

Improvement in Flowering, Yield and Vase Life of French Marigold (Red Brocade) through Application of Mustard Oil Cake and Vermicompost Extracts

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ABSTRACT

Modern flower cultivation is based on the use of organic manures, which play a major role for producing the good quality and higher yield per unit area. There is need to seek alternative nutrient sources, which should be cheap and eco-friendly so that farmers may be able to reduce the investment made on fertilizer with maintaining good soil environmental conditions leading to ecological sustainable farming. The present study was undertaken on the agriculture farm of Horticulture, School of Agriculture, ITM University, Gwalior during the year 2020-21 with the objectives to find out the most effective combination of organic nutrient sources for better growth, yield, vase life of flowers and economics of marigold cultivation. On the basis of the current investigation, it was concluded that the treatment T₁₁ (75% of farm yard manure+25% vermicompost as liquid) produced maximum yield of flowers, net as well as gross income and benefit: cost ratio (1 : 2.54) with improvement in vegetative, floral and vase life characters of flowers in comparison to other treatments.

Key words: Benefit : cost ratio, French marigold, organic sources, vermicompost, vase life

INTRODUCTION

Floriculture is the aesthetic side of horticulture, which consists of growing plants for ornamental purposes. Flowers symbolize purity, beauty, peace, love, passion apart from providing fresh air and fragrance. In India, it is being grown traditionally for religious need, perfume production and landscaping. At present, the floriculture industry has been transformed due to accelerated demand, technological development, growing consciousness for environment and quality flowers.

French marigold (*Tagetes patula* L.) and African marigold (*Tagetes erecta* L.) are cultivated since 15th centuries in the Europe. The Portuguese reported to introduce marigold in India during that period (Doctor, 2017; Mir *et al.*, 2019). It was adopted and spread quickly due to its easy propagation, cultivation, longer flowering phase and beautiful flowers with longer vase

life. Owing to its brilliant flower colour, pleasant appearance, variable shape, size and forms, delightful fragrance and industrial demand, it is being grown at large scale in India covering a greater proportion in traditional flower production. At present, a larger area is being used for commercial cultivation and as bedding plants in landscape design.

Marigold produces sulphur containing secondary compounds mainly in root known as thiophens, which is toxic to nematodes (Gupta *et al.*, 2021). The marigold cultivation not only results in suppression of soil nematodes but also has broad spectrum insecticidal effect. The essential oil from the flower is in great demand in industries. It is a major source of pigments in poultry feed and is commercially used for pigment deposition and for improving colour in poultry products (Mirzah and Djulard, 2017). Thus, it is preferred to be cultivated organically.

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Modern agriculture is shifting towards organic approach to produce good quality produce and maintain the ecological health. Vermicompost is the excreta of earthworms, which is rich in humus and nutrients. It is finely divided peat like material with high porosity, aeration, drainage and water holding capacity and consists about 0.51-1.61% N, 0.19-1.02% P and 0.15-0.73% K (Domínguez *et al.*, 2017). Mustard oil cake is a rich source of nutrients containing 5.2% N, 1.8% P and 1.2% K (Rahman *et al.*, 2018). The vermicompost and mustard oil cakes can be used to prepare the extracts which have greater potential for enhancing growth and economic yield in marigold. Due to huge amount of organic matter, these are good for improvement of physico-chemical properties of soil and ensure the sustainability in soil fertility and productivity (Rahman *et al.*, 2018). In addition to improvement in physico-chemical and biological properties through moisture and soil nutrient conservation, the organic nutrient sources also reduce the production cost in agriculture. The present study was carried out with the objective to find out the most effective combination of organic nutrient sources containing farm yard manure (FYM) and vermicompost oil (VC) or mustard oil cake (MOC) for better improvement in growth, yield and vase life for commercial cultivation of French marigold.

MATERIALS AND METHODS

The experiment was conducted at Research Farm of School of Agriculture, ITM University, Gwalior (M. P.). The location can be characterized as sub-tropical climate with hot and dry summer with maximum temperature exceeding 45°C in May-June. The winters were cold with the temperatures reaching as low as 2°C in December and January. The climatic condition was suitable to grow cauliflower in this region at commercial level. The present investigation was carried out following standard protocols of all agronomical practices. The experimentation was executed during *rabi* season of 2020-21. The experiment was laid out in randomized block design with three replications and 14 treatments viz., T₀-Control, T₁-100% FYM as basal, T₂-50% FYM+50% VC as solid, T₃-50% FYM+50% VC as liquid, T₄-50% FYM+50% MOC as solid, T₅-50% FYM+50% MOC as liquid, T₆-25%

FYM+75% VC as solid, T₇-25% FYM+75% VC as liquid, T₈-25% FYM+75% MOC as solid, T₉-25% FYM+75% MOC as liquid, T₁₀-75% FYM+25% VC as solid, T₁₁-75% FYM+25% VC as liquid, T₁₂-75% FYM+25% MOC as solid and T₁₃-75% FYM+25% MOC as liquid.

The observations were recorded for various parameters viz., plant height (cm), counts of primary branches, length of primary branches (cm), counts of secondary branches, leaf area (cm²), stem girth (cm), plant spread (cm), days taken to bud initiation, bud length (cm), days taken to first blooming, days taken to 50% flowering and 100% flowering, total duration of flowering (days), flower diameter (cm), number of flowers per plant, number of flowers per plot, fresh weight of flowers (g), dry weight of flowers (g), fresh flower yield (q/ha), vase-life with and without water spray treatment and benefit : cost ratio.

RESULTS AND DISCUSSION

The plant growth parameters viz., plant height (cm), count (number) of primary branches, length of primary branches (cm), count of secondary branches, leaf area (cm²), stem girth (cm) and plant spread (cm) were significantly influenced by manures (FYM, vermicompost and mustard oil cake) at all the stages of crop growth viz., 15, 30, 45 and 60 days after transplanting (DAT) (Tables 1 and 2). The maximum plant height (9.48 cm) at 15 days after transplanting (DAT) was recorded in the treatment combination of T₁₁ followed by T₁ (9.42 cm) and T₈ (9.41 cm). The maximum number of primary branches/plant (9.84) at 15 DAT was recorded in the treatment combination of T₁₁ followed by T₈ (9.24) and T₉ (9.04). The maximum length of primary branches (6.41 cm) at 15 DAT was recorded in the treatment combination of T₁₁ followed by T₁ (6.17 cm) and T₁₃ (6.06 cm). The maximum leaf area of (48.30 cm²) was recorded in treatment T₁₁ followed by T₄ (47.05 cm²) and T₉ (45.03 cm²). The maximum stem girth (2.87 cm) was recorded in treatment T₁₁ followed by T₄ (2.80 cm) and T₈ (2.78 cm). The maximum plant spread (11.46 cm) at 15 DAT was recorded in the treatment combination of T₁₁ followed by T₁ (11.27 cm) and T₉ (11.05 cm). Similar trend was reported at 30, 45 and 60 DAT. The observations related to various growth parameters viz., plant height (cm), number of

Table 1. Plant growth parameters viz., plant height (cm), counts (numbers) and length of primary branches (cm) in French marigold under organic cultivation

Treatment	Plant height (cm)				Counts (number) of primary branches				Length of primary branches (cm)			
	15 DAT	30 DAT	45 DAT	60 DAT	15 DAT	30 DAT	45 DAT	60 DAT	15 DAT	30 DAT	45 DAT	60 DAT
T ₀	7.06	11.47	22.33	25.59	7.13	9.26	12.01	15.13	5.73	8.29	16.05	20.34
T ₁	9.42	13.75	26.11	31.06	8.20	10.44	16.36	17.90	6.17	9.51	25.11	29.52
T ₂	9.42	13.08	24.82	27.05	7.62	9.76	14.41	16.74	5.81	9.61	17.07	21.67
T ₃	8.31	12.53	27.16	34.38	6.87	9.99	14.32	16.95	5.48	9.64	22.23	27.67
T ₄	8.93	12.78	26.90	30.01	7.83	10.10	15.14	17.39	5.91	10.53	18.20	23.75
T ₅	8.41	12.08	25.32	31.11	7.47	10.34	15.19	17.47	5.71	10.26	18.31	23.06
T ₆	8.77	13.39	27.32	33.37	8.07	11.03	16.50	19.74	5.73	10.66	21.74	26.92
T ₇	8.01	13.53	26.52	28.23	7.47	11.47	16.51	19.40	5.93	11.17	19.86	23.80
T ₈	9.41	12.47	24.24	28.13	9.24	11.01	16.43	17.94	5.91	11.30	21.83	25.33
T ₉	7.93	12.26	25.22	30.05	9.04	11.37	17.17	19.09	5.87	9.86	18.25	22.65
T ₁₀	8.43	12.21	24.14	31.55	8.54	10.94	13.42	16.70	5.14	10.49	20.95	26.00
T ₁₁	9.48	13.98	27.38	35.33	9.84	12.50	17.23	21.21	6.41	11.71	25.20	30.55
T ₁₂	9.03	12.55	23.05	27.26	8.37	11.20	16.07	18.26	5.90	11.08	23.30	28.92
T ₁₃	8.64	12.42	25.37	31.33	8.43	10.54	14.11	17.27	6.06	11.33	25.15	29.59
C. D. (P=0.05)	2.043	1.007	2.710	1.447	1.947	0.529	1.238	1.269	0.806	0.549	0.881	0.545
S. Em±	0.703	0.346	0.943	0.498	0.670	0.182	0.426	0.437	0.277	0.189	0.303	0.188

Table 2. The counts (numbers) of secondary branches, leaf area (cm²), stem girth (cm) and plant spread (cm) of French marigold under organic cultivation

Treatment	Counts of secondary branches	Leaf area (cm ²)	Stem girth (cm)	Plant spread (cm)			
				15 DAT	30 DAT	45 DAT	60 DAT
T ₀	19.73	21.18	1.81	9.47	10.39	17.08	22.33
T ₁	23.60	35.05	2.55	11.27	12.93	20.59	25.15
T ₂	23.07	22.93	2.08	10.56	12.48	21.85	26.64
T ₃	21.97	37.19	2.31	10.26	12.76	21.31	33.82
T ₄	29.53	47.05	2.80	11.02	12.79	21.63	25.49
T ₅	31.00	33.24	2.63	10.28	12.45	27.16	32.68
T ₆	40.63	43.75	2.33	10.14	12.93	27.45	33.89
T ₇	26.80	34.98	2.34	9.90	13.47	26.14	30.83
T ₈	22.10	25.88	2.78	10.68	13.26	25.95	30.21
T ₉	36.60	45.03	2.73	11.05	13.18	26.11	31.17
T ₁₀	39.07	28.03	2.37	10.31	12.68	32.68	39.10
T ₁₁	46.10	48.30	2.87	11.46	13.98	33.34	39.38
T ₁₂	26.93	41.66	2.43	11.05	13.66	24.84	29.04
T ₁₃	32.90	41.45	2.55	10.95	12.71	32.68	37.56
C. D. (P=0.05)	2.850	0.897	0.172	0.906	0.673	1.112	0.910
S. Em±	0.981	0.308	0.059	0.312	0.232	0.383	0.313

primary branches, length of primary branches (cm), number of secondary branches, leaf area (cm²), stem girth (cm) and plant spread (cm) on French marigold after application of FYM in combination with vermicompost or mustard oil cake in solid or liquid form had confirmed a significant effect of addition of vermicompost or mustard oil cake with FYM in different doses in comparison to FYM 100% alone. This might be associated with continuous availability of

nutrients throughout the growth period of marigold plants. Further, the growth was reported to be significantly influenced by the application of vermicompost in liquid form which might be associated with ability of vermicompost to provide phytohormones as well as micronutrients which were essential for growth of the plants as described by Madhuri *et al.* (2018), Pandey *et al.* (2018), Bordoloi and Talukdar (2019) and Kaushik and Singh (2020).

However, there was no significant variation reported due to difference in proportion of FYM and vermicompost/mustard oil cake except few cases. It is also true that no specific trend was reported regarding form of vermicompost/mustard oil cake in which it was applied.

The floral parameters viz., days taken to bud initiation, bud length (cm), days taken to first blooming, days taken to 50 and 100% flowering and total duration of flowering (days) were significantly influenced by manures (FYM, vermicompost and mustard oil cake) at all the stages of crop flowering parameters of French marigold (*Tagetes patula*) var. Red Brocade (Table 3). The minimum days taken to bud initiation (45.33 days) were recorded in treatment T₁₁ followed by T₁ and T₁₀ (46.33 days), further followed by T₄, T₅, T₁₂ and T₁₃ (47 days). The maximum bud length (5.18 cm) was recorded in treatment T₁₁ followed by T₃ (4.88 cm) and T₇ (4.37 cm). The minimum days taken to first blooming (50.33 days) were recorded in treatment T₁₁ followed by T₂, T₃ and T₁₀ (53.00 days); further followed by T₄ (53.33 days). The minimum days to 50% flowering (59.67 days) were recorded in treatment T₁₁ followed by T₃ (61.33 days) and T₁₀ (61.67 days). The minimum days to 100% flowering (68.67 days) were recorded in treatment T₁₁ followed by T₁₀ and T₁₃ (69.00 days); further followed by T₁₂ (69.33 days). The minimum total duration of flowering (62.67 days) was recorded in treatment T₁₁ followed by T₁ (69.67 days), T₁₀

and T₁₃ (72.33 days). The improvement in flowers as least number of days taken for bud initiation, large bud size, least number of days taken for first blooming, 50 or 100% flowering was reported due to application of 75% FYM in combination with 25% of vermicompost as liquid. Thus, application of vermicompost might be responsible for accelerating synthesis of phytohormones like auxins or gibberellins which could have accelerated the flowering in marigold. The similar findings have been reported by Pandey *et al.* (2018), Bordoloi and Talukdar (2019) and Chaupoo and Kumar (2020).

The observations recorded on yield and related attributes of marigold like flower diameter, flower count and flower weight (fresh and dry) confirmed the significant variation due to various treatments consisting different proportions of FYM and vermicompost or mustard oil cake in solid or liquid form (Table 4). The maximum flower diameter (3.78 cm) was recorded in treatment T₁₁ followed by T₁₃ (3.68 cm) and T₉ (3.63 cm). The maximum number of flowers/plant (79.00) was recorded in treatment T₁₁ followed by T₁₀ (62.67) and T₁₃ (60.67). The maximum number of flowers/plot (1185.00) was recorded in treatment T₁₁ followed by T₁₀ (940.00) and T₁₃ (910.00). The maximum fresh weight of flowers (1.60 g) was recorded in treatment T₁₁ followed by T₁ (1.59 g) and T₄ (1.53 g). The maximum dry weight of flowers (0.28 g) was recorded in treatment

Table 3. The floral parameters of French marigold under organic cultivation

Treatment	Days to bud initiation	Bud length (cm)	Days to first blooming	Days to 50% flowering	Days to 100% flowering	Total duration of flowering (days)
T ₀	54.33	3.03	61.00	71.00	83.33	83.00
T ₁	46.33	3.28	54.00	63.00	70.67	69.67
T ₂	47.67	3.86	53.00	63.00	71.00	76.33
T ₃	47.33	4.88	53.00	61.33	71.33	75.00
T ₄	47.00	3.70	53.33	62.67	72.00	75.33
T ₅	47.00	3.40	54.00	62.33	71.67	76.00
T ₆	48.67	3.57	56.00	67.00	75.00	81.00
T ₇	47.67	4.37	56.67	68.00	75.67	77.67
T ₈	49.00	4.21	57.67	70.33	77.00	73.00
T ₉	49.00	4.17	58.67	70.33	76.67	81.67
T ₁₀	46.33	4.10	53.00	61.67	69.00	72.33
T ₁₁	45.33	5.18	50.33	59.67	68.67	62.67
T ₁₂	47.00	3.45	54.67	63.33	69.33	72.67
T ₁₃	47.00	3.67	54.33	64.33	69.00	72.33
C. D. (P=0.05)	1.569	0.159	2.015	2.018	2.327	3.781
S. Em±	0.540	0.055	0.693	0.694	0.801	1.301

Table 4. The yield related attributes and vase life of French marigold under organic cultivation

Treatment	Flower diameter (cm)	No. of flowers/plant	No. of flowers/plot	Fresh weight of flowers (g)	Dry weight of flowers (g)	Fresh flower yield (q/ha)	Without water spray treatment (days)	With water spray treatment (days)
T ₀	2.79	24.00	245.33	1.27	0.20	20.70	0.67	5.00
T ₁	3.56	33.33	500.00	1.59	0.26	53.23	1.25	5.42
T ₂	3.60	32.33	485.00	1.44	0.25	59.34	1.17	5.50
T ₃	3.51	42.67	640.00	1.41	0.24	60.17	1.42	5.67
T ₄	3.61	40.67	610.00	1.53	0.27	62.05	1.25	5.33
T ₅	3.30	55.00	825.00	1.37	0.22	75.04	1.25	6.58
T ₆	3.60	48.67	730.00	1.45	0.25	70.27	0.58	5.58
T ₇	3.59	39.33	590.00	1.30	0.21	51.24	1.00	5.50
T ₈	3.53	36.67	550.00	1.33	0.23	48.65	0.83	6.42
T ₉	3.63	46.67	700.00	1.33	0.22	62.57	1.00	6.50
T ₁₀	3.45	62.67	940.00	1.45	0.25	90.91	0.83	5.33
T ₁₁	3.78	79.00	1185.00	1.60	0.28	126.35	1.75	6.75
T ₁₂	3.50	42.67	640.00	1.42	0.25	60.30	1.17	5.33
T ₁₃	3.68	60.67	910.00	1.38	0.26	94.06	1.42	5.25
C. D. (P=0.05)	0.385	3.512	52.682	0.318	0.064	14.556	0.514	0.372
S. Em±	0.132	1.208	18.123	0.110	0.022	5.007	0.177	0.128

T₁₁ followed by T₄ (0.27 g), T₁ and T₁₃ (0.26 g). The maximum fresh flower yield (126.35 q/ha) was recorded in treatment T₁₁ followed by T₁₃ (94.06 q/ha) and T₁₀ (90.91 q/ha). All the treatments were reported to affect yield attributes positively in comparison to control. Among various FYM doses, the variation was primarily due to application of vermicompost which could be due to growth promoting response of vermicompost, while mustard oil cake might have protected the plant from insect infestation resulting in better growth and flowering. The current findings can be justified with the results obtained by Patel *et al.* (2018) in African marigold and Sahu *et al.* (2021) in Dahlia.

The vase life with or without water spray treatment was significantly influenced by manures (FYM, vermicompost and mustard oil cake; Table 4). The maximum vase life without water spray treatment (1.75 days) was recorded in treatment T₁₁ followed by T₃ and T₁₃ (1.42 days); further followed by T₁, T₄ and T₅ (1.25 days). The minimum vase life without water spray treatment was found in T₀ control (0.67 days). The maximum vase life with water spray treatment (6.75 days) was recorded in treatment T₁₁ followed by T₅ (6.58 days) and T₉ (6.50 days). The minimum vase life with water spray treatment was found in T₀ control (5.00 days). The vase life is an

important commercial attribute as it provides opportunity for better marketing and high economics. The vase life of marigold with water spray was greater than without water spray which might be associated with maintenance of turgidity of cells in presence of water. In both the cases, vase life was significantly high for the flowers of plant supplied with 50-75% of FYM 25-50% of vermicompost or mustard oil cake in different forms. The vermicompost might be responsible for better quality flowers which were able to remain fresh for longer period, while mustard oil cake was able to protect the plants and flowers with any kind of injury due to insect or disease infestation thus extending the self-life of flowers. The findings are in confirming with findings of Kumura *et al.* (2019) and Kaushik and Singh (2020).

The cost of cultivation of marigold is a function of cost of inputs used during the marigold production. It is the sum total of variable costs and fixed costs. The purchase rate of mustard oil cake is higher than that of FYM and vermicompost but the higher cost of cultivation in T₆ and T₇ (Rs. 168614.00); T₂ and T₃ (Rs. 155642.00) may be due to application of FYM or vermicompost in heavy quantities. Gross returns are the total money amount procured from the market after the sale of marketable produce, which was reported

Table 5. Economics of different treatments and benefit : cost ratio of French marigold cultivation under organic condition

Treatment	Gross returns (Rs./ha)	Cost of cultivation (Rs./ha)	Net returns (Rs./ha)	Benefit : cost ratio
T ₀	82798.22	75692.00	7106.22	0.09
T ₁	212933.33	129692.00	83241.33	0.64
T ₂	237360.00	155642.00	81718.00	0.53
T ₃	240693.33	155642.00	85051.33	0.55
T ₄	248213.33	124317.00	123896.33	1.00
T ₅	300186.67	124317.00	175869.67	1.41
T ₆	281093.33	168614.00	112479.33	0.67
T ₇	204960.00	168614.00	36346.00	0.22
T ₈	194613.33	121617.00	72996.33	0.60
T ₉	250293.33	121617.00	128676.33	1.06
T ₁₀	363653.33	142664.00	220989.33	1.55
T ₁₁	505413.33	142664.00	362749.33	2.54
T ₁₂	241226.67	126992.00	114234.67	0.90
T ₁₃	376240.00	126992.00	249248.00	1.96

higher in T₁₁ (Rs. 505413.33), T₁₃ (Rs. 376240.00), T₁₀ (Rs. 363653.33) and T₅ (Rs. 300186.67) which may be due to higher yield of flowers in these treatments. Similarly, the net returns were also higher in T₁₁ (Rs. 362749.33) followed by T₁₃ (Rs. 249248.00), T₁₀ (Rs. 220989.33) and T₅ (Rs. 175869.67), which may be a result of low cost of inputs and higher yield of flowers in the said treatments. Further, the reported B : C ratio was higher in T₁₁ (2.54), followed by T₁₃ (1.96), T₁₀ (1.55) and T₅ (1.41). The higher ratio of benefit and cost in these treatments might be caused by greater net returns and lower cultivation cost (Table 5). From the present investigation, it was confirmed that application of organic sources of nutrients was not always a profitable practice; however, through proper standardization of doses and forms of application of these sources the benefits from organic cultivation of marigold could be improved. In the present studies, it is confirmed that application of mustard cake or vermicompost in form of liquid is good approach with higher dose of FYM (75%) is most profitable practice which might be associated with availability of sufficient nutrients through higher dose of FYM and effective utilization of liquid sources of nutrients in form of vermicompost or mustard cake. The liquid form might have greater surface contact and greater absorption and utilization of nutrients by the plants resulting in greater yield and so greater economic returns in form of gross returns, net returns and benefit : cost ratio. The findings are in conformity with the recommendations proposed by Madhuri *et al.* (2018).

CONCLUSION

The application of organic sources of nutrients including 75% of FYM in combination with 25% of vermicompost as liquid was found to be the best treatment combination in respect of plant growth, flowering, flower yield and vase life parameters of French marigold var. Red Brocade grown under Gwalior agro-climatic conditions. The maximum benefit : cost ratio (2.54:1) was reported with treatment T₁₁ (75% of FYM+25% of vermicompost as liquid). Considering the research objectives, the experimental findings can be concluded as : treatments with 75% FYM and 25% vermicompost as liquid (T₁₁) was observed as most effective combination for growth and yield in French marigold. Although vase life was good in all treatments, T₁₁ (75% FYM+25% VC liquid) was reported to be best with maximum vase life (1.75 days without water spray and 6.75 days with water spray). T₁₁ was reported as most economical treatment with highest net returns (Rs. 362749.33/ha) and B : C ratio of 2.54 : 1 on net income basis.

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