regions of the world. Commercially gladiolus is grown from its corms for the production of both spikes and corms. In each season daughter corms are produced by the mother corms (Memon et al. 2009). Gladiolus produce cormels once the flower spikes initiate and are produced at full bloom. The size of the produced cormels increased with the downward flow of photosynthates (Hartmann et al., 1981).

Light plays a vital role in plant growth, as it is an important factor of photosynthesis and without it plant cannot prepare their own food. Plants grown under the shed receive light in less amount, which may resultantly affect their growth (Imaizumi and Kay, 2006). Moreover, plants under the shed may have less photosynthetic activities and chlorophyll content, which may also result in less dry matter production (Rao and Mitra, 1998).

The quality of gladiolus flower is an important factor considered in the market. Hence, quality and production of the flowers is influenced by some factors such as corm size, fertilizer management and time of plantation (Arora and Khanna, 1990). Vegetative growth of a plant depends on the quantity and availability of essential nutrients in the soil. Potassium as an important nutrient, directly influences the growth, development and quality of gladiolus plant. Most soils are deficient in available potassium next to nitrogen and phosphorus, (Salisbury and Ross, 1992). Potassium has a major role in regulation of stomata and also maintains water balance in plant tissues. Furthermore, it assists the growth of meristematic tissue, involves in some enzymatic activities, responsible for metabolism of nitrogen, synthesis of proteins, used as catalyst for other reaction, accelerating metabolism of carbohydrate and works in translocation process (Bhandal and Malik, 1988).

Potassium as a catalyst plays a vital role in number of biosynthetic processes of photosynthesis. It also help plant to fight against many diseases. The quality of flower is affected in the absence of potassium even though if the plant is provided with adequate dose of nitrogenous fertilizer (Mukhopadhyay, 1995).

Pierson (1990) in a study recorded high tillers, leaves and biomass in plants grown under direct sunlight as compared to the plants under shade. Moreover, Zhao et al. (2012) recorded highest morphological attributes such as plant height and number of leaves in plants under direct sun light than the plants under shade. Ullah et al. (2016) found significant effect of potassium levels on the vegetative and reproductive attributes of gladiolus cultivars. The quality and yield of cotton plant were enhanced by application of potassium (Aneela et al., 2003).

Keeping in view the importance of light and potassium fertilization, this study was designed to evaluate the influence of growing condition and potassium levels on corm production of gladiolus.

MATERIALS AND METHOD

The influence of potassium levels on gladiolus corm production in open field and intercropping was evaluated at Agriculture Research Institute Mingora, Swat during the spring season 2014. An exotic gladiolus variety "Amsterdam" was used in the experiment. The corms were planted in two different growing conditions in March (2014) at open field and in peach orchard as intercropped while, various potassium levels were applied as another factor. Nitrogen and phosphorous were applied at constant dose (120+90 kg ha^{-1}) to all the treatments including control. Whereas, Urea was used as a source of nitrogen, SSP was taken as a source of phosphorus and SOP was used as a source of potassium. The field was thoroughly prepared and all the standard cultural practices were applied to the experimental field. The distance between row to row and plant to plant were kept 60 and 10 cm, respectively.

Experimental design: The experiment was conducted in the Horticulture Research area, Agricultural Research Institute (ARI), Mingora Swat. The experiment was laid out in randomized complete block design (RCBD) having split plot arrangement, replicated three times. The experiment was composed of 2 factors such as growing conditions and potassium levels. Two growing conditions (open field and intercropping) were allotted to main plots while four levels of potassium (control, 30, 60 and 90 Kg ha^{-1}) were kept in the sub plots. Randomly selected composite soil samples were taken from the site before the experiment and were analyzed in soil and fertility lab, ARI, Mingora Swat for various physico-chemical properties (Table 1). Various attributes were studied for all the replicated treatments and their mean values were finally recorded.

Procedure for data recording: All the data was recorded by adopting standard procedures. Soil moisture and light intensity were observed twice a day (Morning and afternoon) throughout the experiment and the data was recorded by Luster leaf rapitest soil moisture meter. Furthermore, sprouting percentage was determined from the number of sprouted cormels and total cormels planted by the following formula.

$$\text{Sprouting percentage} = \frac{\text{No. of cormels sprouted}}{\text{Total No. of cormels planted}} \times 100$$

Table-1: Physico-chemical analysis of soil

Parameters	Unit	Range	Mean	STD
pH		5.4-7.8	6.9	0.6
Lime	%	2.6-19.3	6.3	3.4
Organic Matter	%	1.2-3.4	2.2	0.6
P	$mgkg^{-1}$	Mehlic No.3 (6.6-39.8) AB-DTPA (40-153)	19.1	8.7
		Mehlic No.3 (6.6-39.8) AB-DTPA (40-153)	6.3	2.9
K	$mgkg^{-1}$	3.2-65.6	149.0	56.1
		26.4-78.4	88.6	29.4
Sand	%	6.4-26.8	30.7	13.8
Silt	%		59.2	12.9
Clay	%		9.9	3.1

The leaf area was measured in cm^2 by leaf area meter. Moreover, plant height was measured in cm using inch tape from soil surface to the apex of the plant. Diameter of corm was recorded in cm using digital vernier caliper. Corms weight was determined in g using electronic balance while, number of cormels $plant^{-1}$ were observed by counting the total number of cormels produced in randomly selected plants of each treatment. All the recorded data of each parameter was taken by randomly selecting 6 plants in each replication of each treatment.

Statistical procedure: The collected data was subjected to analysis of variance techniques, computed by Statistics 8.1 software and means of significant findings were further calculated according to LSD test ($P \leq 0.05$) (Steel and Torri, 1997).

Soil Physico-chemical properties: The mean pH range, lime content, organic matter, P, K and different soil separates along with textural classes are given in Table-1.

RESULTS AND DISCUSSION

Light intensity and Soil Moisture: The light intensity (166.94-foot candle) was significantly higher in open field than the light intensity (76.89-foot candle) recorded in intercropping condition. Whereas, soil moisture was maximum (284.38%) in intercropping as compared to soil moisture (218.25%) of open field (Table-1). The maximum light intensity in the open field and minimum in intercropping may be due to the fact that trees intercept different levels of light and light availability is completely affected by the shading effect of the trees around (Canham et al., 1994)). Similarly, shades create inactive photo synthetically light fall on soil surface (Fetcher et al., 1983; Turton & Duff, 1992). Soil moisture was higher in shaded area than in the open field and the same was also found by Tanga et al. (2014). The reason for this change was reduction in evapotranspiration and increase in relative humidity in the shaded area due to low light intensity (Kessler, 1992).

Table-2: Soil moisture and light intensity of growing conditions.

Month	Light Intensity		Soil Moisture	
	Open field	Intercropping	Open field	Intercropping
March	107.00	53.69	222	298
April	103.44	51.3772	230	316
May	104.53	51.8108	223	294
June	174.70	51.8108	234	300
July	212.23	94.89	219	274
August	203.63	91.45	210	280
September	182.40	82.95	207	256
October	247.62	109.04	201	257
Mean	**166.94**	**76.89**	**218.25**	**284.38**

Sprouting percentage: Sprouting percentage was considerably affected only by growing conditions. The sprouting percentage (93.7) of open field condition was relatively higher than the plants sown in intercropping condition (91.7) (Table-3). The maximum sprouting percentage recorded in open field might be due to the difference in growing conditions because gladiolus is a light loving plant. Light helps in production of optimum photosynthates and dry matter that are necessary for growth and development. These findings are supported by Hangarter, (1997) and Winslow, (1999). Sprouting percentage was decreased by unfavorable environmental condition such as low light (Hong et al., 1989). The rate and proportion of germination was higher in seeds sown under light than in darkness (Colbach, 2002). The germination of seeds either sown fresh or buried in soil for several months is speed up by light (Froud-Williams, 1981; Lonchamp et al., 1984).

Leaf area (cm^2): The growing conditions and potassium levels had significant effect on leaf area. However, their interaction was non-significant (Table-3). The maximum leaf area (71.4 cm^2) was found in plants of intercropping, while the minimum leaf area (61.3 cm^2) was observed at open field plants. The highest leaf area (69.3 cm^2) was recorded in plants treated with 90 kg potassium ha^{-1} in contrast to the lowest leaf area (62.6 cm2) of control treatment.

Leaf length increase with every consecutive increase in shade levels, as 50% shade produced significantly longer leaves than control (Kumar et al., 2013). Ramachandrudu and Thangam, (2009) found increase in leaf length and width in plants kept in shade than in open field which justify the current findings. The leaf size can be influenced by intensity of the light (Jeong et al., 2009; Vendrame et al., 2004). The plants under shade produce dry matter content in less amount as most of the food is allocated for production of shoots and have maximum leaf area (Grime, 1979). Pierson et al. (1990) found that plant exposed to full sunlight had lowest leaf area while plant grown under the shade of 60 and 90% had the highest leaf area.

Potassium plays a vital role in opening and closing of stomata for photosynthesis, which helps in cell growth and division, thus increases the area of leaf (Sober et al., 1981). The average leaf area was increased with the increasing levels of potassium application (Azizi, 1998; Asif et al., 2007).

Plant height (cm): Plant height was influenced by growing conditions and potassium levels. Whereas, the interaction was non-significant (Table-3). The plants grown under condition of intercropping had the maximum plant height (120.2 cm) as compared to the lowest plant height (113.5 cm) in open field. The application of 90 kg potassium ha^{-1} resulted with maximum plant height of 120.4 cm, followed by (118.4 cm) plant treated with 30 kg potassium ha^{-1} while the minimum plant height was noted in control treatment. The plants grown under the shade tends to gain height in search of light. In a study the plants kept under shade of 25% were recorded to have 70% taller than the plants under direct sunlight (Zervoudakis et al., 2012). Moreover, the plants under intensity of low light were noticed maximum height (Wang et al., 2009). Another study showed that plants were taller in shade than those grown under open field conditions (Kumar et al., 2013).

The increase in plant height recorded in current study might be due to the application of potassium because potassium is an important nutrient, which helps in translocation of carbohydrates and regulates various physiological and biochemical activities that are responsible for better growth of the plants (Marschner, 1995). The plant height was increased with the application of potassium (Hussain et al., 2014). Moreover, Uddin et al. (2013) in a study on rice found that plant height was enhanced by application of potassium.

Table-3: Sprouting percentage, leaf area and plant height as influenced by growing conditions and potassium application.

Growing conditions	Sprouting percentage	Leaf area (cm^2)	Plant height (cm)
Open field	93.7 a	61.3 b	113.5 b
Intercropping	91.7 b	71.4 a	120.2 a
LSD	1.1	8.21	4.56
Potassium (Kg ha^{-1})			
0	91.9 a	62.6 c	112.6 c
30	92.4 a	66.2 b	118.4 ab
60	92.8 a	67.3 ab	116.0 bc
90	93.8 a	69.3 a	120.4 a
LSD	NS	2.98	3.50
Interaction	NS	NS	NS

Diameter of Corms (mm): The two growing condition and application of potassium levels significantly varied the diameter of corms while the interaction was found non-significant (Table-4). The maximum diameter of corm (5.3 cm) was observed in plants grown in open field condition while the minimum corm diameter (2.7 cm) was noted in plant under intercropping condition. The highest level of potassium level (90 kg ha^{-1}) produced highest corm diameter (4.3 cm), followed by corm diameter (4.0 cm) produced by application of 60 kg ha^{-1}. Whereas, the least diameter of corm was found in control treatment. Light intensity is one of the important factors influencing the rate of photosynthesis. Photosynthesis helps in many plant processes such as metabolism and provides energy that fuels these processes, which are directly related with the plant’s ability to grow. Therefore, the maximum diameter observed in plants grown in open field of the current study might be due the more photosynthetic activity. As corms are the food storage organs of gladiolus, so the maximum food produced during the photosynthesis process in the presence of sun light have been stored in the corms that might have increased diameter of the corms.

Potassium plays an important role in corm size because potassium has a great role in the availability of other nutrients, water retention and makes roots strong. Therefore, the maximum diameter of corms was obtained in plants treated with 90 kg potassium ha-1 as compare to control. Similar findings were also observed by (Baloch et al., 1991; Sing and Verma, 2001; Bybordi and Makakouti, 2003) that bulb yield was increased by increasing the level of potassium application. The bulb diameter as well as bulb quality were significantly affected by additional dose of potassium application (Desuki et al., 2006).

Corm weight (g): The results showed that corms weight was significantly affected by growing conditions and potassium levels; the interaction among growing conditions and potassium levels was significant (Table-4).

The maximum corms weight (69.9 g) weight were recorded in plants of open field, whereas the minimum corms weight (19.9 g) were recorded in intercropping condition. The maximum corms weight (47.9 g) was taken with application of 90 kg potassium ha^{-1}, followed by (45.7 g) with 60 kg potassium ha^{-1}. The control treatment was recorded with minimum corms weight (42.2 g). The interaction between growing conditions and potassium levels showed that the greatest corms weight (72.3 g) was recorded in plants treated with 90 kg potassium ha^{-1} and planted at open field while the minimum corms weight (16.5 g) was observed in control treatment and planted in intercropping. The maximum corms weight in open field than intercropping might be the influence of light. As light is the major source of photosynthesis process, which help in improving growth and development of Gladiolus (Young, 2003). Ramachandrudu and Thangam, (2009) also mentioned that the corms weight was maximum in open field than the weight of corms in shade, which justifies the findings of present research.

Increase dose of potassium significantly improved the corms weight (Das, 1998). The bulb weight as well as bulb quality were significantly affected by potassium application (Desuki et al., 2006).

Number of cormels $plant^{-1}$: Number of cormels $plant^{-1}$ was significantly influenced by growing conditions and potassium levels, whereas the interaction between growing conditions and potassium levels was non-significant (Table-4). In case of growing conditions, the maximum number of cormels $plant^{-1}$ (19.0) were recorded in plants of open field while the minimum number of cormels $plant^{-1}$ (7.3) were observed at intercropping. The maximum number of cormels $plant^{-1}$ (16.9) was counted in plants applied with 90 kg potassium ha^{-1}, followed by (13.0) with 30 kg potassium ha^{-1}. The minimum number of cormels $plant^{-1}$ (10.6) were taken in control. Ramachandrudu and Thangam (2009) stated that gladiolus plant prefer sun light for better growth and development. Moreover, the results of his findings showed that maximum cormels $plant^{-1}$ were taken in plants grown in open field while minimum were recorded in plants under the shade. Potassium helps in the high number of cormels production. An increase in yield of cormels was observed with application of fertilizers, particularly with potassium (Misra and Singh, 1998). In addition, cormels $plant^{-1}$ was increased with the increase of potassium concentration (Singh et al., 1997; Barma et al., 1998). Number of researchers such as (Niwuzhang and Linx, 1997; Jiang et al., 1998; Sharma et al., 1992; Bybordi and Makakouti, 2003) reported that bulb yield was increased by increasing the level of potassium application.

Table-4: Diameter of corm, corms weight and number of corms $plant^{-1}$ as influenced by growing conditions and potassium application.

Growing conditions	Diameter of corm (cm)	Corms weight (g)	Number of caramels $plant^{-1}$
Open field	5.3 a	69.9 a	19.0 a
Intercropping	2.7 b	19.9 b	7.3 b
LSD	0.43	5.87	4.28
Potassium (Kg ha^{-1})			
0	3.8 c	42.2 d	10.6 b
30	3.9 bc	43.8 c	13.0 b
60	4.0 b	45.7 b	12.1 b
90	4.3 a	47.9 a	16.9 a
LSD	0.19	0.80	2.93
Interaction	NS	1.13	NS

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