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Effect of organic manure, drying methods on flower yield and carotenoid contents in marigold (*Tagetes erecta* L.)

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ABSTRACT : A study was undertaken to evaluate the effect of farm yard manure, vermicompost and drying methods on flower yield and carotenoid contents in marigold (*Tagetes erecta* L.) at Instructional farm, Department of Floriculture College of Horticulture and Forestry, Pasighat, Arunachal Pradesh during October 2009 to September 2010. Two varieties *viz.*, Pusa Basanti Gainda and Pusa Narangi Gainda, three levels of nutrition *viz.*, 0 kg ha^{-1} (control), FYM (25 t ha^{-1}) and vermicompost (10 t ha^{-1}), three levels of drying methods *viz.*, sun drying, ventilated shade drying and hot air oven drying at 50^{0}C were used, for investigation. The experiment was laid out in Factorial Randomized Complete Block Design with three replications. Seedlings of marigold cultivars were transplanted in the respective plots under different treatments in the month of November at spacing 30x30cm. Significant response in vegetative and flowering characters in Pusa Basanti Gainda with respect to Pusa Narangi Gainda except carotenoid contents was observed. Highest plant height (47.46cm), more number of flower buds per plant (23.19), increased flower diameter (66.80mm) and dry weight of single flower (1.38g) and enhanced flower yield (204.64 q ha^{-1}) was observed in cultivars Pusa Basanti Gainda. However, maximum plant spread (24.98 cm), advanced flower bud initiation (35.67 days), increased carotenoid content in fresh petals (285.84µg g^{-1}) and dried petals (30.47µg g^{-1}), highest dried petal yield (11.98q ha^{-1}) was noticed in cultivar Pusa Narangi Gainda. Organic manure showed significant response especially well rotten farm yard manure against vermicompost. Flower yield (206.83 q ha^{-1}), carotenoid content in fresh petal (166.04g) and dried petal (16.53g) was responded by farm yard manure, whereas, vermicompost showed maximum dry weight of single flower (1.38g) and dried petal yield (12.83q ha^{-1}).

KEY WORDS : Marigold, Nutrition, Variety, Drying, Carotenoid contents, Yield

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Marigold (*Tagetes erecta* L.) is one among the important commercial ornamental plants grown in India. One of the most popular flowers due to long duration of flowering, ease of cultivation, wide adaptability and attractively coloured flowers of excellent keeping quality. Flowers are extensively used as loose form for floral decoration, religious offerings, garlands making and flower baskets. Besides its ornamental value, marigold petals are the most concentrated source of xanthophylls and a rich source of lutein (80-90 %). Dry petals of marigold flower contain about 90 per cent (w/w) carotenoids. The petals are dried in such condition that maximum carotenoids retain in them. These dried petals and concentrates are used as feed additives to improve the pigmentation of the poultry skin and the eggs of laying hens. Nutritional management through organic manure are helpful for enhancing yield, quality of flowers and carotenoid content. Thus, a study was undertaken to evaluate the effect of farm yard manure, vermicompost and drying methods on flower yield and carotenoid contents in marigold (*Tagetes erecta* L.).

RESEARCH METHODS

The field experiment was conducted at Instructional farm, Department of Floriculture College of Horticulture and Forestry, Pasighat, Arunachal Pradesh during October

2009 to September 2010. Two varieties *viz.*, Pusa Basanti Gainda and Pusa Narangi Gainda, three levels of nutrition *viz.* 0 kg/ha (control), FYM (25t/ha) and vermicompost (10t/ha), three levels of drying methods *viz.* sun drying, ventilated shade drying and hot air oven drying at 500C were used for investigation. The experiment was laid out in Factorial Randomized Complete Block Design with three replications. Seedlings of marigold cultivars were transplanted in the respective plots under different treatments in the month of November at spacing 30x30cm. Observations on vegetative growth characters *viz.*, plant height, plant spread, number of branches; flowering characters like days to flower bud initiation, days to flower, number of days for 50 per cent flowering, number of flowers plant^{-1}, flower duration, flower diameter, total number of flowers plant^{-1} season^{-1}, dry weight of flowers, yield of flowers, dried petal yield and estimation of total carotenoid in fresh as well as dried flower petals were recorded and analysed statistically as suggested by Panse and Sukhatme (1995).

RESEARCH FINDINGS AND DISCUSSION

Significant response of cultivars and organic manures in vegetative and flowering characters was observed. Highest plant height (47.46cm) was associated with Pusa Basanti Gainda. However, maximum plant spread (24.98cm) was noticed in Pusa Narangi Gainda (Table 1). This might be due to genotypic differences between the cultivars due to which they responded differently. Organic manures had significant response on plant height and spread. Vermicompost showed maximum plant height (45.58cm) and plant spread (24.33cm) which was at par with well rotten farm yard (45.37cm and 24.23cm), respectively. Enhanced plant height may be attributed due to the presence and synthesis of gibberellins in vermicompost. Similar findings have been reported by Gayithri *et al.* (2004) in statice and Pandey *et al.* (2010) in chrysanthemum. Vermicompost also serve as a source of humic and fulvic acid which significantly influences the vegetative growth of the plant (Sinha *et al.*, 2009). Cultivars and nutrition showed significant response in number of branches per plant. More number of branches per plant (10.33) was found in Pusa Basanti Gainda as compared to Pusa Narangi Gainda. Use of well rotten farm yard manure produced maximum number of branches plant^{-1} (10.33) followed by vermicompost (9.70cm). The minimum number of branches plant^{-1} (8.97) was noticed in plot without nutrition. Similar findings were observed in *Pelargonium graveolens* in which well rotten farm yard manure produced significantly higher number of shoots (Bhaskar *et al.*, 2001).

The data presented in Table 2 showed that Pusa Narangi Gainda responded earliness in flower bud initiation (35.67 days) and 50 per cent flowering (70.96 days) against Pusa Basanti Gainda (43.98 days and 80.37 days), respectively. Whereas, more number of flower buds plant^{-1} (23.19) in Pusa

Table 1 : Effect of organic manures and drying methods on vegetative parameters in marigold

Treatments	Plant height (cm)	Plant spread (cm)	No. of branches plant^{-1}
Variety			
V_1	47.46	21.81	10.33
V_2	41.06	24.98	9.00
C.D	1.39	0.75	0.29
Nutrition			
N_0	41.84	21.62	8.97
N_1	45.37	24.23	10.33
N_2	45.58	24.33	9.70
C.D	1.70	0.92	0.36
Drying			
D_0	45.20	23.54	9.63
D_1	44.10	24.30	9.92
D_2	43.48	22.34	9.44
C.D	NS	NS	NS
Interactions			
V_1N_0	44.46	19.62	9.84
V_1N_1	49.16	23.40	10.82
V_1N_2	48.77	22.41	10.33
V_2N_0	39.22	23.63	8.09
V_2N_1	41.58	25.26	9.84
V_2N_2	42.38	26.05	9.07
C.D	NS	NS	NS
V_1D_0	48.46	21.97	10.27
V_1D_1	46.70	21.63	10.42
V_1D_2	47.24	21.83	10.31
V_2D_0	41.95	25.11	9.00
V_2D_1	41.51	26.97	9.42
V_2D_2	39.72	22.85	8.58
C.D	NS	NS	NS
N_0D_0	42.41	20.04	7.97
N_0D_1	42.11	23.99	9.10
N_OD_2	41.00	20.85	9.83
N_1D_0	46.41	22.98	10.27
N_1D_1	44.95	25.57	10.93
N_1D_2	44.75	24.44	9.80
N_2D_0	46.80	27.61	10.67
N_2D_1	45.25	23.35	9.73
N_2D_2	44.68	21.74	8.70
C.D	NS	NS	NS
$V_1N_0D_0$	46.25	19.16	9.40
$V_1N_OD_1$	43.95	20.55	9.53
$V_1N_OD_2$	43.17	19.15	10.60
$V_1N_1D_0$	51.38	24.03	11.13
$V_1N_1D_1$	46.54	22.33	11.40
$V_1N_1D_2$	49.58	23.85	9.93
$V_1N_2D_0$	47.75	22.72	10.27
$V_1N_2D_1$	49.59	22.00	10.33
$V_1N_2D_2$	48.97	22.51	10.40
$V_2N_0D_0$	38.56	20.91	6.53
$V_2N_OD_1$	40.27	27.42	8.67
$V_2N_OD_2$	38.83	22.55	9.07
$V_2N_1D_0$	41.45	21.93	9.40
$V_2N_1D_1$	43.35	28.81	10.47
$V_2N_1D_2$	39.93	25.04	9.67
$V_2N_2D_0$	45.85	32.50	11.07
$V_2N_2D_1$	40.91	24.69	9.13
$V_2N_2D_2$	40.39	20.96	7.00
C.D	NS	NS	NS

NS=Non-significant

Table 2 : Effect of organic manures and drying methods on flowering parameters in marigold

Treatments	Initiation of flower buds (days)	50 per cent flowering (days)	No. of flower buds^{-1}	Diameter of flower (mm)	Fresh weight of single flower (g)	Duration of flower (days)	Flower yield (q ha^{-1})
Variety							
V_1	43.98	80.37	23.19	66.80	10.55	95.53	204.64
V_2	35.67	70.96	19.43	60.77	9.34	83.82	160.73
C.D	1.09	1.47	0.76	1.01	0.32	1.71	14.59
Nutrition							
N_0	41.67	78.94	20.03	61.68	8.61	92.62	148.93
N_1	38.04	72.67	22.42	63.50	10.65	88.18	206.83
N_2	39.77	75.39	21.48	66.17	10.58	88.22	192.29
C.D	NS	NS	NS	NS	0.39	NS	17.87
Drying							
D_0	40.31	76.72	21.39	65.25	10.26	90.12	191.85
D_1	39.12	75.22	21.33	63.18	9.89	89.12	179.20
D_2	40.04	75.06	21.21	62.93	9.69	89.78	177.00
C.D	NS	NS	NS	NS	NS	NS	NS
Interactions							
V_1N_0	45.71	85.33	23.27	66.49	9.33	98.51	183.38
V_1N_1	42.64	78.00	23.04	67.05	11.37	93.89	219.76
V_1N_2	43.58	77.78	23.27	66.86	10.96	94.20	210.77
V_2N_0	37.62	72.56	16.80	56.88	7.89	86.73	114.47
V_2N_1	33.44	67.33	21.80	59.96	9.93	82.47	193.89
V_2N_2	35.96	73.00	19.69	65.48	10.21	82.24	173.81
C.D	NS	NS	NS	NS	NS	NS	NS
V_1D_0	44.13	80.89	23.24	67.78	10.90	95.47	209.28
V_1D_1	42.96	79.56	22.47	66.92	11.18	93.76	208.90
V_1D_2	44.84	80.67	23.87	65.69	9.57	97.38	195.73
V_2D_0	36.49	72.57	19.53	62.71	9.61	84.78	174.41
V_2D_1	35.29	70.89	20.20	59.43	8.61	84.49	149.50
V_2D_2	35.24	69.44	18.57	60.18	9.81	82.18	158.27
C.D	NS	NS	NS	NS	NS	NS	NS
N_0D_0	41.77	78.33	18.50	61.19	8.91	93.43	140.07
N_0D_1	40.80	80.83	21.30	61.66	8.73	92.00	159.51
N_OD_2	42.43	77.67	20.30	62.20	8.18	92.43	147.20
N_1D_0	38.23	74.50	22.67	65.26	11.18	88.03	228.67
N_1D_1	38.13	72.67	23.33	63.82	10.28	86.67	203.56
N_1D_2	37.77	70.83	21.27	61.43	10.48	87.83	188.25
N_2D_0	40.93	77.33	23.00	69.29	10.68	88.90	206.79
N_2D_1	38.43	72.17	19.37	64.05	10.67	86.70	174.53
N_2D_2	39.93	76.67	22.07	65.18	10.40	89.07	195.55
C.D	NS	NS	NS	NS	NS	NS	NS
$V_1N_0D_0$	42.73	84.00	22.27	67.03	9.64	97.13	180.86
$V_1N_OD_1$	45.47	84.00	26.48	67.27	10.77	97.20	229.31
$V_1N_OD_2$	48.93	88.00	21.07	65.17	7.57	101.20	139.98
$V_1N_1D_0$	44.07	80.67	23.73	68.70	12.37	94.20	242.69
$V_1N_ID_1$	41.67	76.67	22.00	67.89	11.13	92.33	211.46
$V_1N_1D_2$	42.20	76.67	23.40	64.55	10.60	95.13	205.14
$V_1N_2D_0$	45.60	78.00	23.73	67.63	10.70	95.07	204.30
$V_1N_2D_1$	41.73	78.00	18.93	65.61	11.63	91.73	185.95
$V_1N_2D_2$	43.40	77.33	27.13	67.36	10.53	95.80	242.06
$V_2N_0D_0$	40.80	72.67	14.73	55.36	8.17	89.73	99.28
$V_2N_OD_1$	36.13	77.67	16.13	56.03	6.70	86.80	89.72
$V_2N_OD_2$	35.93	67.33	19.53	59.22	8.80	83.67	154.42
$V_2N_1D_0$	32.40	68.33	21.60	61.83	10.00	81.87	214.65
$V_2N_ID_1$	34.60	68.67	24.67	59.75	9.43	85.00	195.67
$V_2N_1D_2$	33.33	65.00	19.13	58.31	10.37	80.53	171.37
$V_2N_2D_0$	36.27	76.67	22.27	70.95	10.67	82.73	209.29
$V_2N_2D_1$	35.13	66.33	19.80	62.50	9.70	81.67	163.12
$V_2N_2D_2$	36.47	76.00	17.00	62.99	10.27	82.33	149.04
C.D	NS	NS	NS	NS	NS	NS	NS

NS=Non-significant

Basanti Gainda as compared to Pusa Narangi Gainda (19.43) was observed. Increased flower diameter (66.80mm) and maximum fresh weight of single flower (10.55g) was associated with Pusa Basanti Gainda as compared to Pusa Narangi Gainda (60.77mm and 9.34g), respectively, while, maximum carotenoid contents was obtained from Pusa Narangi Gainda. Sree Kala *et al.* (2002) showed negative indirect effect through flower weight for carotenoid content. Nutrition also responded significantly for enhancing fresh weight of single flower. Well rotten farm yard manure showed maximum fresh weight of single flower (10.65g) which was at par with vermicompost (10.58g). These results are in conformity with the findings of Yadav *et al.* (2000) which reported that farm yard manure had significant response of increased flower weight in African marigold. Maximum diameter and weight of flowers was also observed by Singh (2006) in rose and Gupta *et al.* (2008) in gladiolus. Pusa Basanti Gainda prolonged the flower duration (95.53 days) and maximum flower yield (204.64 qha^{-1}) as compared to Pusa Narangi Gainda (83.82 days, 160.73 qha^{-1}), respectively. Organic manure played a significant role for enhancing the flower yield. Well rotten farm manure responded good for increase in flower yield (206.83qha^{-1}) followed by vermicompost treated plot (192.29qha^{-1}). The increase in flower yield may be due to use of organic manure which helps in improving the fertility and productivity of soils as well as they supply both macro and micro nutrients and improve physical and biological conditions of soil in sustainable crop production. These results are in close conformity with the findings of Nambisan and Krishnan (1983) in tuberose and John *et al.* (2007) in tulip.

The data presented in Table 3 revealed that Pusa Basanti Gainda produced maximum dry weight of single flower (1.38g) as compared to Pusa Narangi Gainda (1.10g). Vermicompost responded for increased dry weight (1.38g) against well rotten farm yard manure (1.27g). Increased dry weight of flower might be due to higher water holding capacity and bulk density of vermicompost as reported by Hidalgo and Harkess (2002) in chrysanthemum. Maximum dry weight of single flower (1.30g) was obtained by ventilated shade drying method followed by sun drying (1.24g). In interaction, maximum dry weight (1.50g) was observed in Pusa Basanti Gainda with vermicompost followed by Pusa Narangi Gainda with vermicompost (1.25g). Pusa Basanti Gainda with ventilated shade drying method produced more dry weight of single flower (1.47g). Nutrition also played significant role for increasing dry weight of single flower. Flowers obtained from vermicompost treated plots when dried under ventilated shade drying showed maximum dry weight of single flower (1.42g). The flowers of Pusa Basanti Gainda obtained from vermicompost treated plot when dried under ventilated shade drying produced maximum dry weight of single flower (1.61g). Nagavallemma (2004) observed that vermicompost renders its beneficial effect by providing nutrients in the available form and also enhances their uptake in plants. However, Pusa Narangi Gainda produced maximum dried petal yield (11.98qha^{-1}) as compared to Pusa Basanti Gainda (9.65qha^{-1}). Vermicompost responded for increased dried petal yield (12.83qha^{-1}) against well rotten farm yard manure (11.84qha^{-1}). Maximum dried petal yield (11.74 qha^{-1} g) was obtained by ventilated shade drying followed by sun drying (10.84qha^{-1}). In interaction, Maximum dried petal yield (14.28qha^{-1}) was observed in Pusa Narangi Gainda with vermicompost followed by Pusa Basanti Gainda with vermicompost (11.39qha^{-1}). Pusa Narangi Gainda with ventilated shade drying produced maximum dried petal yield of single flower (12.77qha^{-1}). Flowers obtained from vermicompost treated plots when dried under ventilated shade drying showed maximum dried petal yield (13.76 qha^{-1}). The flowers of Pusa Narangi Gainda obtained from vermicompost treated plot when dried under ventilated shade produced more dried petal yield of single flower (13.89 qha^{-1}).

Significant responses in carotenoid contents in fresh petals between cultivars and nutrition were observed (Table 3). Pusa Narangi Gainda produced maximum carotenoid content (285.84 µg g^{-1}) as compared to Pusa Basanti Gainda (11.36 µg g^{-1}). Well rotten farm yard manure showed significant response towards carotenoid contents in fresh petal (166.04 µg g^{-1}) followed by vermicompost (141.29 µg g^{-1}). Well ventilated shade drying methods produced maximum carotenoid content in fresh petal (163.32 µg g^{-1}) followed by hot air oven drying at 500C (152.39 µg g^{-1}). In interaction, petals taken from Pusa Narangi Gainda from the plots of well rotten farm yard manure, showed maximum carotenoid contents in fresh petals (320.99 µg g^{-1}) followed by vermicompost treated plot (272.17 µg g^{-1}), whereas, Pusa Basanti Gainda showed least carotenoid contents in fresh petals irrespective of nutrients used. Also, the petals of Pusa Narangi Gainda when subjected to ventilated shade drying produced maximum carotenoid content (314.30µg g^{-1}). Subsequently, petals obtained from plot with well rotten farm yard manure, when dried under ventilated shade drying method showed maximum carotenoid content (202.96µg g^{-1}). While, flower petals of Pusa Narangi Gainda obtained from well rotten farm yard manure treated plot when ventilated shade dried produced more carotenoid contents (392.54µg g^{-1}).

Pusa Narangi Gainda produced maximum carotenoid contents in dried petal (30.47µg g^{-1}) as compared to Pusa Basanti Gainda (1.96 µg g^{-1}). Well rotten farm yard manure responded for increased carotenoid contents in dried petal (16.53 µg g^{-1}) against vermicompost treated plot (15.71 µg g^{-1}). However, maximum carotenoid contents in dried petal (17.13 µg g^{-1}) was obtained by ventilated shade drying followed by hot air oven drying at 500C (15.97 µg g^{-1}) which

Table 3 : Effect of organic manures and drying methods on dry weight and carotenoid content in marigold

Treatments	Dry weight of single flower (g)	Dried petal yield (q ha^{-1})	Carotenoid content in fresh petals (µg g^{-1})	Carotenoid content in dried petals (µg g^{-1})
Variety				
V_1	1.38	9.65	11.36	1.956
V_2	1.10	11.98	285.84	30.47
C.D.	0.05	0.43	1.03	0.25
Nutrition				
N_0	1.07	7.78	138.47	16.40
N_1	1.27	11.84	166.04	16.53
N_2	1.38	12.83	141.29	15.71
C.D	0.04	0.52	1.25	0.31
Drying				
D_0	1.24	9.88	130.09	15.54
D_1	1.30	11.74	163.32	17.13
D_2	1.18	10.84	152.39	15.97
C.D.	0.05	0.64	1.54	0.38
Interactions				
V_1N_0	1.19	6.99	12.57	2.32
V_1N_1	1.46	10.58	11.10	1.77
V_1N_2	1.50	11.39	10.41	1.79
V_2N_0	0.96	8.56	264.37	30.48
V_2N_1	1.08	13.10	320.99	29.63
V_2N_2	1.25	14.28	272.17	31.30
C.D	0.06	0.74	1.78	0.44
V_1D_0	1.46	10.70	9.85	1.75
V_1D_1	1.47	1048	12.35	2.05
V_1D_2	1.21	7.79	11.88	2.08
V_2D_0	1.14	11.19	250.32	29.04
V_2D_1	1.01	12.77	314.30	32.50
V_2D_2	1.15	11.97	292.90	29.87
C.D	0.09	1.10	2.06	0.66
N_0D_0	1.22	8.64	112.51	18.32
N_0D_1	1.03	7.70	151.33	16.36
N_OD_2	0.98	6.99	151.57	14.52
N_1D_0	1.32	12.81	142.74	14.96
N_1D_1	1.28	12.56	202.96	18.34
N_1D_2	1.21	10.15	152.44	16.30
N_2D_0	1.37	12.25	135.02	14.72
N_2D_1	1.42	13.76	135.68	15.31
N_2D_2	1.34	12.49	153.17	17.10
C.D	0.07	0.90	2.17	0.54
$V_1N_0D_0$	1.32	8.43	11.70	1.99
$V_1N_OD_1$	1.29	9.34	13.77	2.66
$V_1N_OD_2$	0.95	3.19	12.24	2.30
$V_1N_1D_0$	1.59	12.67	9.30	1.63
$V_1N_1D_1$	1.52	11.22	13.37	1.56
$V_1N_1D_2$	1.27	7.86	10.63	2.10
$V_1N_2D_0$	1.49	10.99	8.56	1.63
$V_1N_2D_1$	1.61	10.87	9.90	1.91
$V_1N_2D_2$	1.40	12.30	12.77	1.83
$V_2N_0D_0$	1.11	8.84	213.32	34.64
$V_2N_OD_1$	0.76	6.06	288.89	30.06
$V_2N_OD_2$	1.00	10.78	290.90	26.75
$V_2N_1D_0$	1.07	12.96	276.18	28.35
$V_2N_1D_1$	1.04	13.62	392.54	35.04
$V_2N_1D_2$	1.14	12.44	294.24	30.49
$V_2N_2D_0$	1.25	16.52	261.47	27.82
$V_2N_2D_1$	1.22	13.89	261.46	28.71
$V_2N_2D_2$	1.29	12.68	293.57	32.37
C.D.	0.10	1.27	3.07	0.76

was at par with sun drying (15.54 µg g^{-1}). Similar findings were noticed by Singh *et al.* (2002) in zinnia that degradation of pigments was lowest in room dried flowers. In interaction, maximum carotenoid contents (31.30 µg g^{-1}) were observed in Pusa Narangi Gainda with well rotten farm yard manure treated plot. Pusa Narangi Gainda with ventilated shade drying method produced maximum carotenoid contents in dried petal (32.50 µg g^{-1}). Flower petals obtained from well rotten farm yard manure treated plots when ventilated shade dried showed maximum carotenoid contents (18.34µg g^{-1}). While, flower petals of Pusa Narangi Gainda obtained from well rotten farm yard manure treated plot when ventilated shade dried produced more carotenoid contents (35.04µg g^{-1}).

Thus, it was apparent through entire investigation that cultivar Pusa Basanti Gainda and farm yard manure were significantly associated with qualitative and quantitative characters, while Pusa Narangi Gainda yielded more carotenoid contents in ventilated shade drying methods.

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