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Short Communication

Morphological and floral characters of rose as influenced by growing media and growth regulators

Sijo John*, Mini Sankar, U. Sreelatha, K. Ajith Kumar and K. B. Deepthy

College of Horticulture, Kerala Agricultural University, Thrissur 680 656, Kerala

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Abstract

An investigation was carried out to standardise suitable growing media and growth regulators for enhancing morphological and floral characters of rose at College of Horticulture, Vellanikkara during the period 2018 - 2019. Treatments consisted of three different growing media *viz*., soil + M-sand + coco peat + FYM, soil + M-sand + cocopeat + vermicompost, soil + M-sand + cocopeat + poultry manure in the ratio of 2:1:1:1 v/v in combination with growth regulators benzyl adenine (BA) and gibberellic acid (GA) at two different levels *viz*., 200 and 250 ppm. The results revealed that plants grown in growing medium containing FYM with GA at 250 ppm produced superior results with respect to plant height. Vegetative characters such as plant spread, number of branches per plant and number of leaves per branch were higher under the growing media containing FYM along with foliar sprays of BA at 200 and 250 ppm levels. Growing media and growth regulators had significant influence on floral parameters *viz*., stalk length and number of petals per flower. Media containing FYM (M_1) with GA 200 as well as 250 ppm were found to have maximum stalk length. Highest number of petals were observed under media containing FYM (M_1) along with BA 200 and 250 ppm, media containing FYM (M_1) along with GA 200 and 250 ppm, media containing vermicompost (M_2) along with BA 200 ppm and GA 200 ppm as well as media containing poultry manure (M_3) along with BA 200 ppm. Early initiation of flower bud was observed under medium containing FYM (M_1) along with BA 250 ppm (119.22 days).Growing medium consisting of soil + M-sand + cocopeat + FYM (2:1:1:1) along with monthly application of BA at 200 ppm was found to be effective for enhancing growth and yield of rose under protected condition.

Key words: BA, FYM, GA, Growing media, Growth regulators, Rose, TajMahal.

Rose, universally known as Queen of flowers, occupies a prime position in world floriculture industry. It is primarily used in bouquets, flower arrangement and to beautify the locations for special occasions and also for landscape purposes. Ease of availability of wide spectrum of colours, shape and suitability for numerous purposes as well as prolonged vase life are the reasons behind the widespread consumer acceptability of rose. Protected structures ensure the year round production of quality flowers and help to provide automation and climate control also.

Growth and yield of rose depend on the quality of growing medium and its ability to supply enough nutrients to the root system. Physical and chemical characters of growing media influence the availability of essential nutrients and root growth. Exogenous application of growth regulators is found to have effect on improving morphological and floral characters of flower crops by altering the internal plant hormone balance.

The experiment was carried out in the top ventilated rain shelter of Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara,

*Author for correspondences: Phone: 8089514032, Email: sijojohn627@gmail.com

during the period September 2018 to May 2019. Six month old uniform rose grafts of variety 'Tajmahal' were used for the experiment. Planting was done in raised beds of size 2.1 x 1.2 m at a spacing of 30 x 40 cm between rows and plants respectively. The experiment was laid out in factorial RBD with twelve treatments and three replications. Three different growing media combinations *viz*., soil + M-sand + coco peat + FYM (M_1), soil + M-sand + cocopeat + vermicompost (M_2), soil + M-sand + cocopeat + poultry manure (M_3) in the ratio of 2:1:1:1 v/v were used. Growth regulators BA (GR_1 and GR_2) and GA (GR_3 and GR_4) were applied at two different levels *viz.,* 200 and 250 ppm as foliar spray from 2 months after planting and succeeding sprays given at monthly intervals. Observations on vegetative parameters *viz.,* plant height, plant spread, number of branches per plant and number of leaves per branch were recorded at monthly intervals. The data pertaining to different vegetative and floral parameters were statistically analyzed using WASP statistical software.

Significant results could be observed in morphological parameters with respect to growing media and growth regulators.

Vegetative parameters such as plant height, plant spread, number of branches and number of leaves per branch influence the flower yield and quality of rose (Pooja et al., 2017). From the results, it was clear that growing media had significant influence on plant height. M_1 (media containing FYM) was superior in terms of plant height throughout the period of study. Highest plant height (77.96 cm) was noticed at 8 MAP (Table 1). The treatment M_3 (media containing poultry manure) was found to have the lowest plant height throughout the growth period.

Regarding plant spread, growing in M_1 (media containing FYM) was found to give highest plant spread during major part of the growth period. Among all treatments, highest plant spread was recorded at 8MAP and M_2 (media containing vermicompost) and M_1 (media containing FYM) were on par with each other at 4 MAP (Table 2). Lowest plant spread was observed in M_3 (media containing poultry manure) throughout the period of observation.

M_1 (FYM) and M_2 (media containing vermicompost) were observed to be on par with respect to the number of branches per plant except during 5 , 6 and 8 MAP (Table 3).

There was a significant influence of growing media on number of leaves per branch at 3,4 and 5 MAP (Table 4). At 3 MAP, M_1 (media containing FYM) was superior, whereas at 4 and 5 MAP M_1 (media containing FYM) and M_2 (media containing vermicompost) were found to be on par with regard to this parameter.

The positive influence of medium containing FYM on vegetative parameters might be due to the balanced supply of nutrients in available form after decomposition, which led to better root growth and easy absorption of nutrients and resulted in an improvement in vegetative growth. These results are in accordance with the findings of Rajasekhar and Suresh (2015) and Singh (2006) in rose.

From the present study it could be observed that medium containing vermicompost was as effective as medium containing FYM for improvement of vegetative parameters *viz.,* plant height, plant spread, number of branches per plant and number of leaves per branch. Vermicompost is a sustainable source of macro nutrients in the form of nitrates, phosphates, exchangeable calcium, and soluble potassium as well as micro nutrients. Presence of plant growth regulators like gibberellins and cytokinin was also reported in vermicompost (Akter et al., 2017). An improvement in vegetative growth by the incorporation of vermicompost in growing media was reported in various ornamental crops by Pandey et al. (2017) in dahlia and Bhalla et al. (2007) in carnation.

Table 1. Effect of growing media and growth regulators on plant height of rose variety Tajmahal

Treatments		At the time of planting	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	8 MAP
GROWING MEDIA	M_1	20.85	30.09	36.83	57.58	41.95	59.46	67.58	68.92	77.96
	M_2	20.85	26.12	35.25	48.54	41.61	51.37	69.07	66.84	73.91
	M_3	17.44	23.59	26.89	39.24	35.25	44.98	49.93	53.97	64.08
CD (0.05)		0.80	1.10	3.20	3.71	2.87	3.29	3.90	3.24	3.13
GROWTH REGULATOR	GR_1	18.45	26.22	28.99	43.36	37.06	52.49	59.46	61.04	69.72
	GR_2	20.22	24.69	32.01	47.65	41.33	53.88	63.99	59.77	72.97
	GR_3	20.81	26.06	32.89	47.62	38.75	52.14	64.57	63.78	65.69
	GR_4	19.38	29.44	38.08	55.18	41.29	49.24	60.75	68.39	79.56
CD (0.05)		0.92	1.27	3.69	4.28	3.32	NS	NS	3.74	3.61

MAP – Months after planting M_1- FYM, M_2 - Vermicompost, M_3 - Poultry manure
GR_1- BA 200 ppm GR_2- BA 250 ppm GR_3- GA 200 ppm GR_4 – GA 250 ppm

Table 2. Effect of growing media and growth regulators onplant spread of rose variety Tajmahal

Treatments		At the time of planting	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	8 MAP
GROWING MEDIA	M_1	16.10	19.44	23.52	29.25	24.26	27.31	29.65	27.94	30.05
	M_2	16.33	18.23	21.75	26.34	25.05	26.05	26.27	25.78	26.28
	M_3	14.28	16.01	18.64	20.46	19.86	21.75	24.12	25.48	26.51
CD (0.05)		0.46	0.78	0.73	0.92	0.87	0.79	1.10	1.14	1.10
GROWTH REGULATOR	GR_1	15.67	17.41	21.12	27.00	23.39	26.85	27.94	29.32	30.22
	GR_2	15.93	17.77	21.15	25.80	23.60	26.43	30.66	29.72	33.49
	GR_3	15.39	17.31	21.34	25.28	23.56	24.11	24.06	23.71	22.71
	GR_4	15.30	19.09	21.60	23.33	21.67	22.75	24.06	22.85	24.03
CD (0.05)		0.53	0.90	0.85	1.07	1.01	0.91	1.28	1.31	1.26

MAP – Months after planting M_1- FYM, M_2 - Vermicompost, M_3 - Poultry manure
GR_1- BA 200 ppm GR_2- BA 250 ppm GR_3- GA 200 ppm GR_4 – GA 250 ppm

Table 3. Effect of growing media and growth regulators on number of branches per plant of rose variety Tajmahal

Treatments		At the time of planting	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	8 MAP
GROWING MEDIA	M_1	1.82	1.85	1.86	2.00	2.37	2.88	3.00	3.01	3.22
	M_2	1.92	1.73	1.83	2.18	2.42	2.41	2.42	3.05	3.76
	M_3	1.48	1.44	1.35	1.56	1.96	2.14	2.53	2.87	3.25
CD (0.05)		0.21	0.26	0.18	0.22	0.18	0.11	0.16	NS	0.21
GROWTH REGULATOR	GR_1	1.92	1.69	1.74	2.17	2.59	2.78	3.16	3.52	4.15
	GR_2	1.66	1.64	1.54	1.89	2.51	2.93	3.07	3.21	3.58
	GR_3	1.80	1.79	1.76	1.83	1.99	2.16	2.31	2.99	3.17
	GR_4	1.58	1.56	1.68	1.77	1.92	2.03	2.05	2.18	2.74
CD (0.05)		0.24	NS	NS	0.26	0.21	0.13	0.19	0.17	0.24

MAP – Months after planting, M_1- FYM, M_2 - Vermicompost, M_3 - Poultry manure
GR_1- BA 200 ppm GR_2- BA 250 ppm GR_3- GA 200 ppm GR_4 – GA 250 ppm

Table 4. Effect of growing media and growth regulators on number of leaves per branch of rose variety Tajmahal

Treatments		At the time of planting	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	8 MAP
GROWING MEDIA	M_1	3.20	3.95	4.26	4.92	5.28	6.25	5.99	6.16	5.65
	M_2	3.38	3.46	3.99	4.37	5.08	5.71	5.85	6.36	5.34
	M_3	3.37	3.70	3.73	4.03	4.51	5.25	5.53	5.61	5.24
CD (0.05)		NS	NS	NS	0.45	0.43	0.43	NS	NS	NS
GROWTH REGULATOR	GR_1	3.22	3.57	3.98	4.39	4.51	5.85	5.69	6.04	5.78
	GR_2	3.71	3.72	4.00	4.78	5.58	6.21	6.11	6.33	6.34
	GR_3	3.09	3.87	4.26	4.45	5.17	5.71	5.86	5.73	4.61
	GR_4	3.24	3.66	3.74	4.15	4.54	5.17	5.50	6.09	4.93
CD (0.05)		NS	NS	NS	NS	0.50	0.49	NS	NS	0.48

MAP – Months after planting M_1- FYM, M_2-Vermicompost, M_3 - Poultry manure
GR_1- BA 200 ppm GR_2- BA 250 ppm GR_3- GA 200 ppm GR_4 – GA 250 ppm

Table 5. Effect of M x GR interaction on plant height of rose variety Tajmahal

Treatments	At the time of planting	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	8 MAP
M_1 x GR_1	18.98	32.30	32.12	51.68	46.09	62.12	71.98	64.74	75.48
M_1 x GR_2	20.08	23.13	33.61	52.69	40.07	59.08	71.40	63.55	73.84
M_1 x GR_3	22.15	26.27	31.39	55.49	37.94	59.66	70.10	62.08	70.94
M_1 x GR_4	22.18	38.67	50.20	70.46	43.70	57.01	56.84	85.32	91.60
M_2 x GR_1	19.28	23.82	32.84	42.02	35.61	50.28	57.96	64.77	72.52
M_2 x GR_2	24.88	29.15	36.28	51.14	46.38	61.43	80.95	70.92	77.04
M_2 x GR_3	20.86	24.27	33.90	45.85	40.69	45.33	67.52	72.13	67.96
M_2 x GR_4	18.41	27.26	38.00	55.15	43.78	48.44	69.84	59.54	78.12
M_3 x GR_1	17.08	22.55	22.01	36.38	29.47	45.09	48.45	53.61	61.16
M_3 x GR_2	15.72	21.80	26.16	39.14	37.55	41.12	39.62	44.84	68.04
M_3 x GR_3	19.42	27.65	33.38	41.51	37.62	51.44	56.09	57.13	58.17
M_3 x GR_4	17.55	22.39	26.04	39.93	36.39	42.29	55.58	60.33	68.97
CD (0.05)	1.60	2.20	6.40	7.42	5.75	6.58	7.81	6.48	6.26
CV	4.81	4.90	11.45	9.04	8.57	7.48	7.41	6.05	5.14

M_1 x GR_1 - FYM+ BA 200 ppm, M_1 x GR_2 - FYM + BA 250 ppm, M_1 x GR_3 - FYM + GA_3 200 ppm, M_1 x GR_4 - FYM + GA_3 250 ppm, M_2 x GR_1 - Vermicompost + BA 200 ppm,M_2 x GR_2 - vermicompost + BA 250 ppm, M_2 x GR_3 - vermicompost + GA_3 200 ppm, M_2 x GR_4 -vermicompost+ GA_3 250 ppm, M_3 x GR_1 - poultry manure + BA 200 ppm, M_3 x GR_2 - poultry manure + BA 250 ppm, M_3 x GR_3 - poultry manure + GA_3 200 ppm, M_3 x GR_4 - poultry manure + GA_3 250 ppm , MAP – Months after planting

Table 6. Effect of M x GR interaction on plant spread ofrose variety Tajmahal

Treatments	At the time of planting	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	8 MAP
M_1 x GR_1	17.06	19.92	24.17	32.09	24.30	28.96	31.94	30.19	37.08
M_1 x GR_2	15.19	17.69	22.96	29.71	26.49	28.65	33.43	30.54	35.71
M_1 x GR_3	15.75	18.15	21.20	27.68	24.05	26.58	26.79	26.23	23.81
M_1 x GR_4	16.39	21.99	25.73	27.52	22.17	25.02	26.45	24.79	23.57
M_2 x GR_1	16.47	17.93	21.86	27.71	26.49	28.21	29.39	28.99	27.25
M_2 x GR_2	17.60	19.50	21.78	27.27	25.28	28.87	28.54	28.42	30.96
M_2 x GR_3	15.59	17.76	21.91	26.25	25.40	23.34	23.68	23.51	22.41
M_2 x GR_4	15.65	17.73	21.42	24.11	23.02	23.78	23.44	22.19	24.50
M_3 x GR_1	13.46	14.39	17.31	21.19	19.36	23.38	22.48	28.77	26.32
M_3 x GR_2	14.98	16.12	18.71	20.39	19.02	21.77	29.99	30.21	33.78
M_3 x GR_3	14.81	15.99	20.89	21.89	21.22	22.40	21.69	21.39	21.91
M_3 x GR_4	13.84	17.55	17.64	18.35	19.82	19.44	22.28	21.56	24.02
CD (0.05)	0.92	2.11	1.46	1.84	1.74	1.57	2.20	2.27	2.19
CV	3.50	5.13	4.05	4.30	4.47	3.70	4.88	5.09	4.68

M_1 x GR_1 - FYM+ BA 200 ppm, M_1 x GR_2 - FYM + BA 250 ppm, M_1 x GR_3 - FYM + GA_3 200 ppm, M_1 x GR_4 - FYM + GA_3 250 ppm, M_2 x GR_1 - Vermicompost + BA 200 ppm,M_2 x GR_2 - vermicompost + BA 250 ppm, M_2 x GR_3 - vermicompost + GA_3 200 ppm, M_2 x GR_4 - vermicompost+ GA_3 250 ppm, M_3 x GR_1 - poultry manure + BA 200 ppm, M_3 x GR_2 - poultry manure + BA 250 ppm, M_3 x GR_3 - poultry manure + GA_3 200 ppm, M_3 x GR_4 - poultry manure + GA_3 250 ppm, MAP – Months after planting

Regarding the plant height, significant variation could be observed due to plant growth regulators during the period of observation. Foliar application of GA at 250 ppm has recorded greatest plant height in major part of growth period. Increase in plant height due to the application of GA might be due to the stimulation of cell production beneath the apical region resulting in the generation of new cells in this region, and increase in the size of the meristematic region. Similar findings were observed in the reports of Baghele et al. (2014); Kumar et al. (2012) and Arun et al. (2000).

Significant effect of growth regulators on plant spread was noticed throughout the period of observation. Application of BA at 250 ppm was found to produce the highest plant spread in major part of growth period at 4, 5 and 7 MAP . This treatment was observed to be on par with GR_1 (BA at 200 ppm). Application of BA at 200 ppm as well as 250 ppm was found to produce the highest number of branches throughout the experimental period, except at 1 and 2 MAP. Cytokinins have the ability to enhance the production of lateral buds by the way of suppressing apical dominance. This might have caused production of more number of

Table 7. Effect of M x GR interaction on number of branches per plant of rose variety Tajmahal

Treatments	At the time of planting	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	8 MAP
M_1 x GR_1	1.91	1.87	2.00	2.41	2.82	3.41	3.64	3.83	4.53
M_1 x GR_2	2.04	2.08	1.91	1.74	2.39	3.25	3.55	2.87	3.77
M_1 x GR_3	1.79	1.62	1.62	1.68	2.16	2.48	2.43	2.80	2.26
M_1 x GR_4	1.56	1.83	1.91	2.18	2.12	2.39	2.39	2.54	2.32
M_2 x GR_1	2.12	1.83	1.83	2.55	2.75	2.67	2.81	3.26	4.32
M_2 x GR_2	1.58	1.49	1.43	2.25	2.45	2.43	2.41	3.37	3.55
M_2 x GR_3	2.25	2.16	2.31	2.20	2.37	2.38	2.39	3.24	3.91
M_2 x GR_4	1.74	1.43	1.75	1.75	2.12	2.16	2.08	2.34	3.29
M_3 x GR_1	1.75	1.38	1.39	1.55	2.20	2.27	3.04	3.49	3.61
M_3 x GR_2	1.37	1.34	1.27	1.68	2.68	3.13	3.25	3.39	3.44
M_3 x GR_3	1.37	1.61	1.35	1.62	1.46	1.62	2.12	2.93	3.36
M_3 x GR_4	1.45	1.44	1.39	1.38	1.52	1.53	1.70	1.68	2.62
CD (0.05)	0.42	NS	0.37	0.45	0.37	0.22	0.33	0.30	0.42
CV	14.51	18.74	13.06	13.86	9.83	5.37	7.39	6.08	7.28

M_1 x GR_1 - FYM+ BA 200 ppm, M_1 x GR_2 - FYM + BA 250 ppm, M_1 x GR_3 - FYM + GA_3 200 ppm, M_1 x GR_4 - FYM + GA_3 250 ppm, M_2 x GR_1 - Vermicompost + BA 200 ppm,M_2 x GR_2 - vermicompost + BA 250 ppm, M_2 x GR_3 - vermicompost + GA_3 200 ppm, M_2 x GR_4 -vermicompost+ GA_3 250 ppm, M_3 x GR_1 - poultry manure + BA 200 ppm, M_3 x GR_2 - poultry manure + BA 250 ppm, M_3 x GR_3 - poultry manure + GA_3 200 ppm, M_3 x GR_4 - poultry manure + GA_3 250 ppm MAP – Months after planting

Table 8. Effect of M x GR interaction on number of leaves per branch of rose variety Tajmahal

Treatments	At the time of planting	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	8 MAP
M_1 x GR_1	3.45	3.99	4.37	4.91	4.84	6.94	6.14	6.30	6.14
M_1 x GR_2	2.95	3.80	3.83	5.85	6.12	6.08	6.04	6.24	6.49
M_1 x GR_3	3.04	4.45	4.62	4.23	5.33	6.54	6.20	5.61	4.73
M_1 x GR_4	3.37	3.56	4.24	4.70	4.83	5.43	5.57	6.49	5.25
M_2 x GR_1	3.08	3.62	3.70	4.23	5.08	5.76	5.66	6.03	5.83
M_2 x GR_2	4.70	3.56	4.37	4.24	6.18	6.75	6.31	6.50	5.48
M_2 x GR_3	2.99	3.37	4.12	5.12	4.31	5.47	5.64	6.53	5.08
M_2 x GR_4	2.74	3.31	3.77	3.91	4.74	4.87	5.81	6.39	4.99
M_3 x GR_1	3.12	3.11	3.89	4.03	3.63	4.85	5.27	5.79	5.38
M_3 x GR_2	3.49	3.80	3.81	4.24	4.45	5.81	5.99	6.24	7.05
M_3 x GR_3	3.24	3.80	4.04	3.99	5.89	5.12	5.74	5.04	4.01
M_3 x GR_4	3.62	4.11	3.20	3.84	4.06	5.21	5.12	5.39	4.55
CD (0.05)	NS	NS	NS	0.89	0.87	0.86	NS	NS	0.84
CV	19.60	14.60	12.46	11.88	10.36	8.87	11.51	12.07	9.13

M_1 x GR_1 - FYM+ BA 200 ppm, M_1 x GR_2 - FYM + BA 250 ppm, M_1 x GR_3 - FYM + GA_3 200 ppm, M_1 x GR_4 - FYM + GA_3 250 ppm, M_2 x GR_1 - Vermicompost + BA 200 ppm,M_2 x GR_2 - vermicompost + BA 250 ppm, M_2 x GR_3 - vermicompost + GA_3 200 ppm, M_2 x GR_4 -vermicompost+ GA_3 250 ppm, M_3 x GR_1 - poultry manure + BA 200 ppm, M_3 x GR_2 - poultry manure + BA 250 ppm, M_3 x GR_3 - poultry manure + GA_3 200 ppm, M_3 x GR_4 - poultry manure + GA_3 250 ppm MAP – Months after planting

branches and an improvement of plant spread. Growth enhancement due to the external application of growth regulators have been reported in rose by several workers Baghele et al., 2014; Vasudevan and Kannan, 2015; Mondal and Sarkar, 2017; and Mondal and Sarkar, 2018.

Number of leaves per branch was found to have direct correlation with flower production (Pooja et al., 2017). An improvement in number of leaves by the foliar application of benzyl adenine was reported by Baghele et al. (2014) and Dekhaney et al. (2000) in rose. From the results, it could be observed that there was significant variation in number of leaves per branch due to growth regulators during 4, 5 and 8 MAP. GR_2 (BA at 250 ppm) was superior in terms of number of leaves per branch which was on par with GR_3 (GA at 200 ppm) at 4 MAP. At 5 MAP GR_1 (BA at 200 ppm) and GR_2 (BA at 250 ppm) were on par and 8 MAP, GR_2 (BA at 250 ppm) was found to be superior in terms of this parameter.

Growing media and growth regulator interaction had significant effect on plant height during the period of observation (Table 5). Tallest plants were produced by the treatment combination of M_1 x GR_4

(media containing FYM + GA at 250 ppm) at 1, 2, 3,7 and 8 MAP. At 6 MAP plant height was highest under the treatment M_2 x GR_2 (media containing vermicompost + BA at 250 ppm). At 4 MAP M_2 x GR_2, M_1 x GR_1, M_1 x GR_4, M_2 x GR_3, M_2 x GR_4 were on par with one another with regard to plant height. The maximum plant height of 91.60 cm was observed in the treatment combination M_1 x GR_4 (media containing FYM + GA at 250 ppm) at 8 MAP. More absorption and translocation of nutrients due to enhanced root growth in the medium enriched with FYM coupled with growth accelerating effect of GA might have caused an improvement in plant height in treatments consisting of FYM and gibberellic acid. These results were in conformity with the findings of Pooja et al. (2017) in rose.

Regarding plant spread there was significant effect of M x GR interaction among different treatments (Table 6). M_1 x GR_1 (FYM + BA at 200 ppm) and M_1 x GR_2 (media containing FYM + BA at 250 ppm) were superior from 3 to 8 MAP. At 1&2 MAP highest plant spread was under the treatment combination of M_1 x GR_4 (media containing FYM + GA at 250 ppm) whereas at the time of planting it was under M_2 x GR_2 (media containing vermicompost + BA at 250 ppm).

Significant variation in number of branches due to M x GR interaction could be noticed throughout the period of experiment except at 1 MAP (Table 7). M_1 x GR_1 (media containing FYM + BA at 200 ppm) was observed to have highest number of branches from 4 to 8 MAP. During initial three months, more number of branches was noticed under the treatment of M_2 x GR_3 (medium containing vermicompost + GA at 200 ppm) and at 3 MAP it was under M_2 x GR_1 (medium containing vermicompost + BA at 250 ppm). The maximum number of branches of 4.53 was produced under M_1 x GR_1 (medium containing FYM + BA at 200 ppm) at 8 MAP.

There was no significant variation in number of leaves per branch due to M x GR interaction except at 3, 4, 5 and 8 MAP (Table 8). Growth regulators BA in two concentrations *viz*., 200 and 250 ppm along with growing medium enriched with FYM was found to have positive influence on this parameter at 3 and 5 MAP. At 4 MAP, treatment M_2 x GR_2 (media containing vermicompost + BA at 250 ppm) was found to have the highest number of leaves per branch.

Addition of organic manures *viz*., FYM and vermicompost might have improved the physio-chemical properties of the soil which in turn increased the nutrient absorption of the plant. Application of BA or GA might have resulted in cell division, elongation and production of maximum number of lateral branches resulting in an improvement in plant spread as well as number of leaves per branch. Similar findings were reported by Rajasekhar and Suresh (2015) in rose.

Growing medium had significant effects on floral characters, and medium containing FYM (M_1) was found to be superior with respect to floral characters *viz*., length of flower bud (3.37 cm), diameter of flower bud (2.16 cm), number of flowers /plant (5.04), number of petals/ flower (51.92), stalk length (47.94 cm) and flower diameter at fully opened stage (8.44 cm) (Table 9). Medium containing FYM (M_1) and medium containing vermicompost (M_2) were on par with regard to other floral parameters such as length of flower shoot, neck girth and stalk girth of flower. This might be due to enhanced availability of N and K from growing medium containing FYM which improved the quality of flower as reported by Khanna et al. (2016) in China aster; Ahmed et al. (2004) in dahlia; Rajasekhar and Suresh (2015), Prasad et al. (2017), Pooja et al. (2017) in rose; Sekar and Sujata (2001) in gerbera; and Bhatia et al. (2004) in carnation. Vermicompost also had significant positive effect on floral characters. Soil properties such as bulk density, porosity, soil pH as well as microbial activity were found to be improved by the application of vermicompost in growing medium. Improvement in soil properties might have

Table 9. Effect of growing media and growth regulators on floral characters of Rose variety'Tajmahal'

Treatments		Days taken for flower bud initiation	Days taken from flower bud initiation to commercial stage of harvest	Days taken from flower bud initiation to complete opening	Length of flower bud (cm)	Diameter of flower bud (cm)	Number of flowers per plant	Number of petals per flower	Length of flower shoot (cm)	Neck-length (cm)	Neck-girth (mm)	Stalk length of flower (cm)	Stalk girth of flower (mm)	Flower diameter at fully opened stage (cm)	Flower persistence (days)
GROWING															
MEDIA	M_1	129.41	14.63	20.45	3.37	2.16	5.04	51.92	40.11	7.24	2.96	47.94	4.66	8.44	15.99
	M_2	136.19	15.04	20.55	3.24	2.06	4.40	46.24	38.54	6.92	2.93	45.53	4.49	7.95	16.44
	M_3	140.45	14.45	20.59	3.12	1.98	3.76	47.50	32.74	6.56	2.69	39.97	4.12	7.46	15.52
CD (0.05)	4.65	NS	NS	0.11	0.08	0.63	2.77	1.77	0.23	0.12	1.44	0.21	0.35	NS	
GROWTH															
REGULATOR	GR_1	133.35	14.66	21.00	3.27	2.08	5.38	50.87	35.16	6.23	2.93	41.75	4.37	8.33	16.95
	GR_2	132.21	14.65	20.75	3.25	2.11	5.10	47.08	36.93	5.90	2.87	43.01	4.53	7.75	15.99
	GR_3	137.50	14.81	20.45	3.24	2.10	3.84	46.91	38.79	7.68	2.89	47.92	4.58	7.73	15.76
	GR_4	138.34	14.71	19.91	3.21	1.99	3.28	49.36	37.64	7.81	2.75	45.25	4.22	7.99	15.24
CD (0.05)	NS	NS	0.66	NS	NS	0.72	NS	2.04	0.27	NS	1.66	0.25	0.41	NS	

M_1- FYM, M_2-Vermicompost, M_3 - Poultry manure GR_1- BA 200 ppm GR_2- BA 250 ppm GR_3- GA 200 ppm GR_4 – GA 250 ppm

Table 10. Effect of M x GR interaction onfloral characters of Rose variety'Tajmahal'

Treatments	Days taken for flower bud initiation	Days taken from flower bud initiation to commercial stage of harvest	Days taken from flower bud initiation to complete opening	Length of flower bud (cm)	Diameter of flower bud (cm)	Number of flowers per plant	Number of petals per flower	Length of flower shoot (cm)	Neck-length (cm)	Neck-girth (mm)	Stalk length of flower (cm)	Stalk girth of flower (mm)	Flower diameter at fully opened stage (cm)	Flower persistence (days)
M_1 x GR_1	130.24	14.55	20.37	3.39	2.19	6.77	52.97	37.123	6.62	3.12	44.99	4.63	9.25	15.95
M_1 x GR_2	119.22	14.77	21.09	3.36	2.15	5.67	52.43	39.40	6.21	2.93	44.22	5.03	8.04	15.96
M_1 x GR_3	132.65	15.17	20.43	3.43	2.30	4.16	51.18	42.43	8.40	2.98	52.48	4.75	8.24	16.72
M_1 x GR_4	135.54	14.03	19.91	3.28	1.98	3.56	51.12	41.49	7.75	2.82	50.09	4.25	8.23	15.34
M_2 x GR_1	123.44	14.99	21.61	3.33	2.11	5.16	49.77	37.18	6.29	2.99	43.07	4.55	8.14	17.51
M_2 x GR_2	136.21	15.36	21.23	3.31	2.10	4.90	43.30	39.22	5.86	2.94	46.40	4.43	8.03	16.80
M_2 x GR_3	143.42	14.24	19.41	3.12	1.98	3.87	40.78	38.63	7.18	2.98	46.68	4.55	7.63	15.52
M_2 x GR_4	141.70	15.60	19.96	3.22	2.06	3.66	51.13	39.13	8.35	2.80	45.99	4.42	8.02	15.95
M_3 x GR_1	146.39	14.44	21.03	3.10	1.94	4.21	49.86	31.20	5.78	2.67	37.19	3.94	7.60	17.39
M_3 x GR_2	141.20	13.83	19.94	3.08	2.07	4.74	45.50	32.19	5.65	2.74	38.41	4.13	7.19	15.20
M_3 x GR_3	136.44	15.03	21.51	3.17	2.01	3.49	48.79	35.30	7.46	2.71	44.60	4.43	7.32	15.04
M_3 x GR_4	137.78	14.51	19.87	3.15	1.92	2.61	45.85	32.30	7.35	2.64	39.69	3.99	7.72	14.45
CD (0.05)	**9.25**	**1.06**	**1.15**	**NS**	**NS**	**NS**	**5.55**	**NS**	**0.23**	**NS**	**2.88**	**NS**	**NS**	**NS**
CV	**4.03**	**4.29**	**3.32**	**4.21**	**5.06**	**16.89**	**6.75**	**5.64**	**4.02**	**5.15**	**3.83**	**5.83**	**5.27**	**8.10**

M_1 x GR_1 - FYM+ BA 200 ppm, M_1 x GR_2 - FYM + BA 250 ppm, M_1 x GR_3 - FYM + GA_3 200 ppm, M_1 x GR_4 - FYM + GA_3 250 ppm, M_2 x GR_1 - Vermicompost + BA 200 ppm, M_2 x GR_2 - vermicompost + BA 250 ppm, M_2 x GR_3 - vermicompost + GA_3 200 ppm, M_2 x GR_4 -vermicompost+ GA_3 250 ppm, M_3 x GR_1 - poultry manure + BA 200 ppm, M_3 x GR_2 - poultry manure + BA 250 ppm, M_3 x GR_3 - poultry manure + GA_3 200 ppm, M_3 x GR_4 - poultry manure + GA_3 250 ppm

increased nutrient uptake by plant resulting in faster mobilization of photosynthates and early transformation from vegetative to reproductive phase and production of more number of flowers. These results are in accordance with the findings of Akter et al. (2017); Pandey et al. (2017) and Chamani et al. (2008).

With respect to the influence of growth regulators, more number of flowers/ plant (5.38 and 5.10) as well as largest flowers at fully opened stage (8.33 and 7.99 cm) were observed under BA at 200 and 250 ppm. Production of more lateral branches, more number of leaves and high chlorophyll content in leaves as the result of the foliar application of BA might have enhanced the photosynthetic area as well as assimilation and translocation of carbohydrates to the growing point resulting in production of more number of flowers. Similar results could be found in the results of Nambiar et al. (2012) in dendrobium, and Vasudevan and Kanan (2015) in rose variety Tajmahal. Stalk length of the flower was found to be maximum under GA at 200 ppm (47.92 cm) whereas GA 200 ppm and BA 200 ppm were on par with highest length of flower shoot (38.79 and 36.94 cm respectively). This might be due to the effect of GA which could accelerate cell division and improve the longitudinal growth of cells, leading to vertical growth of plants as reported by Arun et al. (2000); Roberts et al. (1999); Hashemabadi and Zarchini (2010) and Saffari et al. (2004) in rose.

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had significant influence on floral parameters *viz*., stalk length and number of petals per flower (Table 10). Media containing FYM (M_1) with GA 200 as well as 250 ppm were found to have maximum stalk length (52.48 and 50.09 cm respectively). Highest number of petals were observed under media containing FYM (M_1) along with BA 200 and 250 ppm, medium containing FYM (M_1) along with GA 200 and 250 ppm, medium containing vermicompost (M_2) along with BA 200 ppm and GA 200 ppm as well as media containing poultry manure (M_3) along with BA 200 ppm. Early initiation of flower bud was observed under medium containing FYM (M_1) along with BA 250 ppm (119.22 days). Easy availability of nutrients from growing media enriched with FYM along with beneficial effects of growth regulators BA and GA might have caused an improvement in yield and quality of flower. Similar results were found in the findings of Arun et al., (2000) in rose, Saffari et al., (2004) in rose, Ramalingam, K. (2008) in rose, Vasudevan and Kannan, (2015) in rose, Rajasekar et al. (2017) in rose, , Sekar and Sujata, (2001) in gerbera, and Bhatia et al., (2004) in carnation cv. Sunrise.

The study recommends that growing medium consisting of soil + M-sand + cocopeat + FYM (2:1:1:1) along with monthly application of BA at 200 ppm can be used for enhancing growth and yield of rose under protected condition.

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