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RESPONSE OF MARIGOLD CULTIVARS TO DIFFERENT HUMIC ACID LEVELS

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ABSTRACT

An experiment on "Response of marigold cultivars to humic acid levels" was performed at Ornamental Nursery, Department of Horticulture, The University of Agriculture Peshawar, during 2015. The experiment was designed as Randomized Complete Block Design (RCBD) with split plot arrangement and the treatments were replicated thrice. Seedlings of marigold cultivars were transplanted on 9th October 2015 at a distance of 30 cm (Plant to Plant) and 60 cm (Row to Row). The seedlings of marigold cultivars (Orange, Yellow, Golden and White) were tested against four different levels of humic acid (0, 2, 4 and 6 kg ha^{-1}). The experimental data were collected on days to flowering, number of flowers plant^{-1}, flower diameter, flower fresh weight, flower dry weight, flower vase life, number of leaves, leaf area, plant height and number of branches^{-1}. Humic acid levels significantly affected most of the growth parameters mentioned above. Best results were recorded on humic acid at the rate of 6 kg ha^{-1}for days to flowering (36 days), number of flowers plant^{-1} (30), flower diameter (9.1 cm), flower fresh weight (20.2 g), flower dry weight (1.8 g), flower vase life (13 days), number of leaves plant^{-1} (136.2), leaf area (14.3 cm^2), plant height (34.8 cm) and number of branches plant^{-1} (15.9) were. Among cultivars yellow cultivar showed maximum flower diameter (10.5 cm), flower fresh weight (18.6 g), flower dry weight (1.6 g), number of leaves plant^{-1} (131.4), plant height (35.0 cm) and number of branches plant^{-1} (14.0). Orange cultivar showed minimum days to flowering (36 days), maximum number of flowers plant^{-1} (31.3), flower vase life (14) and leaf area (16 cm^2). Humic acid levels and cultivars interaction was non-significant in all parameters. Marigold Cv. Yellow and Orange both performed well in the agro-climatic conditions of Peshawar valley. Humic acid level at the rate of 6 kg ha^{-1} proved superior in enhancing the growth of marigold and hence recommended for better production of marigold.

Key words: cultivars, humic acid, growth, levels of humic acids

INTRODUCTION

Marigold (*Tageteserecta* L.) a member of the family Compositae, originated from North America, and quickly becomes a commercial flower, and its demand is increasing in the subcontinent with every passing day (Asif *et al*., 2008).In South Asia there is great demand of marigold during religious festival, where they used to adorn statues and building. Marigold is

also used in ceremonies and weddings and loose flowers are sold for the purpose of making garlands (Malik *et al*., 1994).

Marigold flowers are used as cut flowers and are also grown for beautification in many landscapes because of its variable height and various colors of flowers. It is commonly used as a bedding plant, border plant and is ideal for newly planted shrubbery to provide desirable color and fill space. Marigold is ideal for rockeries, endings, hanging baskets, window boxes and pots (Malik *et al*., 1994 and Bosma *et al*., 2003).

From medicinal point of view both foliage and petals of flower are equally important (Malik *et al*., 1994). In yellow and orange flowers of marigold the important and active substances like lavonoids, carotenoids, essential oils and vitamin A are made and stored. Marigold plant is used to treat stomach and intestines diseases and the extraction from flowers is used to dye some types of foods and fats (Omidbeigi *et al*., 2005). Poultry industries mostly use marigold to improve quality xanthophyll contents of contents (Delgado-Vergas *et al*., 1998). The marigold flowers are natural source of xanthophyll which is use as natural additive for chicken feed which result in shiny egg yolks (Bosma *et al*., 2003).Orange shading blossoms of marigold contain more xanthophyll substance when contrasted with yellow shading blooms. The essential shade of xanthophyll is lutein and on account of this lutein orange shading marigold creates more blossoms when contrasted with different cultivars (Quackenbush and Miller 1972). This lutein, have additionally cancer prevention agent properties which is valuable in security against eye sicknesses (Vankar et al. 2009).Marigold is well known for its medical properties and the oil of marigold contains antioxidants contents (Pérez *et al*., 2006). Marigold is also used for fabrics dying commercially, where flower extracts produce colors on fabrics (Vankar *et al*., 2009).

MATERIALS AND METHODS

An experiment ‘‘Response of marigold cultivars to humic acid levels’’ was performed in autumn, 2015 at Ornamental Nursery of Horticulture Department, The University of Agriculture, Peshawar. The required seedlings were purchased from a registered nursery in Hayatabad Peshawar.

Experimental design

Randomized Complete Block Design (RCBD) with split plot arrangement was used for this research and treatments were replicated thrice. Seedlings of Marigold cultivars were transplanted on 9th October 2015 at a distance of 30 cm (Plant to Plant) and 60 cm (Row to Row). Humic acid levels (0, 2, 4 and 6 kg ha^{-1}) were subjected to main plots and marigold cultivars (Orange, Yellow, Golden and White) were applied to subplots. The field was split into twelve main plots and forty eight sub plots. Area of main plot was (2.1 m × 2.4 m). Humic acid was applied to the soil in solution form after irrigation. All cultural practices were done uniformly.

The materials used and the procedure followed was out-lined below.

Factor A (Humic acid) Main plot	**Factor B (Cultivars) Sub plot**
H_1: Control	C_1: Orange
H_2: 2 kg ha^{-1}	C_2: Yellow
H_3: 4 kg ha^{-1}	C_3: Golden
H_4: 6 kg ha^{-1}	C_4: White

Variables studied

The data were recorded on the following parameters.

1. Days to flowering
2. Number of flowers plant^{-1}
3. Flower diameter (cm)
4. Flower fresh weight (gm)
5. Flower dry weight (gm)
6. Flower vase life
7. Number of leaves plant^{-1}
8. Leaf area (cm^2)
9. Plant height (cm)
10. Number of branches plant^{-1}

RESULTS AND DISCUSSION

Data was collected on days to flowering, number of flowers plant^{-1}, flower diameter (cm), flower fresh weight (g), flower dry weight (g), flower vase life, number of leaves plant^{-1}, leaf area (cm2), plant height (cm) and number of branches plant^{-1}.
In Tables 1-10 results of all the above mentioned attributes are presented.

1. Days to flowering

Results regarding days to flowering of marigold cultivars as influenced by humic acid levels are shown in Table 1. Statistical analysis shows that humic acid levels and the difference between cultivars were found significant while their interaction was found non- significant.

Mean data in table showed that early flowering was noted with the application of 6 kg ha^{-1}humic acid (36 days), followed by 4 kg ha^{-1} humic acid (42 days) while delayed flowering was observed in control plots (55 days).

Among the cultivars minimum days to flowering were noticed in orange cultivar (36 days), followed by yellow cultivar (45 days) and maximum days to flowering were recorded in white cultivar (51 days) which is statistically similar with golden cultivar.

The results also showed that days to flowering were significantly decreased with increasing concentration of humic acid level, due to the fact that humic acid enhance photosynthesis, chlorophyll content and plant nutrient uptake. This is further supported by Memon *et al*. (2014) who revealed that humic acid application is inversely proportional to days to flowering. They observed this in Zinnia plants.

2. Number of flower plant^{-1}

Data recorded for number of flower plant^{-1} of marigold cultivars as influenced by humic acid levels are presented in below Table 2. Statistical analysis shows that humic acid levels and the difference among cultivars were found significant while the interaction was found non-significant.

These results confirmed that maximum number of flowers plant^{-1} was observed with the application of 6 kg ha^{-1}humic acid (30), which is statistically at par with the application of 4 kg ha^{-1}humic acid while the minimum number of flowers plant^{-1} was noted in untreated plots (21.1).

Among the cultivars, maximum number of flowers plant^{-1} was noticed in orange cultivar (31.3), followed by golden cultivar (28) while minimum number of flowers plant^{-1} was noted in white cultivar (18).

Number of flowers was increased with increasing humic acid. It is because of fact that humic acid has positive effect on nutrients absorption which ultimately increased the number of flowers. Similarly Azzaz *et al*. (2007) investigated that marigold gave 14.5 % more flowers at high rate of humic acid over the untreated marigolds.

3. Flower diameter (cm)

Data related to flower diameter of marigold cultivars as influenced by humic acid levels are shown in Table 3. Statistical analysis shows that humic acid levels and the difference between cultivar were found significant while the interaction was found non- significant.

Maximum flower diameter was recorded with the application of 6 kg ha^{-1} of humic acid (9.1 cm), followed by 4 kg ha^{-1}humic acid (6.3 cm) while minimum flower diameter was observed in control plots (3.6 cm) which is statistically related with the application of 4 kg ha^{-1}humic acid.

Among the cultivars maximum flowers diameter was recorded in yellow cultivar (10.5 cm), followed by orange cultivar (6.4 cm) and minimum flowers diameter was observed in white cultivar (2 cm).

The current findings show that flower diameter was significantly increased with humic acid levels. It is due to the fact that humic acid increased photosynthesis which in return give more food to the plant and ultimately increased flower diameter, these results are further justified by Memon*et al*. (2014) who revealed that humic acid application is directly proportional to flower diameter, in zinnia plant.

4. Flower fresh weight (g)

Data regarding fresh flower weight of marigold cultivars as influenced by humic acid levels are shown in Table 4. Statistical analysis shows that humic acid levels and cultivars significantly affected fresh flower weight while the interaction between humic acid levels and cultivars was found non- significant.

Mean values in the table indicated that maximum flower fresh weight was noted with the application of 6 kg ha^{-1}humic acid (20.6 g), followed by 4 kg ha^{-1}humic acid (16 g) while minimum flower fresh weight was noted in untreated plots (9.3 g).

Maximum flowers fresh weight was noticed in yellow cultivar (18.6 g), followed by orange cultivar (15.6 g) and minimum flowers fresh weight was observed in white cultivar (11.6 g) which is statistically similar with golden cultivar.

Flower fresh weight was significantly increased by humic acid it might be due to the reason that humic acid improved nutrient uptake which ultimately increased growth and yield. The present findings are justified by Ali *et al*. (2014) who revealed that increment in fresh weight increased with higher concentration of humic acid, and stated that humic acid have apparently a vital role in the fresh weight of tulip.

The current results are also in line with Tina *et al*. (2015) who evaluated the effect of foliar application of humic acid on quantitative and qualitative yield of marigold and stated that the

highest and lowest amount of fresh flower yield were obtained at the rate of 500 mg L^{-1} humic acid and control treatments respectively.

5. Flower dry weight (g)

The results of flower dry weight of marigold cultivars as influenced by humic acid levels are shown in Table 5. Statistical analysis shows that humic acid levels and the difference between cultivars were found significant while the interaction of factors remains non-significant.

Data in the table showed that maximum flower dry weight was noted with the application of 6 kg ha^{-1}humic acid (1.8 g), followed by 4 kg ha^{-1} humic acid (1.3 g) while minimum flower dry weight was recorded in control plots (0.6g) which is statistically similar with the influence of2 kg ha^{-1} humic acid.

Among cultivars maximum flowers dry weight was noticed in yellow cultivar (1.6 g), followed by orange cultivar (1.2 g) and minimum flowers dry weight was observed in white cultivar (0.8 g). The increase in flower dry weight with the application of humic acid could be the humic acid improved nutrient uptake which ultimately increased yield. Azzaz *et al.* (2007) also revealed that the dry weight of marigold flowers was increased with high rate of humic acid over untreated plants.

6. Flower vase life

Data on flower vase life of marigold cultivars as influenced by humic acid levels are shown in Table 6. Statistical analysis shows that humic acid levels and the difference between cultivar was found significant while the interaction between humic acid levels and cultivars was found non- significant.

Maximum flower vase life was recorded with the application of 6 kg ha^{-1} humic acid (13days) which is statistically similar with the application of 4 kg ha^{-1} humic acid, while minimum flower vase life was obtained in control plots (8days).

Among cultivars maximum vase life of marigold flower was noticed in orange cultivar (14 days), followed by yellow cultivar (11 days) and minimum flower vase life was noted in white cultivar (8 days).

Humic acid increased vase life of flower, it might be due to application of humic acid, which reduced ethylene synthesis. Our results are justified by Yazdani *et al.* (2014), who stated that humic acid prolonged vase life of gerbera flowers and claimed that humic acid has preservative role in the vase life and also in reduction of ethylene production.

7. Number of leaves $plant^{-1}$

Data pertaining to number of leaves $plant^{-1}$ of marigold cultivars as influenced by humic acid levels are indicated in Table 7. Statistical analysis shows that humic acid levels and the difference between cultivars were found significant while the interaction was found non-significant.

Results showed that maximum number of leaves $plant^{-1}$was observed with the application of 6 kg ha^{-1}humic acid (136.2) which is statistically same with the influence of4 kg ha^{-1}humic acid while minimum number of leaves $plant^{-1}$ was observed in control plots (104.4).

As for as cultivars are concerned maximum number of leaves plant^{-1} was noticed in yellow cultivar (131.4), followed by orange cultivar (123) and minimum number of leaves plant^{-1}was observed in white cultivar (112.2).

The obtained results might be due the phenomena humic acid has positive effect and it also has hormone-like activity on vegetative growth. these results were also shared by Kamari *et al.* (2010) who revealed that high concentrations of humic acid increased the number of leaves plant^{-1}in marigold as compared to control which could be due to positive mineral effect and also hormone like activity of humic acid on vegetative growth.

8. Leaf area (cm^2)

The results noted for leaf area of marigold cultivars as influenced by humic acid levels are presented in Table 8. Statistical analysis shows that humic acid levels and the difference between cultivar were found significant while the interaction between humic acid levels and cultivars was found non- significant.

Results shows that highest leaf area was observed with the application of 6 kg ha^{-1}humic acid (14.8 cm^2), followed by 4 kg ha^{-1} humic acid (11.7 cm^2) while the lowest leaf area was observed in control plots (8.5 cm^2).

Among cultivars highest leaf area was observed in orange cultivar (16 cm^2), followed by yellow cultivar (12 cm^2) and minimum leaf area of marigold was noted in white cultivar (7.9 cm^2) which is statistically same with golden cultivar.

The current results shows that leaf area was significantly enhanced with increasing concentration of humic acid, it is because of the fact that availability of humic acid for longer periods is responsible for increasing photosynthetic activity, which in return increased leaf area. Ahmad *et al*. (2013) also obtained the same results who investigated that gladiolus plants receiving 7000 ml ha^{-1} humic acid produced the greatest leaf area while those without humic acid application produced lowest leaf area.

9. Plant height (cm)

Data related to plant height of marigold cultivars as influenced by humic acid levels are indicated in Table 9. Statistical analysis shows that humic acid levels and the difference between cultivar were found significant while the interaction was found non- significant.

More plant height was gained with the application of 6 kg ha^{-1} humic acid (34.8 cm), followed by 4 kg ha^{-1} humic acid (31.5 cm) while lowest plant height was observed in control plots, where no humic acid was applied (24.5 cm).

Among cultivars more plant height was noticed in yellow cultivar (35 cm) which is statistically at par with orange cultivar and lowest plant height was noticed in white cultivar (24.2 cm).

Highest plant height could be due to the reason that humic acid increases media moisture storage and enhanced nutrient absorption. These findings are realized by Memon *et al*. (2014) who revealed that humic acid application on zinnia plant is directly proportional to plant height.

10. Number of branches plant^{-1}

Data recorded for number of branches plant^{-1} for marigold cultivars as influenced by humic acid levels are indicated in Table 10. Statistical analysis shows that humic acid levels and the difference between cultivar was found significant while the interaction was found non-significant.

Highest number of branches plant^{-1} was noted in plants treated with6kg ha^{-1}humic acid (15.9), followed by 4kg ha^{-1}humic acid (13.1) while the lowest number of branches plant^{-1}was observed in control plots (9.5) which is statistically similar with the application of 2 kg ha^{-1} humic acid.

Among cultivars maximum number of branches plant^{-1} was noticed in yellow cultivar (14) which is statistically similar with golden cultivar and minimum number of branches plant^{-1}was observed in white cultivar (7.9).

The current findings indicated that humic acid had positive affect on number of branches plant^{-1}this might be due to the fact that humic acid increases absorption of nutrients which in return affects shoot yield. These findings are in line with Azzaz *et al.* (2007) who also found the highest number of branches plant^{-1} in marigold due to the addition of high rate of humic acid.

Table 1. Days to flowering of marigold cultivars as affected by humic acid levels.

	Humic acid (kg ha^{-1})				
Cultivar	0	2	4	6	**Mean**
Orange	43	36	36	28	**36 c**
Yellow	55	49	40	35	**45 b**
Golden	63	55	47	39	**51 a**
White	60	59	46	41	**51 a**
Mean	**55 a**	**50 b**	**42 c**	**36 d**	

LSD for Humic Acid at 5% level of probability = 4.94
LSD for Cultivar at 5% level of probability = 4.80
Means followed by the same letter(s) are not significantly different from one another at 5 % level of probability.

Table 2. Number of flower of marigold cultivars as affected by humic acid levels.

	Humic acid (kg ha^{-1})				
Cultivar	0	2	4	6	**Mean**
Orange	25.4	31.1	32.2	36.3	**31.3 a**
Yellow	23	26	30.7	32.4	**28 b**
Golden	23.8	24.7	30.3	30.3	**27.3 b**
White	12	15.3	23.7	21	**18 b**
Mean	**21.1 c**	**24.3 b**	**29.2 a**	**30 a**	

LSD for Humic Acid at 5% level of probability = 2.59
LSD for Cultivar at 5% level of probability = 3.01
Means followed by the same letter(s) are not significantly different from one another at 5 % level of probability.

Table 3. Flower diameter (cm) of marigold cultivars as affected by humic acid levels.

	Humic acid (kg ha^{-1})				
Cultivar	0	2	4	6	**Mean**
Orange	3.9	3.3	8.1	10.1	**6.4 b**
Yellow	8	7.3	11.4	15.2	**10.5 a**
Golden	1.7	3.4	4.7	6.3	**4 c**
White	0.6	1.8	1	4.7	**2 d**
Mean	**3.6 c**	**4 c**	**6.3 b**	**9.1 a**	

LSD for Humic Acid at 5% level of probability = 2.01
LSD for Cultivar at 5% level of probability = 1.52
Means followed by the same letter(s) are not significantly different from one another at 5 % level of probability.

Table 4. Flower fresh weight (g) of marigold cultivars as affected by humic acid levels.

	Humic acid (kg ha^{-1})				
Cultivar	0	2	4	6	**Mean**
Orange	10.5	14.1	17.1	20.8	**15.6 b**
Yellow	12.4	16.6	19.2	26.2	**18.6 a**
Golden	8.8	10.7	13.3	16.7	**12.4 c**
White	5.6	9.4	14.4	17	**11.6 c**
Mean	**9.3 d**	**12.7 c**	**16 b**	**20.2 a**	

LSD for Humic Acid at 5% level of probability = 1.64
LSD for Cultivar at 5% level of probability = 2.72
Means followed by the same letter(s) are not significantly different from one another at 5 % level of probability.

Table 5. Flower dry weight (g) of marigold cultivars as affected by humic acid levels.

	Humic acid (kg ha^{-1})				
Cultivar	0	2	4	6	**Mean**
Orange	0.7	1.0	1.3	1.8	**1.2 b**
Yellow	0.9	1.1	1.7	2.5	**1.6 a**
Golden	0.5	0.6	1.0	1.5	**0.9 bc**
White	0.4	0.5	1.0	1.4	**0.8 c**
Mean	**0.6 c**	**0.8 c**	**1.3 b**	**1.8 a**	

LSD for Humic Acid at 5% level of probability = 0.42
LSD for Cultivar at 5% level of probability = 0.31
Means followed by the same letter(s) are not significantly different from one another at 5 % level of probability.

Table 6. Flower vase life (days) of marigold cultivars as affected by humic acid levels.

	Humic acid (kg ha^{-1})				
Cultivar	0	2	4	6	**Mean**
Orange	10.1	13.2	16.5	17.2	**14.3 a**
Yellow	7.4	9.3	13.2	14.2	**11 b**
Golden	7.8	10.8	12.1	12.8	**10.9 b**
White	5.7	8	8.8	9.4	**8.0 c**
Mean	0	2	4	6	

LSD for Humic Acid at 5% level of probability = 1.58
LSD for Cultivar at 5% level of probability = 1.47
Means followed by the same letter(s) are not significantly different from one another at 5 % level of probability.

Table 7. Number of leaves of marigold cultivars as affected by humic acid levels.

	Humic acid (kg ha^{-1})				
Cultivar	0	2	4	6	**Mean**
Orange	105.6	123.1	127.7	135.6	**123.0 b**
Yellow	114.6	126.6	139.9	144.3	**131.4 a**
Golden	103.6	118	129.7	134.6	**121.5 ab**
White	92.9	104.8	120.8	130.2	**112.2 c**
Mean	**104.2 c**	**118.1 b**	**129.5 a**	**136.2 a**	

LSD for Humic Acid at 5% level of probability =8.38
LSD for Cultivar at 5% level of probability = 9.20
Means followed by the same letter(s) are not significantly different from one another at 5 % level of probability.

Table 8. Leaf area (cm^2) of marigold cultivars as affected by humic acid levels.

	Humic acid (kg ha^{-1})				
Cultivar	0	2	4	6	**Mean**
Orange	13	14.3	16.4	20.2	**16 a**
Yellow	8.5	10.3	13.1	16.1	**12 b**
Golden	6.7	8.4	9.4	11.3	**9 c**
White	5.6	6.4	8	11.4	**7.9 c**
Mean	**8.5 d**	**9.9 c**	**11.7 b**	**14.8 a**	

LSD for Humic Acid at 5% level of probability = 1.34
LSD for Cultivar at 5% level of probability = 1.37
Means followed by the same letter(s) are not significantly different from one another at 5 % level of probability.

Table 9. Plant height (cm) of marigold cultivars as affected by humic acid levels.

	Humic acid (kg ha^{-1})				
Cultivar	0	2	4	6	**Mean**
Orange	26.9	30.5	32.8	37.8	**32 a**
Yellow	29	31.5	37.6	42.0	**35 a**
Golden	21.7	27.2	30.2	31.3	**27.6 b**
White	20.3	23.1	25.3	27.9	**24.2 c**
Mean	**24.5 d**	**28.1 c**	**31.5 b**	**34.8 a**	

LSD for Humic Acid at 5% level of probability = 0.98
LSD for Cultivar at 5% level of probability = 3.14
Means followed by the same letter(s) are not significantly different from one another at 5 % level of probability.

Table 10. Number of branches of marigold cultivars as affected by humic acid levels.

	Humic acid (kg ha^{-1})				
Cultivar	0	2	4	6	**Mean**
Orange	9.2	9.2	12.0	15.0	**11.4 b**
Yellow	10.9	12.2	15.1	17.9	**14 a**
Golden	11.2	12.3	14.9	16.4	**13.7 a**
White	6.5	7.8	10.2	14.3	**9.7 c**
Mean	**9.5 c**	**10.4 c**	**13.1 b**	**15.9 a**	

LSD for Humic Acid at 5% level of probability = 2.08

LSD for Cultivar at 5% level of probability = 1.31

Means followed by the same letter(s) are not significantly different from one another at 5 % level of probability.

CONCLUSION AND RECOMMENDATIONS

On the basis of current experiment the following conclusion has been drawn:

- Humic acid application at the rate of 6 kg ha^{-1} was found significant for days to flowering, number of flowers plant^{-1}, flower diameter, flower fresh weight, flower dry weight, flower vase life, number of leaves, leaf area, plant height and number of branches^{-1}while poor results were obtained in control plots.
- Yellow and Orange cultivars responded well to humic acid levels, as compared to other studied cultivars.
- Both Yellow and Orange cultivars are recommended for better production under the agro-climatic conditions of Peshawar.

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