

Soil Fertility Status, Nutrient Uptake and Productivity of Marigold (*Tagetes erecta* Linn.) as Influenced by Fertilizer Doses and Plant Growth Regulators

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Authors' contributions

This work was carried out in collaboration among all authors. Author NB designed the study, managed the literature searches, conducted the field experiment, performed the laboratory analyses for vermicompost and comlizer, statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author JD provided the administrative and technical support, monitored the field experiment and reviewed the first draft of the manuscript. Authors NCD, ICB, BKS and Kaushik Das provided the technical support, monitored the field experiment and reviewed the first draft of the manuscript. Author Kankana Deka managed the analyses of the crop growth and yield parameters of the study. Author KG managed the laboratory analyses for plant and soil parameters. All authors read and approved the final manuscript.

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ABSTRACT

Aims: A field experiment was conducted to evaluate soil fertility status, nutrient uptake, growth and yield of African marigold (*Tagetes erecta* Linn.) as influenced by fertilizer management with or without foliar spray of plant growth promoting chemicals.

Study Design: The field experiment was conducted with eight treatments, each being replicated thrice in a randomized block design (RBD).

Place and Duration of Study: Instructional cum research (ICR) farm, Assam Agricultural University, Jorhat, Assam (India), between September 2013 and January 2015.

Methodology: The treatments comprised of an unfertilized plot, application of 2500 kg ha⁻¹ vermicompost at planting followed by 10 kg ha⁻¹ each of N, P₂O₅ and K₂O in two equal splits at the time of planting and at 30 days after planting (DAP), 2500 kg ha⁻¹ vermicompost as mixture with fertilizer (*comlizer*) 10:10:10 kg ha⁻¹ (*Comlizer-1*) or 30:10:30 kg ha⁻¹ (*Comlizer-2*) of N, P₂O₅ and K₂O, respectively applied in two splits (planting and at 30 DAP). Each *comlizer* treatment had two supplementary treatments of spraying either vermiwash solution (10% on second and third weeks and 20% solution on fourth and fifth weeks after planting) or indole butyric acid (IBA) and kinetin mixture (IBA-kinetin) solution (0.01% each on second and third weeks and 0.02% each on fourth and fifth weeks after planting), respectively.

Results: The soil pH, organic carbon and available phosphorous contents after harvest of the crop were not affected by the treatments. The available nitrogen content in soil significantly increased in *comlizer-2*, but the available potassium content was not affected by the fertilizer doses. The NH₄-N and NO₃-N in soil at 15 and 45 DAP increased significantly with application of *comlizer-2*. Phosphorous and potassium uptake by aerial biomass of marigold at 21 and 42 days after planting significantly increased in *Comlizer-2*, but the effect of foliar spray was not significant. The highest fresh flower yield was produced by application of *Comlizer-2* with foliar spray of vermiwash, and differed significantly to the rest of the treatments.

Conclusion: Application of mineral fertilizers as mixture with vermicompost and integrated with foliar spray of growth regulators showed promising results. Further works with higher doses of nutrient and compost, frequency and intensity of foliar application of growth regulators are required to develop cost effective nutrient management practice.

Keywords: Mineral fertilizer; organic fertilizer; foliar application; biological activity; growth regulator.

1. INTRODUCTION

Commercial horticulture has recently been recognized playing an important role in livelihood improvement of small farm units in India. The higher return, relative to other crop groups, was the main driving force for diversification in favour of commercial flower cultivation [1] or fruits and vegetables [2]. There had been a continuous increase in area under floriculture and production of loose and cut flowers during 2006-07 to 2013-14 in India [1]. African marigold is an important flower crop among the loose and cut flowers cultivated in Assam. The crop is normally grown in winter with seed sowing in October to November followed by transplanting of seedlings on attaining a height of 5-7 cm [3]. The 'Siracole' variety had been reported to have the potential for year-round flower production [4] but its performance as a late kharif crop in the state had not yet been reported. The feasibility of September or October planting is expected to fetch higher

income through early flower availability in the market, and compensate the failure of other kharif crops due to unwarranted rainfall during sowing.

Marigold shows good response to fertilizers to meet up its high requirements of nitrogen and potassium, especially at early growth stages. The positive response of marigold to potassium levels in terms of growth characters and yield had been reported [5], while enhanced nitrogen dose increased flower yields but with a decline in oil content [6]. Foliar application of organic fertilizer instead of mineral fertilizer produced higher nutrient concentrations in marigold [7]. The combined application of vermicompost and vermiwash enhancing growth and yield of okra [8], and the potential of vermiwash as foliar spray in other crops was reported [9]. Improved growth parameters in tomato were observed under moderate and severe drought stress with spraying of kinetin [10]. *Comlizer*, a mixture of compost and fertilizer, could reduce half of the

chemical fertilizer doses without yield decline in tuberose [11]. Split application of N, P and K fertilizer was recently reported to enhance the yield of marigold as an intercrop with banana [12]. The present study was accordingly planned to evaluate different doses of nitrogen and potassium fertilizers as mixture with vermicompost (*comlizer*) in split applications with or without foliar spray of vermiwash or commercial plant growth regulators on soil fertility, nutrient uptake, growth and yield of African marigold (*Tagetes erecta* Linn.) cv. 'Siracole'.

2. MATERIALS AND METHODS

A field experiment was conducted at Assam Agricultural University's ICR farm (situated at 91 m above MSL and 26°44'N, 94°10'E) during 2013-14 and 2014-15 (September to January). The treatments comprised of an T_1 - unfertilized plot, T_2 - 2500 kg ha⁻¹ vermicompost before planting followed by recommended dose of 10:10:10 kg ha⁻¹ of N, P₂O₅ and K₂O in two equal splits at the time of planting and at 30 days after planting (DAP), T_3 - 2500 kg ha⁻¹ vermicompost and 10:10:10 kg ha⁻¹ of N, P₂O₅ and K₂O applied as instant compost-fertilizer mixture (*comlizer-1*) at planting and 30 DAP, T_4 - T_3 + foliar spray of 10% (v/v, liquid fertilizer: water) vermiwash solution at 14 and 21 DAP and 20% vermiwash solution at 28 and 35 DAP, T_5 - T_3 + foliar spray of 0.01% (w/v, solute: water) each of IBA and kinetin (IBA-kinetin) solution at 14 and 21 DAP and 0.02% IBA-kinetin solution at 28 and 35 DAP, T_6 - 2500 kg ha⁻¹ vermicompost and 30:10:30 kg ha⁻¹ of N, P₂O₅ and K₂O applied as instant compost-fertilizer mixture (*comlizer-2*) in two equal splits at planting and at 30 DAP, T_7 - T_6 + foliar spray of 10% vermiwash solution at 14 and 21 DAP followed by 20% vermiwash solution at 28 and 35 DAP and T_8 - T_6 + foliar spray of IBA-kinetin solution 0.01% at 14 and 21 DAP and 0.02% at 28 and 35 DAP. The vermicompost used in the experiment contained total nutrients as 1.62% N, 0.96% P, 2.01% K in 2013 season, and 1.81% N, 0.89% P, 1.84% K in 2014 season. The vermiwash available in the local market was used for spray in the experiment without biochemical analysis. The treatments were replicated thrice in a randomized block design with individual plot size of 3.6 m x 3.0 m on a sandy loam soil with dry bulk density 1.39 Mg m⁻³, pH 5.5, electrical conductivity 0.15 dS m⁻¹, organic carbon 6.4 g kg⁻¹, cation exchange capacity 5.64 c mol (p⁺) kg⁻¹, available N, P, K of 248.3, 19.6, 88.2 kg ha⁻¹ and NH₄-N

and NO₃-N of 46.4 and 22.6 mg kg⁻¹, respectively.

Seedlings of African marigold (*Tagetes erecta* Linn.) cv. 'Siracole' were planted on 25th September in 2013 (seedling height 7.88±0.14 cm) and 1st October in 2014 (seedling height 7.47±0.22 cm) at a uniform spacing of 30 cm between plants and rows. The harvesting of marigold flowers in each season was completed by the end of January. The different plant growth characters, yield attributes were recorded in five previously marked plants of each plot, and the mean values were considered for data analysis and interpretation. The representative plant samples were collected at different growth stages for nutrient content and chlorophyll analysis. Surface (0-15 cm) soil samples were collected at different growth stages and after harvest of the crop in each season. The various parameters for soil and plant analysis were estimated following standard protocol described elsewhere and as shown in the Table 1.

The vermicompost in each season was evaluated for bacterial count, both before and one hour after mixing with mineral fertilizer (*comlizer*). The population of *Azotobacter* and phosphate solubilizing bacteria (PSB) was estimated by plating 100 microlitres of vermicompost or *comlizer*, prepared through serial dilution of 1 gram of the respective sample, separately in Burk's medium and Pikovskaya's medium, respectively. The colony forming units (cfu) were counted in the plates after incubation at 28±2°C for 48–72 hours and the values were expressed as cfu gram⁻¹ for the specific dilution [19]. The NH₄-N and NO₃-N in the soils were determined colorimetrically in 1 N sodium sulphate extract after suitable dilution [20]. The chlorophyll was extracted by mixing a known mass of marigold leaves in 80% (w/w) acetone and centrifugation at 5000 rpm for 15 minutes after keeping the content at 4°C overnight in dark. The absorbance of the supernatant extract was measured against an 80% acetone blank in a *uv-vis*-spectrophotometer, and the chlorophyll contents were calculated as described elsewhere [21]. The flower yield in every plucking was recorded separately for each plot and the cumulative total was converted to fresh flower yield per hectare. A one-way ANOVA was carried out to compare the means of the different treatments. When significant F-values were detected, the differences between individual means were tested using the least significant difference (LSD) test.

Table 1. Methods used for determination of various soil and plant parameters

Parameter	Method
Bulk density	gravimetric method with undisturbed soil [15] using a stainless steel metallic core (5.4 cm internal diameter and 12 cm height)
Soil pH	soil: water (10:25) suspension, glass electrode pH meter [13]
Electrical conductivity	soil: water (10:25) suspension, conductivity bridge [13]
Cation exchange capacity	centrifuge method [14]
Organic carbon	K ₂ Cr ₂ O ₇ wet oxidation method [16]
Available nitrogen	alkaline KMnO ₄ method [17]
Available phosphorous	Bray 1 solution [18] extract using uv-vis spectrophotometer [14]
Available potassium	1 N CH ₃ COONH ₄ extract (pH 7.0) using flame photometer [13]
Total N in plant and vermicompost	Kjeldahl method as described elsewhere [14]
Total P and K in plant and vermicompost	di-acid digestion of the sample followed by estimation of P in uv-vis spectrophotometer and K in flame photometer [13]

3. RESULTS AND DISCUSSION

3.1 Bacterial Population and pH in Vermicompost and Comlizer

The pH and bacterial population in vermicompost and *comlizer* are presented in Table 2. The pH of the vermicompost was not affected by mixing of mineral fertilizer, irrespective of N and K doses (*comlizer 1* and *comlizer 2*). The population of *Azotobacter* and phosphate solubilizing bacteria (PSB) significantly decreased one hour after mixing with mineral fertilizer, but the effect of N and K doses was not significant.

The reduction in population of bacteria in vermicompost after mixing with mineral fertilizers conforms to the results reported earlier [22,23]. The reduction in bacterial population due to mixing of mineral fertilizer was due to production of toxic substance by urea through a complex mechanism not clearly known [24].

3.2 Growth and Yield Parameters

3.2.1 Plant height and number of branches

The plant height of marigold was not affected by the treatments at 30 days after planting (DAP), but differed significantly thereafter (Table 3). The tallest plant, in each season, at 60 and 90 DAP was recorded with application of vermicompost 2500 kg ha⁻¹ and enhanced doses of N and K fertilizers mixture (*comlizer-2*), which differed statistically to *comlizer-1* at 60 and 90 DAP and *comlizer-1* and *comlizer-1*+IBA-kinetin at 90 DAP. The effect of enhanced doses of N and K fertilizers or spraying of vermiwash or growth regulator on plant height was statistically not significant.

The number of primary branches and secondary branches in a plant significantly increased due to fertilizer application (Table 4). Among the fertilizer treatments, *comlizer-2* produced more number of primary and secondary branches over VC-NPK or *comlizer-1*. The effect of spraying vermiwash or growth regulators (IBA-kinetin) on number of primary branches was observed for *comlizer-1*, but was absent with *comlizer-2*.

In case of secondary branches, significant increase was observed due to foliar spray of vermiwash with *comlizer-1*, while the effect of growth regulators was not recorded irrespective of fertilizer doses. The lowest plant spread was recorded under unfertilized condition (Table 4) and differed significantly to fertilizer treatments. Among the fertilizer treatments, enhanced doses of N and K (*comlizer-2*) significantly increased plant spread than application of VC-NPK or *comlizer-1*. In case of vermiwash, the effect was significant when supplemented with *comlizer-1* but not with *comlizer-2*, while the growth regulators did not show any effect irrespective of *comlizer-1* or *comlizer-2*.

3.2.2 Dry matter accumulation, nutrient uptake and total chlorophyll content in leaves

The dry matter accumulation (DMA) in marigold plants significantly increased at 21 and 42 DAP due to fertilizer application compared to unfertilized plants (Table 5). Application of enhanced N and K fertilizer doses (*comlizer-2*) with or without growth regulators showed significant positive effect on DMA of marigold over *comlizer-1* and VC-NPK. Foliar spray of vermiwash or growth regulators on DMA at 21 and 42 DAP was not significant, irrespective of fertilizer doses.

Table 2. Bacterial population and pH of vermicompost and *comlizer* in 2013-14 and 2014-15 seasons

Treatment	pH*		PSB [#] (-log 10 ⁻⁵ cfu g ⁻¹)		Azotobacter (-log 10 ⁻⁵ cfu g ⁻¹)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Vermicompost	5.6	5.7	8.7	7.3	5.5	6.3
<i>Comlizer 1</i>	5.8	6.0	7.2	6.2	4.3	4.9
<i>Comlizer 2</i>	5.9	6.1	6.5	6.3	3.9	4.1
LSD <i>P</i> = .05	NS	NS	1.4	0.9	0.7	0.9
CV (%)	9.6	7.3	12.6	9.2	10.9	12.5

*1:2.5 sample: water suspension, [#]phosphate solubilizing bacteria

Table 3. Plant height (cm) of marigold at different growth stages of 2013-14 and 2014-15

Treatments	30 DAP*		60 DAP		90 DAP	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Unfertilized	29.6	28.8	40.7	41.3	49.5	51.0
VC-NPK	36.6	35.8	46.7	48.0	59.7	60.9
<i>Comlizer-1</i>	34.1	36.1	45.7	45.9	54.9	55.1
<i>Comlizer-1</i> +vermiwash	32.7	34.6	46.9	47.2	56.1	57.4
<i>Comlizer-1</i> +IBA-kinetin	33.4	31.5	44.7	45.7	55.1	55.4
<i>Comlizer-2</i>	36.3	33.9	46.6	47.6	58.6	60.1
<i>Comlizer-2</i> +vermiwash	34.7	36.2	48.7	50.1	61.3	63.7
<i>Comlizer-2</i> +IBA-kinetin	35.0	35.6	46.7	47.2	58.9	59.8
LSD <i>P</i> = .05	NS	NS	3.0	3.9	5.1	4.7
CV	7.6	10.9	5.4	5.6	6.0	4.8

*DAP – days after planting

Table 4. Number of primary and secondary branches and plant spread of marigold at 90 days after planting

Treatments	Number of primary branches/plant		Number of secondary branches/plant		Plant spread (cm)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Unfertilized	3.9	3.5	12.9	14.0	37.0	35.5
VC-NPK	4.7	4.8	18.7	18.2	43.7	45.3
<i>Comlizer-1</i>	4.5	4.3	17.3	17.9	42.4	41.1
<i>Comlizer-1</i> +vermiwash	5.2	5.5	19.4	20.1	47.2	49.0
<i>Comlizer-1</i> +IBA-kinetin	5.1	5.1	18.5	18.7	45.7	45.6
<i>Comlizer-2</i>	5.3	5.5	20.4	20.7	49.3	50.0
<i>Comlizer-2</i> +vermiwash	5.4	5.5	20.7	21.1	51.2	54.6
<i>Comlizer-2</i> +IBA-kinetin	5.3	5.5	20.1	19.6	48.5	50.7
LSD <i>P</i> = .05	0.5	0.7	1.7	2.0	3.8	5.1
CV	7.3	9.3	6.1	7.0	5.4	7.2

The nutrient uptake by aerial biomass of marigold at 21 and 42 DAP (pooled mean over 2013-14 and 2014-15 seasons) increased significantly due to fertilizer application (Figs. 1a, b, c). Among the fertilizer treatments, the difference in N, P and K uptake was not significant between VC-NPK and *comlizer-1* with or without foliar spray. Enhanced N and K fertilizer doses supplemented with foliar spray of vermiwash (*comlizer-2*+IBA-kinetin) significantly

increased N, P and K uptake by marigold at over VC-NPK or *comlizer-1* at both 21 and 42 days after planting. However, the effect of foliar spray with vermiwash or growth regulators was not observed irrespective of *comlizer-1* or *comlizer-2* (Figs. 1a, b, c).

The total chlorophyll contents (pooled mean over 2013-14 and 2014-15 seasons) in leaves of marigold at 21 and 42 DAP are shown in Fig. 2.

Application of fertilizer increased total chlorophyll content of leaves significantly over unfertilized plant. The effect of applying *comlizer-2*+vermiwash on total chlorophyll contents in

marigold leaves at 42 DAP was significantly higher over all the fertilizer treatments (Fig. 2), however the effect was not observed at 21 DAP.

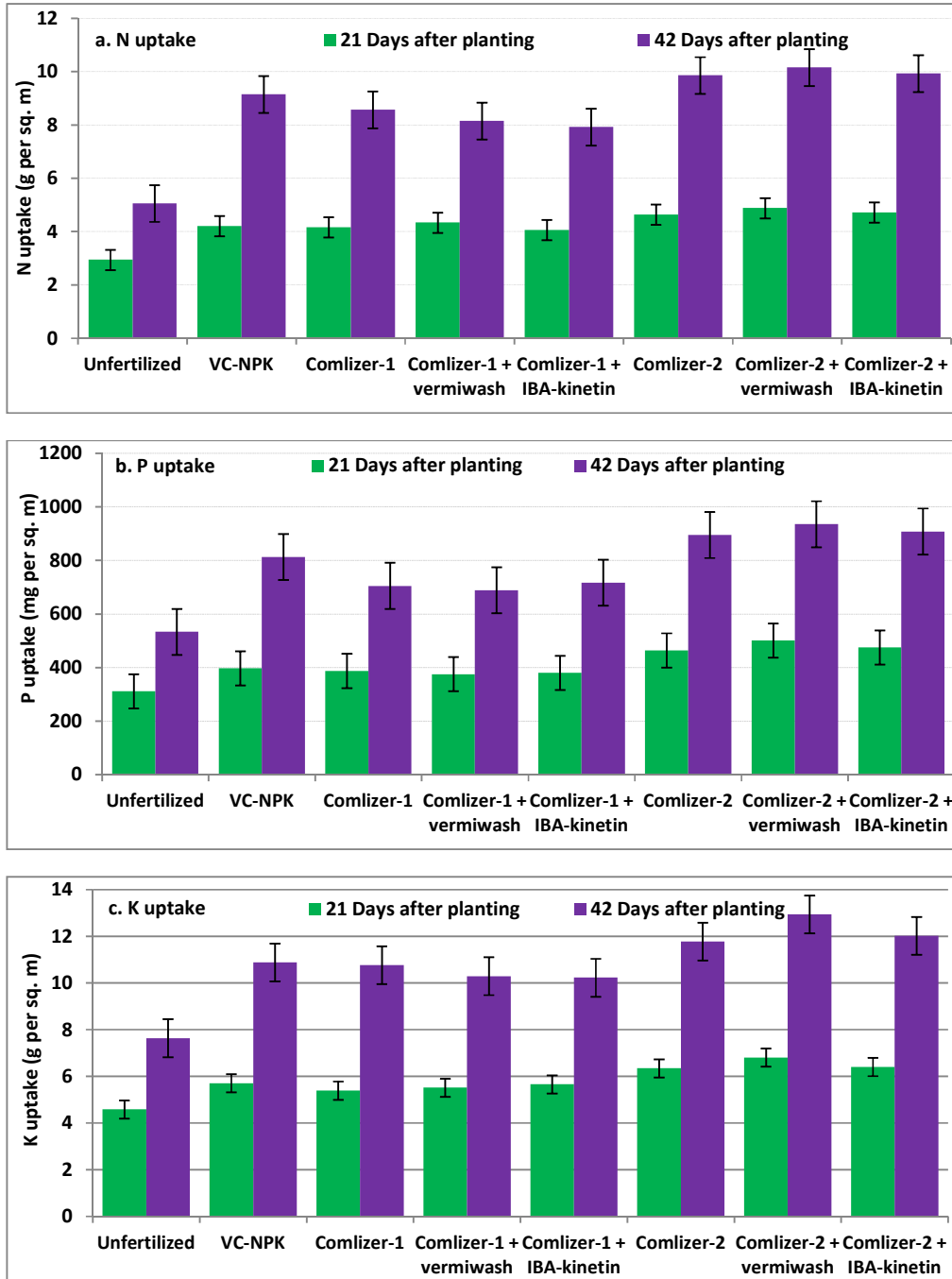


Fig. 1. Nutrient uptake (pooled mean over 2013-14 and 2014-15 seasons) by aerial biomass of marigold at different growth stages (a) nitrogen uptake (b) phosphorous uptake (3) potassium uptake (error bars at specific growth stage signify LSD value among the treatments)

Table 5. Dry matter accumulation in marigold at 21 and 42 DAP in 2013-14 and 2014-15 seasons

Treatments	21 DAP (g m ⁻²)		42 DAP (g m ⁻²)	
	2013-14	2014-15	2013-14	2014-15
Unfertilized	140.2	153.7	232.8	247.9
VC-NPK	199.6	183.6	368.1	322.6
Comlizer-1	184.8	171.0	345.0	324.2
Comlizer-1+vermiwash	166.4	173.5	302.4	326.0
Comlizer-1+IBA-kinetin	171.6	172.1	322.9	310.9
Comlizer-2	198.2	207.9	425.0	401.5
Comlizer-2+vermiwash	212.8	198.9	473.0	451.1
Comlizer-2+IBA-kinetin	201.0	210.9	444.5	459.5
LSD <i>P</i> = .05	40.1	48.4	59.3	77.8
CV	8.76	6.60	11.3	9.2

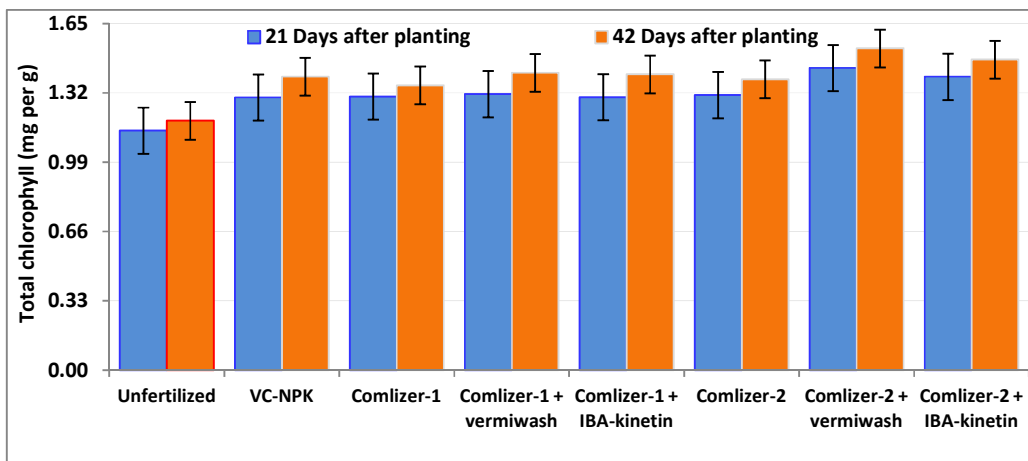


Fig. 2. Total chlorophyll content in marigold leaves (pooled mean over 2013-14 and 2014-15 seasons) at different growth stages (error bars at specific growth stage signify LSD value among the treatments)

3.2.3 Flower bud initiation and flower characters

The days to flower bud initiation in marigold was not affected by the treatments (Table 6). The lowest mean flower diameter and mean flower weight was recorded in unfertilized plants, and was statistically significant to other treatments. Application of vermicompost as mixture with enhanced N and K fertilizer doses (*comlizer-2*), and supplemented with foliar spray of vermiwash produced significantly larger flowers in terms of diameter and mass compared to VC-NPK or *comlizer-1*.

3.2.4 Flower yields and cost of cultivation of marigold

Application of fertilizers produced higher number of flowers in a plant over unfertilized condition (Table 6), but the effect of different treatments

was not significant. Highest fresh flower yield (t/ha) was recorded with *comlizer-2* supplemented with foliar spray of vermiwash, which differed significantly to rest of the treatments, while the lowest flower yield in unfertilized plot significantly differed to rest of the treatments. The maximum net return per rupee expenditure for cultivation of marigold was recorded for VC-NPK treatment in both the seasons.

Improved growth of African marigold, in terms of plant height, number of branches per plant, leaf chlorophyll content, with enhanced nitrogen fertilizer dose [25], and vermiwash foliar spray was earlier reported [26] and conform to the findings of the present investigation. The increase in total chlorophyll content of rose due to the application of kinetin was reported [27]. However, such effect of spraying kinetin and IBA was not observed in this study. Similar effect of

spraying kinetin and indole acetic acid (IAA) on maize growth and yield but with higher concentrations of Na, Ca and K in leaves was earlier observed [28]. Increasing kinetin concentration decreased Mg, K and Fe concentrations in maize leaves and consequently resulted in low chlorophyll content [29]. The low effectiveness of IBA and kinetin in the present study accordingly might be due to ample nutrient concentrations in the leaves. The positive effect of foliar spray with vermiwash solution was because of additional contents of nutrients with growth hormones and enzymes [30-32] compared to IBA-kinetin solution. Improved overall growth and yield in African marigold with application of chemical fertilizer with compost and foliar spray of humic acid was earlier reported [12]. Increase in flower diameter and weight could be attributed to increased photosynthetic activity that favoured an increased accumulation of dry matter, nutrient uptake [33] and also efficient partitioning of photosynthates towards the sink [12].

3.3 Soil Fertility Status

3.3.1 Ammonical and nitrate nitrogen in soil

The ammonical nitrogen ($\text{NH}_4\text{-N}$) and nitrate nitrogen ($\text{NO}_3\text{-N}$) in soil (pooled mean over 2013-14 and 2014-15 seasons) significantly increased at 21 DAP due to fertilizer application (Fig. 3a, b). The increase in $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ due to enhanced doses of N, K fertilizers (*comlizer-2*) was significantly superior over VC-NPK or *comlizer-1*. Foliar application of vermiwash or growth regulators did not produce significant effect on inorganic forms of nitrogen in soil. At 42 DAP, the $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ in soil with *comlizer-*

1 was significantly higher than VC-NPK, and was at par with *comlizer-2* (Fig. 3a, b). Similar to 21 DAP, the effect of vermiwash or growth regulators was not observed at 42 DAP.

3.3.2 Available nutrient status

The soil fertility status after harvest of marigold in each season is shown in Table 7. The soil pH, organic carbon and available phosphorous contents were not affected by the treatments. The available nitrogen content decreased significantly in unfertilized plot, while that increased due to application of enhanced doses of nitrogen (*comlizer-2*). In case of available potassium content in soil, the value significantly decreased in the unfertilized plot.

The mixture of vermicompost and RDF (*comlizer-1*) was not effective in improving the growth and yield of marigold compared to their separate applications (VC-NPK). It was earlier observed that herbage and oil yield of rosemary with the application of chemical fertilizer NPK 300:50:50 kg/ha was at par with vermicompost (8 t ha^{-1}) and chemical fertilizer NPK 150:25:25 kg ha^{-1} [34]. Blending potting media with cow dung and vermicompost showed a synergistic effect on growth and flowering of marigold plants [35], while fertilizer mixture of 90:75:75 kg/ha N:P:K as pellets could produce higher flower yield in marigold over the surface broadcast of fertilizers [36]. Accordingly, further work with higher doses of fertilizers than those used in this study may provide additional knowledge and clarity on response of marigold to applied nutrients. The observed effect of *comlizer-2*+vermiwash in the present study was due to good early vegetative growth under consistent pool of available nutrients in soil [37] and additional supplements

Table 6. Flower yield in 2013 and 2014 seasons and economics of marigold cultivation

Treatments	No. of flowers plant ⁻¹		Fresh flower yield (t ha ⁻¹)			B:C* ratio
	2013-14	2014-15	2013-14	2014-15	Mean	
Unfertilized	45.0	49.3	11.8	12.4	12.10	0.88
VC-NPK	69.3	70.7	18.4	19.0	18.70	1.40
<i>Comlizer-1</i>	69.0	66.5	17.3	17.6	17.45	1.33
<i>Comlizer-1</i> +vermiwash	65.7	68.7	17.7	18.2	17.95	1.30
<i>Comlizer-1</i> +IBA-kinetin	68.2	66.7	17.1	17.9	17.50	1.15
<i>Comlizer-2</i>	73.3	70.0	18.4	18.9	18.65	1.32
<i>Comlizer-2</i> +vermiwash	77.3	74.3	19.5	20.0	19.75	1.30
<i>Comlizer-2</i> +IBA-kinetin	70.6	67.3	18.7	19.0	18.85	1.14
LSD	12.0	9.7	0.8	1.0		
CV	11.7	9.6	6.3	7.4		

*Calculated based on net return with mean yield of 2013-14 and 2014-15 seasons

Table 7. Soil fertility status after harvest of marigold in 2013-14 and 2014-15 seasons

Treatments	Soil pH		Organic C (g kg ⁻¹)		Available nutrients in soil (kg ha ⁻¹)					
	2013-14	2014-15	2013-14	2014-15	N		P		K	
					2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Unfertilized	5.57	5.45	6.6	6.7	235.8	242.8	16.3	18.8	76.4	80.4
VC-NPK	5.21	5.32	7.4	7.5	263.4	258.6	19.0	20.0	90.4	87.9
Comlizer-1	5.29	5.40	7.2	7.4	259.9	261.5	18.0	19.1	86.7	88.4
Comlizer-1+vermiwash	5.44	5.37	7.5	7.3	264.7	258.5	17.8	20.8	86.8	88.2
Comlizer-1+ IBA-kinetin	5.34	5.35	7.0	7.1	257.1	265.1	17.5	18.9	87.6	86.2
Comlizer-2	5.42	5.24	7.5	7.3	286.8	285.2	19.1	19.8	93.4	90.7
Comlizer-2+ vermiwash	5.35	5.33	7.1	7.2	291.5	280.9	19.1	20.1	95.0	89.3
Comlizer-2+ IBA-kinetin	5.29	5.36	7.4	7.1	287.3	281.3	18.7	18.4	90.9	91.3
LSD	NS	NS	NS	NS	21.1	15.5	NS	NS	8.6	5.2
CV	5.2	4.4	5.6	6.8	9.2	7.8	7.7	8.8	10.2	7.3

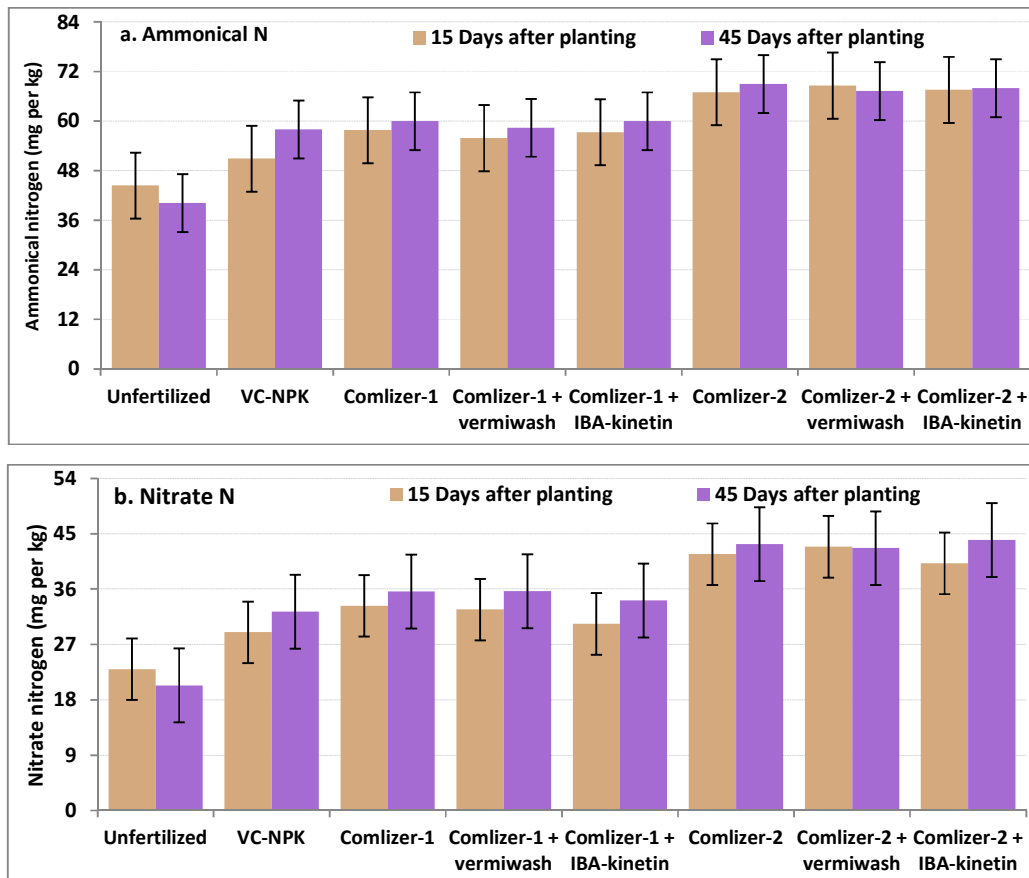


Fig. 3. Inorganic nitrogen fractions in soil (pooled mean over 2013-14 and 2014-15 seasons) at different growth stages of marigold (a) $\text{NH}_4\text{-N}$ and (b) $\text{NO}_3\text{-N}$ (error bars at specific growth stage signify LSD values among the treatments)

through vermiwash foliar spray (30-32), that facilitated better root system to support competitive growth and reproduction in the later stages of the crop [37]. Direct relationship between application of kinetin, auxin, gibberellin and uptake of Ca, Mg, P, K and their ratios in wheat leaves and grains had already been reported [38]. However, the effect of combined application of growth regulators on growth and yield of marigold was not clearly understood and further investigations are required for clarity.

4. CONCLUSION

Compost mixture with mineral fertilizer, with or without enhanced doses, (*comlizer*) was not effective in improving growth and yield of African marigold, compared to their separate applications. Foliar spray of mixed solution of IBA and kinetin with *comlizer* did not produce significant effect on growth and yield of marigold,

irrespective of N and K fertilizer doses. Supplementing *comlizer* with foliar spray of vermiwash at enhanced doses of N and K fertilizers significantly improved growth parameters increasing the flower yield of marigold. However, it was not cost effective and hence compost mixture with recommended doses of NPK fertilizers is not recommended. Future work evaluating compost mixture with lower doses of mineral fertilizer and different manure sources on nutrient dynamics in soil and plant system may provide cost effective nutrient management with sustainable crop productivity.

CONSENT

All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki

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COMPETING INTERESTS

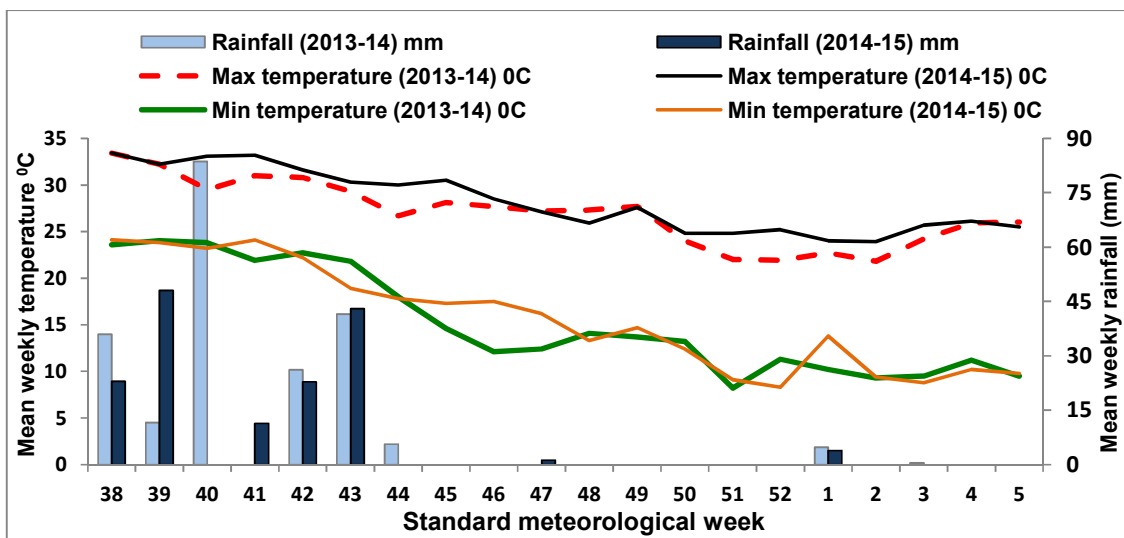
Authors have declared that no competing interests exist.

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APPENDIX



Weekly average maximum, minimum temperature (°C) and rainfall (mm) during the study

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