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Effect of paclobutrazol, cycocel and time of application on biomass accumulation of African marigold

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Abstract
The present experiment entiled "Effect of paclobutrazol, cycocel and Time of application on biomass accumulation of African Marigold" was studied at the Horticulture Research cum Instructional Farm, Department of Floriculture and Landscaping, College of Agriculture, IGKV, Raipur (C.G.) during *rabi* season of the year 2018-19 and 2019-20. The experiment was conducted in Factorial Randomized Block Design (FRBD) with three replications having twenty one treatment combinations of two plant growth retardants with three doses each *i.e.* Paclobutrazol (PBZ) @ 50, 100 and 150 ppm and Cycocel (CCC) @ 500, 750 and 1000 ppm along with water spray (control) as factor A and three time of application viz. 30 DAT, 45 DAT and 30 and 45 DAT as factor B. The results indicated that the biomass parameters (*like,* fresh weight of shoot, dry weight of shoot, fresh weight of root and dry weight of root) recorded significantly best with treatment G_6: cycocel (CCC) @ 1000 ppm during both the years (2018-19 and 2019-20) and on mean basis. The result revealed that among the time of application of paclobutrazol, cycocel, treatment D_1: application at 30 DAT registered significantly superior for biomass parameters (*i.e.* fresh weight of shoot, dry weight of shoot, fresh weight of root and dry weight of root) during both the years (2018-19 and 2019-20) and on mean basis as compare to rest of the other treatments.

Keywords: Biomass accumulation, cycocel, marigold, paclobutrazol

1. Introduction

African marigold (*Tagetes erecta* L.) is an economically important ornamental crop widely cultivated for loose flowers, garlands, landscaping and commercial floriculture (Sahu *et al.,* 2021) [1]. Its growth, flowering and overall plant architecture are influenced by genetic, environmental and hormonal factors. Biomass accumulation is an important indicator of plant growth and physiological performance, reflecting the allocation of assimilates between vegetative organs, particularly shoots and roots. Optimum plant growth and biomass distribution are essential for maintaining plant vigour, structural stability and ornamental quality. Excessive vegetative growth, however, may affect plant architecture and reduce suitability for particular production systems. Plant growth retardants, particularly paclobutrazol and cycocel (chlormequat chloride), offer potential for regulating vegetative development through the inhibition of gibberellin biosynthesis, thereby modifying shoot elongation and plant growth patterns (Sahu *et al.*, 2023) [2]. The effectiveness of these compounds depends on their concentration, application method and timing of application. Biomass-related parameters, including fresh weight of shoot, dry weight of shoot, fresh weight of root, dry weight of root, root shoot ratio on fresh weight basis and root shoot ratio on dry weight basis, provide useful indicators of plant growth and assimilate partitioning. Understanding these responses can help determine suitable growth-regulation practices. Therefore, the present investigation was undertaken to evaluate the effects of paclobutrazol, cycocel and time of application on biomass accumulation in African marigold.

2. Materials and Methods

Field experiment was conducted during *rabi* season 2018-19 and 2019-20 at Horticultural Research cum Instructional Farm, Department of Floriculture and Landscape Architecture, CoA, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The experiment was conducted in Factorial Randomized Block Design (FRBD) with three replications having twenty one treatment combinations of two plant growth retardants with three doses each *i.e.* Paclobutrazol (PBZ) @ 50, 100 and 150 ppm and Cycocel (CCC) @ 500, 750 and 1000 ppm along with water spray (control) as factor A and three time of application *viz*. 30 DAT, 45 DAT and 30 and 45 DAT as factor B.

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3. Results

Fresh weight of shoot (g)

Marked differences were noticed among paclobutrazol and cycocel treatments on maximum fresh weight of shoot**.** The perusal of data clearly indicates that significantly maximum fresh weight of shoot (203.79, 194.17 and 198.98 g) per plant was registered with treatment G_6: CCC 1000 ppm during both the years as well as on mean basis, respectively. Whereas, the minimum fresh weight of shoot (152.30, 145.40 and 148.85 g) per plant was observed with treatment G_0: water spray during both the years as well as on mean basis, respectively. The data on maximum fresh weight of shoot as significantly influenced by time of application of paclobutrazol and cycocel. The significantly maximum fresh weight of shoot (184.97, 171.67 and 178.32 g) per plant was obtained under treatment D_1: application at 30 DAT, during both the years as well as on mean basis. While, the minimum fresh weight of shoot (169.47, 157.97 and 163.72 g) per plant was observed with treatment D_2: application at 45 DAT during both the years as well as on mean basis, respectively. The interaction effects between plant growth retardants and their time of application was found non-significant with regards to fresh weight of shoot of African marigold during both the years and on mean basis.

Dry weight of shoot (g)

The significantly maximum dry weight of shoot (101.69, 93.29 and 97.49 g) per plant was recorded with treatment G_6: CCC 1000 ppm, during both the years as well as on mean basis, respectively. However, the lowest dry weight of shoot (86.43, 69.36 and 77.90 g) per plant was noted with treatment G_0: water spray during both the years as well as on mean basis, respectively. As regards to time of application of growth retardants, treatment D_1: application at 30 DAT show significantly higher dry weight of shoot (96.01, 83.24 and 89.62 g) per plant as compared to rest of the treatment. The minimum dry weight of shoot (90.36, 75.62 and 82.99 g) per plant was noted with treatment D_2: application at 45 DAT during both the years as well as on mean basis, respectively. The interaction effects between plant growth retardants and their time of application was found non-significant with regards to dry weight of shoot of African marigold during both the years and on mean basis.

Fresh weight of root (g)

Among the treatments of plant growth retardants (paclobutrazol, cycocel), treatment G_6: CCC 1000 ppm noted significantly maximum fresh weight of root (61.10, 63.67 and 62.38 g) per plant during both the years and on mean basis, respectively. One the other hand, the minimum fresh weight of root (40.99, 41.86 and 41.43 g) was registered under treatment G_0: water spray during both the years and on mean basis, respectively. On the perusal of data it is clear that fresh weight of root was significantly influenced by different time of application of plant growth retardants (paclobutrazol, cycocel), on African marigold. The highest fresh weight of root (54.73, 54.61 and 54.67 g) was recorded with the treatment D_1: application at 30 DAT, during both the years as well as on mean basis, respectively. Whereas, minimum fresh weight of root (47.64, 48.43 and 48.03 g) per plant was noted under treatment D_2: application at 45 DAT, during both the years as well as on mean basis, respectively. The interaction effects between plant growth retardants (paclobutrazol, cycocel) and their time of application was found non-significant with regards to fresh weight of root of African marigold during both the years and on mean basis.

Dry weight of root (g)

Among different treatments of plant growth retardants (paclobutrazol, cycocel), treatment G_6: CCC 1000 ppm noted significantly higher dry weight of root (25.51, 25.01 and 25.26 g) per plant as compared to rest of the treatments. Whereas, treatment G_0: water spray recorded minimum dry weight of root (17.97, 16.40 and 17.19 g) per plant during both the years and on mean basis, respectively. The significantly maximum dry weight of root (22.85, 24.43 and 22.64 g) per plant was noted with treatment D_1: application at 30 DAT, during both the years and on mean basis, respectively. However, treatment D_2: application at 45 DAT gave minimum dry weight of root (19.49, 18.83 and 19.16 g) per plant during both the years as well as on mean basis, respectively. The interaction effects between plant growth retardants and their time of application was found non-significant with regards to dry weight of root of African marigold during both the years and on mean basis.

Root shoot ratio on fresh weight basis

Different treatments of plant growth retardant (paclobutrazol, cycocel) failed to show significant influence on root shoot ratio on fresh weight basis of African marigold during both the years as well as on mean basis. However, maximum root shoot ratio on fresh weight basis (0.300, 0.328 and 0.314) per plant was noted with treatment G_6: CCC 1000 ppm and minimum root shoot ratio on fresh weight basis (0.269, 0.289 and 0.279) was recorded with treatment G_0: water spray during the both the years and on mean basis, respectively. In case of different application time of growth retardants (paclobutrazol, cycocel) show non-significant impact on root shoot ratio on fresh weight basis during both the years as well as on mean basis. The maximum root shoot ratio on fresh basis (0.024, 0.317 and 0.306) was recorded in treatment D_1: application at 30 DAT. However, treatment D_2: application at 45 DAT, show minimum root shoot ratio on fresh basis (0.281, 0.307 and 0.294) during both the years as well as on mean basis, respectively. The interaction effects between plant growth retardants and their time of application was found non-significant with regards to shoot ratio on fresh basis of African marigold during both the years and on mean basis.

Root shoot ratio on dry weight basis

Different treatments of plant growth retardant (paclobutrazol, cycocel) failed to show significant influence on root shoot ratio on dry basis of African marigold during both the years as well as on mean basis. However, maximum root shoot ratio on dry weight basis (0.252, 0.268 and 0.260) was noted with treatment G_6: CCC 1000 ppm and minimum root shoot ratio on dry basis (0.209, 0.237 and 0.223) was recorded with treatment G_0: water spray during the both the years and on mean basis, respectively. Different application time of growth retardants show non-significant impact on root shoot ratio on dry basis during both the years as well as on mean basis. Maximum root shoot ratio on dry weight basis (0.237, 0.269 and 0.253) was recorded in treatment D_1: application at 30 DAT. However, treatment D_2: application at 45 DAT show minimum root shoot ratio on dry basis (0.216, 0.250 and 0.233) during both the years as well as on mean basis, respectively. The interaction effects between plant growth retardants (paclobutrazol, cycocel) and their time of application was found non-significant with regards to shoot ratio on dry weight basis of African marigold during both the years and on mean basis.

4. Discussion of biomass parameters

Effect of paclobutrazol and cycocel

Maximum fresh and dry weight of shoot and root was significantly influenced by plant growth retardants (paclobutrazol, cycocel), during the period of experiment. An increase in fresh and dry weight of shoot and root might be due to cycocel play a vital role in the inhibition of cell division and elongation of the apical meristem. Thus, reduction in plant height and increase in root and shoot on fresh and dry weight basis with application of plant growth retardants These results are in agreement with the finding of Bora *et al.* (2004) [3] in soybean.

Effect of time of application

The maximum biomass yield (fresh and dry weight of shoot, fresh and dry weight of root, was recorded with the application of cycocel (CCC) at 1000 ppm at 30 DAT. This may be due to probably early application (30 DAT) of plant growth retardants (paclobutrazol, cycocel) quickly arrested the activity of gibberellic acid in plant cells by interfering with the oxidative steps of gibberellin precursor ent-kauren to

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production of carbohydrates might have been utilized to increase the number of branches, number of leaves, plant spread, leaf area, numbers of flowers and increase the size of root system (number, thickness, fresh and dry weights) of marigold plants. The results of this experimental findings are in accordance with the findings of Bora *et al.* (2004) [3] in soybean, Youssef *et al.* (2013) [4] in *Tabernaemontana coronaria,* Sardoei *et al*. (2014) in *Cannabis Sativa,* Ghatas (2016) in Chrysanthemum, L, and Atteya *et al.* (2018) [5] in *Tagetes patula* Khobragade *et al.* (2019) [6] in African marigold.

Table 1. Effect of paclobutrazol, cycocel and time of application on fresh weight of shoot, dry weight of shoot and fresh weight of root of African marigold

Treatment	Fresh weight of shoot (g)			Dry weight of shoot (g)			Fresh weight of root (g)		
	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean
Paclobutrazol, Cycocel (G)									
G_1	162.08	159.02	160.55	90.92	76.34	83.63	46.43	48.73	47.58
G_2	185.21	169.36	177.28	93.79	80.12	86.95	53.67	53.78	53.72
G_3	193.12	172.08	182.60	95.60	88.56	92.08	57.10	54.07	55.58
G_4	177.33	157.27	167.30	88.96	74.21	81.58	50.22	48.42	49.32
G_5	178.09	161.80	169.94	94.66	78.29	86.48	51.90	52.14	52.02
G_6	203.79	194.17	198.98	101.69	93.29	97.49	61.10	63.67	62.38
G_0	152.30	145.40	148.85	86.43	69.36	77.90	40.99	41.86	41.43
SEm±	4.70	4.25	3.69	2.38	2.53	1.99	1.94	1.84	1.32
CD ($P = 0.05$)	13.44	12.14	10.54	6.82	7.24	5.68	5.55	5.25	3.77
Time of application (D)									
D_1	184.97	171.67	178.32	96.01	83.24	89.62	54.73	54.61	54.67
D_2	169.47	157.97	163.72	90.36	75.62	82.99	47.64	48.43	48.03
D_3	182.10	167.11	174.61	93.08	81.21	87.15	52.52	52.39	52.46
SEm±	3.08	2.78	2.41	1.56	1.66	1.30	1.27	1.20	0.86
CD ($P = 0.05$)	8.80	7.95	6.90	4.46	4.74	3.72	3.64	3.43	2.47
Interaction									
G_1D_1	170.57	164.00	167.28	93.50	80.80	87.15	49.91	52.67	51.29
G_1D_2	158.00	149.72	153.86	87.40	72.80	80.10	43.71	43.89	43.80
G_1D_3	157.67	163.33	160.50	91.87	75.43	83.65	45.66	49.63	47.64
G_2D_1	197.22	174.48	185.85	95.87	81.23	88.55	58.67	57.29	57.98
G_2D_2	160.17	159.77	159.97	92.50	76.64	84.57	44.65	49.95	47.30
G_2D_3	198.23	173.83	186.03	93.00	82.48	87.74	57.69	54.10	55.89
G_3D_1	197.50	179.94	188.72	100.57	93.37	96.97	59.22	56.96	58.09
G_3D_2	189.67	160.53	175.10	90.77	84.83	87.80	53.93	49.75	51.84
G_3D_3	192.21	175.76	183.99	95.47	87.47	91.47	58.14	55.50	56.82
G_4D_1	184.67	167.07	175.87	90.73	71.00	80.87	54.55	52.44	53.50
G_4D_2	166.00	150.33	158.17	87.03	75.83	81.43	46.28	45.06	45.67
G_4D_3	181.33	154.42	167.88	89.10	75.78	82.44	49.82	47.77	48.79
G_5D_1	179.70	168.33	174.02	96.43	82.27	89.35	54.33	54.17	54.25
G_5D_2	170.73	152.07	161.40	95.40	72.20	83.80	48.21	48.57	48.39
G_5D_3	183.83	164.99	174.41	92.13	80.42	86.28	53.17	53.70	53.43
G_6D_1	207.77	202.52	205.15	108.50	103.13	105.82	64.53	67.48	66.01
G_6D_2	196.60	187.67	192.13	93.23	80.41	86.82	56.89	59.38	58.14
G_6D_3	207.00	192.33	199.67	103.33	96.33	99.83	61.88	64.13	63.01
G_0D_1	157.37	145.33	151.35	86.47	70.87	78.67	41.88	41.27	41.57
G_0D_2	145.13	145.73	145.43	86.17	66.65	76.41	39.78	42.41	41.10
G_0D_3	154.40	145.13	149.77	86.67	70.57	78.62	41.33	41.89	41.61
SEm±	8.15	7.36	6.39	4.13	4.39	3.44	3.37	3.18	2.24
CD ($P = 0.05$)	NS	NS	NS	NS	NS	NS	NS	NS	NS

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Table 2. Effect of paclobutrazol, cycocel and time of application on dry weight of root, Root: shoot ratio on fresh weight basis and Root: shoot ratio on dry weight basis of African marigold

Treatment	Dry weight of root (g)			Root: shoot ratio on fresh weight basis			Root: shoot ratio on dry weight basis		
	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean
Paclobutrazol, Cycocel (G)									
G_1	20.09	19.32	19.71	0.287	0.306	0.297	0.221	0.253	0.237
G_2	20.77	20.82	20.79	0.289	0.317	0.303	0.222	0.260	0.241
G_3	23.63	22.79	23.21	0.296	0.315	0.306	0.247	0.259	0.253
G_4	19.04	18.87	18.96	0.284	0.310	0.297	0.214	0.256	0.235
G_5	21.57	21.47	21.52	0.292	0.322	0.307	0.229	0.276	0.252
G_6	25.51	25.01	25.26	0.300	0.328	0.314	0.252	0.268	0.260
G_0	17.97	16.40	17.19	0.269	0.289	0.279	0.209	0.237	0.223
SEm±	0.94	0.83	0.74	0.011	0.011	0.007	0.011	0.011	0.009
CD ($P = 0.05$)	2.67	2.37	2.12	NS	NS	NS	NS	NS	NS
Time of application (D)									
D_1	22.85	22.43	22.64	0.296	0.317	0.306	0.237	0.269	0.253
D_2	19.49	18.83	19.16	0.281	0.307	0.294	0.216	0.250	0.233
D_3	21.34	20.75	21.04	0.288	0.313	0.301	0.230	0.256	0.243
SEm±	0.61	0.54	0.48	0.007	0.007	0.005	0.007	0.007	0.006
CD ($P = 0.05$)	1.75	1.55	1.39	NS	NS	NS	NS	NS	NS
Interaction									
G_1D_1	21.10	21.17	21.13	0.295	0.321	0.308	0.227	0.261	0.244
G_1D_2	19.07	18.37	18.72	0.277	0.293	0.285	0.218	0.253	0.236
G_1D_3	20.10	18.44	19.27	0.290	0.304	0.297	0.219	0.245	0.232
G_2D_1	21.13	22.62	21.88	0.299	0.328	0.313	0.221	0.280	0.250
G_2D_2	19.50	18.20	18.85	0.277	0.312	0.295	0.211	0.238	0.225
G_2D_3	21.67	21.63	21.65	0.291	0.311	0.301	0.233	0.263	0.248
G_3D_1	26.57	25.15	25.86	0.300	0.317	0.308	0.266	0.273	0.270
G_3D_2	19.93	20.20	20.07	0.286	0.312	0.299	0.219	0.237	0.228
G_3D_3	24.40	23.02	23.71	0.303	0.316	0.309	0.257	0.265	0.261
G_4D_1	19.31	20.33	19.82	0.296	0.314	0.305	0.212	0.287	0.249
G_4D_2	18.90	18.03	18.47	0.279	0.303	0.291	0.218	0.238	0.228
G_4D_3	18.92	18.25	18.59	0.278	0.313	0.296	0.213	0.242	0.228
G_5D_1	24.30	21.01	22.65	0.305	0.322	0.314	0.253	0.254	0.254
G_5D_2	19.53	20.30	19.92	0.282	0.320	0.301	0.205	0.285	0.245
G_5D_3	20.87	23.10	21.98	0.289	0.325	0.307	0.228	0.288	0.258
G_6D_1	29.38	29.57	29.47	0.310	0.333	0.322	0.270	0.286	0.278
G_6D_2	21.75	20.70	21.22	0.290	0.317	0.303	0.234	0.259	0.247
G_6D_3	25.40	24.77	25.08	0.300	0.333	0.317	0.251	0.260	0.255
G_0D_1	18.18	17.17	17.67	0.267	0.283	0.275	0.210	0.242	0.226
G_0D_2	17.74	16.03	16.89	0.273	0.294	0.284	0.208	0.242	0.225
G_0D_3	18.00	16.01	17.01	0.267	0.290	0.278	0.210	0.228	0.219
SEm±	1.62	1.44	1.28	0.019	0.020	0.013	0.020	0.019	0.015
CD ($P = 0.05$)	NS	NS	NS	NS	NS	NS	NS	NS	NS

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