AATCC Review

18 February 2025: Received
14 April 2025: Revised
21 April 2025: Accepted
23 May 2025: Available Online

https://aatcc.peerjournals.net/

Original Research Article

Open Access

Assessing the Impact of Sustainable Nutrient Regimens on the Growth Metrics, Floral Dynamics and SoilHealth of *Viola × wittrockiana*

Shivani Thakur[1*], Jasbir Singh Wazir[1], Suman Bhatia[1], Pardeep Kumar[2] and Vivek Bhanwala[3]

[1]*Department of Floriculture and Landscape Architecture, Dr YS Parmar University of Horticulture and Forestry,Nauni, Solan, 173230, Himachal Pradesh, India*
[2]*Department of Soil Science and Water Management, Dr YS Parmar University of Horticulture and Forestry,Nauni, Solan, 173230, Himachal Pradesh, India*
[3]*Department of Horticulture, Guru Kashi University, Sardulgarh Road, Talwandi Sabo, Bathinda, 151302, Punjab*

Highlights

- *Natural bio-inputs showed significant potential in improving growth, flowering and soil quality in potted pansies*
- *The use of bio-enhancers accelerated flowering, refined plant architecture and improved floral characteristics.*
- *Superior pot aesthetics and extended blooming duration emphasized their ornamental and commercial appeal.*
- *Enhanced microbial activity and enriched soil nutrients confirmed the sustainability of natural farming in ornamental horticulture.*

ABSTRACT

As contemporary environmental challenges increasingly threaten the sustainability of agricultural production systems, natural farming emerges as a cost-effective and eco-friendly solution. By employing agro-ecological principles, NF not only bolsters soil health and biodiversity but also minimizes input costs. By improving microbial dynamics and enzymatic activity in the soil, this methodology contributes significantly to climate change adaptation and resilient food production. A research study was executed to evaluate the influence of Ghanjeevamrit and Jeevamrit on two potted pansy cultivars. The results indicated that administering Ghanjeevamrit at an 80 g per pot rate, along with a 10% Jeevamrit foliar application, yielded the earliest flowering, optimized plant height and spread, maximized flower count, extended flowering duration, improved pot presentability ratings and recorded the highest total viable microbial counts, in addition to elevated soil chemical properties. The investigation on the effects of Ghanjeevamrit and Jeevamrit on potted pansy cultivars grown in mid-hill settings has numerous limitations. The controlled, small-scale experimental design limits the applicability of findings to open-field circumstances or other crop species. Furthermore, the study's short length limits an evaluation of the long-term effects of these natural inputs on soil health, insect dynamics, and overall ecosystem sustainability. Unstandardized preparation and application techniques for natural inputs, such as Jeevamrit and Ghanjeevamrit, might result in unpredictable outputs, limiting repeatability and scalability across agro-climatic zones.

Keywords: *Pansy, natural farming, jeevamrit, ghanjeevamrit, soil health, microbial inoculants, sustainable agriculture*

Introduction

Emerging in mid-20th century India, the Green Revolution radically transformed agricultural practices by integrating synthetic agrochemicals and mechanization to amplify crop yields [1]. Despite success in food production, the strategy's heavy reliance on agrochemicals triggered ecological damage, including soil degradation and microbial decline [2]. Nitrogen-based fertilizers and livestock are primary contributors to agriculture environmental footprint, responsible for emissions and nitrate contamination [3, 4]. With over 30% of land undergoing degradation agriculture and human health suffer, despite intensive farming inputs [5]. Declining soil health and fluctuating yields threaten species, cause desertification and contaminate resources [6].

Corresponding Author: **Shivani Thakur*

DOI: https://doi.org/10.21276/AATCCReview.2025.13.03.44

Biomagnified residues of agrochemicals in food negatively affect human immunity, brain function, and endocrine systems[7]. Concerns are rising that continuing chemical-based agriculture may cause irreversible damage to soil health. With sustainability emerging as a worldwide priority, natural farming methods promoted by leaders like Masanobu Fukuoka (Japan), Subhash Palekar (India) and Chao (Korea) offer promising solutions.Natural farming rooted in agro-ecological principles and dependent on cost-effective, farm-derived inputs, presents significant opportunities for enhancing the financial sustainability of agricultural practices while also addressing challenges related to food security [8,9,10]. As an agroecological strategy, natural farming promotes symbiotic plant cultivation with the environment, focusing on structural and agronomic aspects. By enriching soil health via crop diversity, mulching, nutrient recycling and biotic support, it limits the need for synthetic inputs [11]. Additionally, it removes farmer's dependency on external markets, offering financial independence by forbidding outside purchases [12] with microbial inputs to improve soil flora, enabling nutrient mineralization and supporting sustainable yields.

Viola × wittrockiana, widely recognized as the pansy, stands as a pivotal species within the floricultural realm, particularly in the global edible flower industry. Ranked among the top five best-selling bedding plants globally, it thrives as a cool-season crop in both advanced and emerging markets [13]. Its pronounced cold hardiness and extended flowering window make it a quintessential floriculture asset, frequently deployed in both private horticulture and expansive public landscapes [14]. Though inherently perennial , pansies are frequently cultivated as biennials or annuals due to their propensity to grow leggy and lose compactness over time [15]. Renowned for their multifaceted role in landscape architecture, pansies are esteemed for their ability to blanket extensive garden beds with a profusion of vibrant shades. Their ability to craft dynamic visual displays, especially in early spring, makes them a favored choice for bedding schemes, potted arrangements and decorative accents in balconies, bay windows, and staircases. With their striking heart-shaped foliage and face-like patterns, Sakata SMG-II hybrids not only enhance visual appeal but also extend into the culinary domain, where their edible foliage and blossoms are used in garnishes and crystallized sweets [16]. Acknowledging the commercial and edible significance of potted pansies, this research aims to cultivate modern hybrid strains through the implementation of nature-informed agronomic practices to boost vigour and achieve optimal yields while assessing their influence on overall growth, flowering and potting compost properties, thereby fostering ecosystem sustainability.

Materials and Methods

Experimental site and planting material

The research work was executed at Dr. YS Parmar University of Horticulture and Forestry Experimental Research Farm, under the Department of Floriculture and Landscape Architecture in Nauni, Solan, Himachal Pradesh, India in the year 2020-2021. The study area, nestled in the mountainous terrain of the Northwest Himalayas, lies at 1276 meters above sea level and is mapped at 30°52′02″ N latitude and 70°11′30″ E longitude. Annual rainfall ranges from 1000-1300 mm, mainly between July and September, with additional precipitation during January and February, sometimes accompanied by hail and snow. Hybrid seeds of two colour variants sourced from Sakata Seed India Ltd., were obtained from a Delhi distributor. Table 1 provides detailed information about the seeds. Healthy, uniform-sized seedlings at the 4-5 leaf stage were transplanted into seven-inch pots (one seedling/pot) containing soil, FYM and coco-peat substrate (1:1:1, v/v) and subsequently watered.Pre-experiment soil chemical properties were assessed and listed in Table 2. Pots were kept in full sunlight under open conditions.

Table 1: Detailed description of cultivars

Characters	Description
Scientific Name	*Viola × wittrockiana*
Common Name	Pansy
Cultivars	i) SMG-II Fire with Blotch ii) SMG-II White with Blotch
Hardiness	Winter hardy, can tolerate up to -10°C
Flowering Period	Early Spring, Spring, Autumn
Growth Pattern	Mounded, Compact form
Special Features	Adaptable to shaded conditions
Irrigation Needs	Moderate
Fertilizer Schedule	Bi-weekly feeding
Plant Spacing	18–20 cm (7–8 inches) apart
Plant Height	20 cm (8 inches)
Plant Spread	25 cm (10 inches)
Light Preference	Prefer full sun

Table 2: Initial Potting compost characteristics

	Contents	Values obtained	Soil status	Method employed	References
1.	Soil pH	6.88	Normal	Potentiometric method using (1:2 soil-to-water suspension)	[17]
2.	Electrical conductivity (dS/m)	1.11	Normal	Wheat stone bridge circuit method (1:2 soil-to-water suspension)	[17]
3.	Organic carbon (%)	4.66	Very High	Rapid titration method	[18]
4.	Available Nitrogen (kg/ha)	276	Low	Micro Kjeldahl method	[19]
5.	Available Phosphorus (kg/ha)	44.5	High	Olsen method	[20]
6.	Available Potassium (kg/ha)	552.7	High	Flame photometric method	[21]

Experimental details and application protocol

In this experiment, fourteen treatments were employed. Adopting three replications and ten pots in each, the experiment had been carried out utilizing a factorial completely randomized design.The experiment consists of a factorial design, viz., variety and treatment modules.

The details of the treatments are outlined as follows: Factor A; Variety (V_1 and V_2); Factor B; Treatments (T_1 : Control; T_2: Ghanjeevamrit @ 40g per pot + Foliar spray of 5 % Jeevamrit; T_3: Ghanjeevamrit @ 60g per pot + Foliar spray of 5 % Jeevamrit; T_4: Ghanjeevamrit @ 80g per pot + Foliar spray of 5 % Jeevamrit; T_5: Ghanjeevamrit @ 40g per pot + Foliar spray of 10 % Jeevamrit; T_6 : Ghanjeevamrit @ 60g per pot + Foliar spray of 10 % Jeevamrit; T_7: Ghanjeevamrit @ 80g per pot + Foliar spray of 10 % Jeevamrit).

Jeevamrit and Ghanjeevamrit preparation

The formulation of Jeevamrit involved mixing 10 kg of cow dung, 10 liters of cow urine, 2 kg of black jaggery, 2 kg of pulse flour and 100 g of soil for microbial inoculation. Water was added to make up 200 liters and the mixture was stirred twice daily in a clockwise motion. After five days, the mixture was filtered and the filtered liquid was applied as a foliar spray (5-10%) every 20 days after transplanting, continuing until peak flowering. Ghanjeevamrit, made from 100 kg cow dung, 1 kg gram flour, 1 kg jaggery, 5 L cow urine and a handful of soil was fermented for 2-3 days, dried and applied as a drench at transplanting, 20-25 days after and during flower emergence. Two pinchings were performed by removing the apical portion of the plant at 20 and 40 days after transplanting. Manual irrigation was provided using a watering can, adjusting to the climatic needs throughout the experiment.

Vegetative and flowering attributes

Key vegetative traits, including plant height, spread, number of leaves and shoots per plant along with flowering characteristics like the days to first bloom, number of flowers per plant, flowering duration and pot presentability were recorded at the appropriate stages of data collection.The pot presentability was evaluated based on a point system adapted from [22], with each parameter receiving points out of a total of 100, as detailed in Table 3. From each replication and treatment group, five randomly selected plants were assessed for both vegetative and flowering attributes.

Table 3: Pot presentability scoring criteria using a 100-point system

Parameters	Description	Maximum points
a) Appearance as whole plant	I. Fresh appearance with no indication of senescence	12.5
	II. No mechanical, insect, mite or disease damage on flower or stems	12.5
b) Flowering	I. Number of flowers per plant	12.5
	II. Number of flowers open at a time per pot	12.5
For number of flowers per plant and numbers of flowers open at a time per pot following scores have been given:		
Number of flowers per plant		**Maximum points**
< 20		9.5
20-23		10.5
23-25		11.5
> 25		12.5
Number of flowers open at a time per pot		**Maximum points**
< 9		9.5
9-11		10.5
11-13		11.5
> 13		12.5
c) Form	I. Plant height	12.5
	II. Plant spread	12.5
d) Stem and Foliage	I. Plant with strong stem	12.5
	II. Foliage without chlorosis or necrosis	12.5

Soil sample collection and analysis of chemical properties

Composite potting compost samples were collected both before and after the experiment, dried in the shade, sieved through a 2 mm mesh and stored in polythene bags for later analysis. A conductivity meter was used to analyzesoil pH and electrical conductivity, while organic carbon content was measured by the Walkley–Black method. Available nitrogen (N) was determined using the alkaline potassium permanganate method, phosphorus (P) by Olsen's method and potassium was extracted and measured using ammonium acetate.

Soil microbiological properties

At the end of the trial, microbiological properties of the soil were examined for each treatment. The viable microbial count of potting compost samples was measured using the serial dilution spread plate technique [23], with nutrient agar, potato dextrose agar and Kenknight&Munaier's medium. The microbial population was expressed as colony-forming units per gram of soil (cfu/g soil).

Statistical analysis

Statistical analysis of the data collected throughout the experiment was carried out based on the methodology [24]. A completely randomized design (CRD) was implemented and a two-way analysis of variance (ANOVA) was applied to the combined data, with comparisons between treatments conducted at a 0.05% significance level. Moreover, using R Studio a correlation analysis was conducted to examine the relationship between growth, flowering traits and soil properties.

Results and Discussion

Vegetative and flowering attributes

As delineated in Table 4, the array of treatment combinations exerted a substantial influence on both the stature and dispersion of the plants. Treatment T_7 yielded a remarkable height of 18.52 cm and an expansive spread of 13.60 cm, in stark contrast to treatment T_1, which registered a significantly lower height of 15.52 cm and a modest spread of merely 11.47 cm. In a comparative analysis, the variety V_1 exhibited superior vertical growth at 18.46 cm, overshadowing V_2 which measured 15.37 cm. Nevertheless, V_2 demonstrated a more pronounced lateral expansion, achieving 12.79 cm compared to V_1 11.96 cm. Within the interplay of these factors, the V_1T_7 interaction yielded the tallest plants at 20.13 cm, while the V_2T_4 combination realized the maximum spread at 14.75 cm. Conversely, the most modest height was registered in V_1T_4 at 20.07 cm, with the least spread observed in V_1T_1 at 11.39 cm.In the analysis of treatment T_7, the apex values for leaf quantity (30.74) and shoot proliferation (23.15) per individual plant were meticulously recorded. In juxtaposition, the cultivar V_2 yielded 30.64 leaves and 22.00 shoots.

The repercussions of treatments, varieties and their interactions on the emergence of flowering and the aggregate flower number were exceedingly significant, whereas the interplay between treatment and variety revealed an inconsequential effect on flower count as detailed in Table 5.T_7 achieved the earliest flowering at 74.35 days, contrasting with the control group (T_1), which required 78.47 days. Variety V_2 emerged earlier at 76.60 days, while V_1 needed 77.61 days. The V_2T_7 interaction reported the earliest emergence at 72.43 days, while V_1T_1 took the longest at 80.97 days. In terms of the number of flowers, T_7 produced the highest at 27.40, comparable to T_4 26.97, both significantly surpassing other treatments, while T_1 yielded the fewest at 18.07. Variety V_2 led with 23.49 flowers, edging out V_1 23.11.

Flower size is a pivotal element in the cultivation of potted plants, with larger blooms serving as indicators of superior display quality and allure. Evaluating the treatment combinations, T_2 yielded the largest bloom diameter at 7.26 cm, statistically similar to T_5 at 7.06 cm, while T_7 displayed the smallest diameter of 6.75 cm. Among the varieties, V_2 achieved the maximum flower diameter of 7.28 cm, in contrast to V_1 which presented the minimal diameter of 6.73 cm. The length of the flowering period plays a crucial role in determining the lifespan of potted plant displays.The maximum flowering duration was noted at 82.78 days for plants treated with 80 g of Ghanjeevamrit and a 10% foliar application of Jeevamrit (T_7), in stark contrast to the control treatment (T_1), which recorded a mere 73.43 days. The variety V_2 exhibited a superior flowering duration of 79.83 days over V_1 at 78.03 days. Furthermore, within interaction effects, the V_2T_7 treatment combination yielded the longest flowering duration of 86.10 days, while V_1T_1 presented the shortest duration of 72.20 days. The analysis of pot presentability scores (Table 5) indicates significant impacts of both treatments and varieties on pot presentability.

T_7 recorded the highest presentability score (93.82) which was found to be at par (92.73) in treatment T_4. On the other side, the control with no application had the lowest presentability score (80.02) (T_1).Among varieties highest score (87.11), was inV_2, whereas V_1 had the lowest (86.24) score.Interactions between substrates and varieties didn'tshow significant effects on pot presentability scores, yet highest score (94.47) was achieved in the V_2T_7 treatment, whereas the lowest (79.93) in V_1T_1.

Soil chemical properties

Chemical properties of the substrate are also greatly influenced by the experiment as shown in Table 6. The results obtained revealed that none of the treatments had a substantial impact on pH and EC of the potting substrate. The application of diverse organic sources, on the other hand, was shown to increase the soil pH and bring it to a neutral state. The pH and EC values in all treatments ranged from 6.52 to 6.93 and 0.67 dS/mto 0.83 dS/m. A noteworthy maximum of 5.88 % and 5.42 % of organic carbon was observed in T_7 and V_2 whereas the lowest value of soil organic carbon was found to be 4.58 % and 5.24 % in T_1 and V_1. Among the interaction effects of treatments and varieties, V_2T_7 had the highest organic carbon level (5.92 %) and minimum (4.57 %) in V_1T_1.

The findings in Table 7 reveal that the levels of N, P and K in the soil were notably influenced by the treatment applications.In terms of nutrient content, T_7 yielded an elevated N, P, and K concentration of 424.88 kg/ha, 15.06 kg/ha, and 333.27 kg/ha, respectively, whereas T_1 registered the lowest values at 241.65 kg/ha, 9.10 kg/ha, and 211.93 kg/ha. As per the effect of varieties, V_2 exhibited superior nutrient concentrations of nitrogen (338.93 kg/ha), phosphorus (12.15 kg/ha) and potassium (260.11 kg/ha), surpassing V_1 which recorded 334.67 kg/ha of N, 11.97 kg/ha of P and 252.14 kg/ha of K. In terms of interactions between treatments and varieties, the V_2T_7 combination led to the apex nutrient accumulation (427.87 kg/ha N, 15.08 kg/ha P, and 337.57 kg/ha K), while the minimal values (239.80 kg/ha N, 9.05 kg/ha P, and 208.57 kg/ha K) were detected in V_1T_1.

Table 4: Effect of sustainable nutrient regimens on vegetative characters of Viola × wittrockiana

Treatment combinations	Plant height			Plant Spread			Number of leaves per plant			Number of shoots per plant		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1 : Absolute control	16.86	14.19	**15.52**	11.39	11.55	**11.47**	29.91	30.31	**30.11**	17.80	20.77	**19.28**
T_2 :Ghanjeevamrit @ 40g per pot + Foliar spray of 5 % Jeevamrit	17.17	14.47	**15.82**	11.45	11.61	**11.53**	30.02	30.49	**30.25**	22.97	21.50	**22.23**
T_3 :Ghanjeevamrit @ 60g per pot + Foliar spray of 5 % Jeevamrit	18.11	15.30	**16.71**	12.00	12.87	**12.43**	30.27	30.46	**30.37**	19.97	20.20	**20.08**
T_4 :Ghanjeevamrit @ 80g per pot + Foliar spray of 5 % Jeevamrit	20.07	16.78	**18.43**	11.77	14.75	**13.26**	30.16	31.06	**30.61**	22.83	22.63	**22.73**
T_5 :Ghanjeevamrit @ 40g per pot + Foliar spray of 10 % Jeevamrit	17.46	14.88	**16.17**	11.57	11.85	**11.71**	30.20	30.51	**30.35**	20.47	22.93	**21.70**
T_6 :Ghanjeevamrit @ 60g per pot + Foliar spray of 10 % Jeevamrit	19.43	15.05	**17.24**	12.09	13.17	**12.63**	30.30	30.54	**30.42**	20.60	21.73	**21.17**
T_7 :Ghanjeevamrit @ 80g per pot + Foliar spray of 10 % Jeevamrit	20.13	16.92	**18.52**	13.48	13.72	**13.60**	30.37	31.11	**30.74**	22.07	24.23	**23.15**
Mean	**18.46**	**15.37**		**11.96**	**12.79**		**30.18**	**30.64**		**20.96**	**22.00**	
Factor	**C.D (5%)**	**SEm**		**C.D (5%)**	**SEm**		**C.D (5%)**	**SEm**		**C.D (5%)**	**SEm**	
Variety (V)	0.09	0.03		0.36	0.13		0.19	0.04		0.95	0.33	
Treatments (T)	0.17	0.06		0.67	0.25		0.35	0.12		1.78	0.61	
V × T	0.24	0.08		0.95	0.35		NS	0.14		NS	0.86	

Table 5: Effect of sustainable nutrient regimens on flowering attributes of Viola × wittrockiana

Treatment combinations	Days to first flower emergence			Number of flowers			Flower Diameter(cm)			Duration of flowering			Pot Presentability		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1 : Absolute control	80.97	75.97	**78.47**	17.73	18.40	**18.07**	6.80	7.54	**7.17**	72.20	74.67	**73.43**	79.93	80.10	**80.02**
T_2 :Ghanjeevamrit @ 40g per pot + Foliar spray of 5 % Jeevamrit	78.47	77.60	**78.03**	20.87	21.00	**20.93**	6.88	7.63	**7.26**	78.10	79.30	**78.70**	83.73	82.80	**83.27**
T_3 :Ghanjeevamrit @ 60g per pot + Foliar spray of 5 % Jeevamrit	78.70	77.77	**78.23**	22.20	22.40	**22.30**	6.87	7.44	**7.16**	78.57	78.50	**78.53**	86.03	87.53	**86.78**
T_4 :Ghanjeevamrit @ 80g per pot + Foliar spray of 5 % Jeevamrit	75.33	76.97	**76.15**	26.80	27.13	**26.97**	6.34	7.25	**6.79**	81.23	79.53	**80.38**	91.60	93.87	**92.73**
T_5 :Ghanjeevamrit @ 40g per pot + Foliar spray of 10 % Jeevamrit	76.80	77.33	**77.06**	22.60	23.60	**23.10**	6.84	7.27	**7.06**	78.23	80.73	**79.48**	84.50	86.13	**85.32**
T_6 :Ghanjeevamrit @ 60g per pot + Foliar spray of 10 % Jeevamrit	76.77	78.13	**77.45**	24.20	24.47	**24.33**	6.70	6.96	**6.83**	78.40	79.97	**79.18**	84.70	84.90	**84.80**
T_7 :Ghanjeevamrit @ 80g per pot + Foliar spray of 10 % Jeevamrit	76.27	72.43	**74.35**	27.33	27.40	**27.37**	6.64	6.86	**6.75**	79.47	86.10	**82.78**	93.17	94.47	**93.82**

Mean	**77.61**	**76.60**		**23.11**	**23.49**		**6.73**	**7.28**		**78.03**	**79.83**		**86.24**	**87.11**	
Factor	**C.D (5%)**	**SEm**		**C.D (5%)**	**SEm**		**C.D (5%)**	**SEm**		**C.D (5%)**	**SEm**		**C.D (5%)**	**SEm**	
Variety (V)	0.93	0.32		0.30	0.07		0.19	0.06		1.19	0.41		0.59	0.12	
Treatments (T)	1.73	0.59		0.56	0.10		0.35	0.12		2.23	0.76		1.09	0.41	
V × T	2.45	0.84		NS	0.21		NS	0.17		3.15	1.08		NS	0.52	

Table 6: Effect of sustainable nutrient regimens on pH and EC of potting compost

Treatment combinations	pH			EC (dS/m)			Organic Carbon (%)		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1: Absolute control	6.46	6.58	**6.52**	0.61	0.77	**0.67**	4.57	4.58	**4.58**
T_2: Ghanjeevamrit @ 40g per pot + Foliar spray of 5 % Jeevamrit	6.51	6.79	**6.65**	0.69	0.76	**0.73**	5.05	4.99	**5.02**
T_3: Ghanjeevamrit @ 60g per pot + Foliar spray of 5 % Jeevamrit	6.59	6.65	**6.62**	0.86	0.78	**0.82**	4.84	5.33	**5.08**
T_4: Ghanjeevamrit @ 80g per pot + Foliar spray of 5 % Jeevamrit	6.56	6.66	**6.61**	0.81	0.85	**0.83**	5.74	5.72	**5.73**
T_5: Ghanjeevamrit @ 40g per pot + Foliar spray of 10 % Jeevamrit	6.83	7.03	**6.93**	0.73	0.74	**0.74**	5.33	5.56	**5.45**
T_6: Ghanjeevamrit @ 60g per pot + Foliar spray of 10 % Jeevamrit	6.94	6.79	**6.86**	0.67	0.78	**0.73**	5.32	5.82	**5.57**
T_7: Ghanjeevamrit @ 80g per pot + Foliar spray of 10 % Jeevamrit	6.80	6.97	**6.88**	0.83	0.74	**0.79**	5.84	5.92	**5.88**
Mean	**6.67**	**6.78**		**0.74**	**0.77**		**5.24**	**5.42**	
Factor	**C.D (5%)**	**SEm**		**C.D (5%)**	**SEm**		**C.D (5%)**	**SEm**	
Variety (V)	NS	0.01		NS	0.02		0.11	0.03	
Treatments (T)	NS	0.02		NS	0.04		0.21	0.07	
V × T	NS	0.06		NS	0.05		0.29	0.10	

Soil microbiological properties

As illustrated in Table 8, distinct treatment regimens dramatically affected the microbial consortium within the soil, leading to notable shifts in the prevalence of advantageous bacteria, fungi, and actinomycetes. Concerning varietal effects, V_2 varietal impact resulted in the highest microbial population (116.82 ×10^4 cfu/g), surpassing the lower microbial count of V_1 (113.57 ×10^4 cfu/g). Among treatment regimens, T_7 dominated with the largest microbial concentration (127.56 ×10^4 cfu/g), while T_1 had the least populous microbial presence (104.58 ×10^4 cfu/g). Interaction analysis further revealed that the V_2T_7 combination yielded the maximum microbial count (130.62 ×10^4 cfu/g), while V_1T_1 registered the lowest value (103.76 ×10^4 cfu/g).

Discussion

Vegetative and flowering attributes

Plant height is a crucial factor influencing yield potential. The increased presence of beneficial bacteria in fermented bioformulations likely fosters enhanced vegetative growth from organic amendments, supported by sufficient nutrient reserves. Additionally, growth hormones in fermented liquid formulations have been demonstrated to improve photosynthetic dynamics, significantly boosting plant height [25]. Nitrogen enhances structural integrity by being a core protein element, while phosphorus, crucial for phospholipids, boosts nutrient translocation and root geometry, leading to improved rhizosphere health and increased plant spread [26]. Investigations on African marigold [27] and China aster [28] underscored Jeevamrit's pivotal role in promoting significant vertical plant growth.

The significant increase in flower count per plant can be attributed to the high nutrient concentrations (N @ 0.16%, P @ 0.02%, K @ 0.123%) and growth-enhancing microorganisms present in Jeevamrit, which efficiently proliferate and enhance soil bioactivity. Among NPK, Nitrogen, as the principal driver of vital life processes, substantially promotes flower production, synergized by enhanced nitrogen fixation and phosphorus solubilization capacities [26].

The enlargement of flower size under the influence of Jeevamrit can likely be attributed to the enhanced nutrient solubilization and absorption facilitated by microbial activity.Beyond the availability of NPK, the presence of growth-enhancing agents, GA_3 and IAA in Jeevamrit may have played a pivotal role in augmenting flower diameter. In our investigation, it was elucidated that drench application of Ghanjeevamrit coupled with a foliar spray of Jeevamrit, engendered remarkable enhancements in overall pot presentation.These findings corroborate the results in the study of petunia [29], which underscored that the utilization of Jeevamrit markedly enhanced growth dynamics, floral proliferation and visual attractiveness.

Soil chemical properties

The experimental analysis focused on evaluating the influence of various natural farming techniques on the chemical composition and biological integrity of soil in potted pansy cultivation. It was noted that both the soil pH and electrical conductivity (EC) maintained a consistent equilibrium, regardless of the application of differing natural agricultural inputs. These findings on soil pH and EC align with [30], who noted that only long-term testing alters certain physicochemical properties of soil. Enhanced organic carbon content from cow-based manure was linked to both direct organic input and improved root systems, with decomposition boosting levels further [31,32]. Organic inputs like Jeevamrit and Ghanjeevamrit further boosted OC levels by enhancing microbial activity and fostering carbon accumulation. Similarly, natural farming inputs in our study led to higher soil carbon compared to untreated controls [33]. The application of Jeevamrit in garden peas resulted in a marked elevation of soil organic carbon content [34].

The incorporation of Ghanjeevamrit and Jeevamrit in our study led to a notable increase in the availability of vital nutrients in the soil. This enhancement is likely due to accelerated nitrogen mineralization, driven by increased microbial activity associated with these biological farming inputs [35]. Strategically, optimizing the dosage and application timing of

Jeevamrit can significantly enhance soil nitrogen levels, which in turn improves agricultural productivity in natural farming systems [36]. Our findings showed differences in the available phosphorus content among the treatment groups, likely caused by the enhanced release of organic acids during mineralization in treatments involving Ghanjeevamrit and Jeevamrit, which increased the solubility of indigenous phosphates [37]. Notably, analogous findings regarding showing an increase in soil phosphorus content are consistent with those of [38], who explored Jeevamrit's application in enhancing soil properties under natural farming systems.) Research on bioorganic nutrient amendments also corroborates our results, as they examined the effects on residual soil fertility, nutrient uptake, and okra yields [39]. Soil potassium levels diminished with organic amendments, attributed to the lack of external potassium and plant utilization but this decline was mitigated by the proliferation of microflora stimulated by Jeevamrit and Ghanjeevamrit[40].

Table 7: Effect of sustainable nutrient regimens on potting compost parameters of Viola × wittrockiana

Treatment combinations	Available Nitrogen (kg /ha)			Available Phosphorus (kg /ha)			Available Potassium (kg /ha)			Viable Microbial count (× 10^4 cfu/gsoil)		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1 : Absolute control	239.80	243.50	**241.65**	9.05	9.14	**9.10**	208.57	215.30	**211.93**	103.76	105.41	**104.58**
T_2 :Ghanjeevamrit @ 40g per pot + Foliar spray of 5 % Jeevamrit	305.00	303.33	**304.17**	9.94	10.03	**9.99**	218.30	220.43	**219.37**	108.88	110.80	**109.84**
T_3 :Ghanjeevamrit @ 60g per pot + Foliar spray of 5 % Jeevamrit	315.20	326.33	**320.77**	10.01	10.04	**10.03**	229.17	234.17	**231.67**	111.67	116.26	**113.96**
T_4 :Ghanjeevamrit @ 80g per pot + Foliar spray of 5 % Jeevamrit	419.63	423.77	**421.70**	14.73	14.76	**14.75**	324.80	334.67	**329.73**	121.88	123.20	**122.54**
T_5 :Ghanjeevamrit @ 40g per pot + Foliar spray of 10 % Jeevamrit	313.90	315.43	**314.67**	12.01	12.92	**12.46**	218.70	234.33	**226.52**	110.51	113.62	**112.07**
T_6 :Ghanjeevamrit @ 60g per pot + Foliar spray of 10 % Jeevamrit	327.27	332.30	**329.78**	12.98	13.11	**13.05**	236.50	244.30	**240.40**	113.81	117.83	**115.82**
T_7 :Ghanjeevamrit @ 80g per pot + Foliar spray of 10 % Jeevamrit	421.90	427.87	**424.88**	15.04	15.08	**15.06**	328.97	337.57	**333.27**	124.50	130.62	**127.56**
Mean	**334.67**	**338.93**		**11.97**	**12.15**		**252.14**	**260.11**		**113.57**	**116.82**	
Factor	**C.D (5%)**	**SEm**		**C.D (5%)**	**SEm**		**C.D (5%)**	**SEm**		**C.D (5%)**	**SEm**	
Variety (V)	1.83	0.42		0.16	0.05		2.02	0.72		0.45	0.16	
Treatments (T)	3.43	1.09		0.31	0.10		3.79	1.36		0.85	0.30	
V × T	4.85	1.53		NS	0.15		5.35	1.97		1.20	0.41	

Soil microbiological properties

Increased microbial diversity in the soil is most likely driven by the combined use of Ghanjeevamrit, Jeevamrit and mulching [38]. Ghanjeevamrit was shown to improve soil properties by potentially lowering bulk density [41] promoting better aeration, and providing carbon as a vital energy source for microbial activity [42]. Jeevamrit functions as a potent stimulant, nurturing a robust microbial ecosystem that thrives in the soil. Enhancements in soil microbiological properties attributed to Jeevamrit application as reported by [43]. Additionally, [31] highlighted that both Jeevamrit and Ghanjeevamrit substantially enhance microbial activity in the soil, thus improving nutrient availability for crops. Our results reveal a markedly elevated microbial population in the Jeevamrit and Ghanjeevamrit treated pots, affirming its beneficial influence on soil microbiology relative to the control group.

Correlation analysis of growth and flowering attributes of *Viola × wittrockiana* with soil properties

In Fig. 1, the correlation matrix highlights both strong positive and weak negative relationships between growth and flowering attributes with soil parameters. The correlation values, represented by dark blue for strong positives and dark red for weak negatives, suggest that soil factors such as pH, EC, organic carbon (OC) and nutrient levels significantly affect plant growth and flowering. The matrix shows moderate to strong positive correlations between growth parameters and nutrients like nitrogen (N) and potassium (K), emphasizing the role of nutrient-rich soils in promoting growth. The number of flowers is positively correlated with plant height and spread, while the duration of flowering moderately correlates with growth traits.

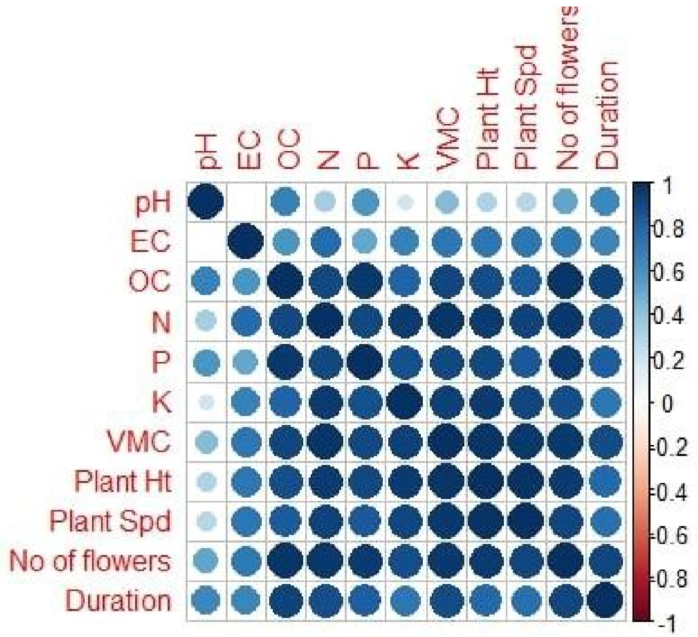

Figure 1. Correlation analysis of growth and flowering attributes of *Viola wittrockiana*which is influenced by different soil properties (EC- Electrical conductivity OC- Organic carbon, N- nitrogen, P- phosphorus, K- potassium, VMC- viable microbial count, Plant Ht- Plant height, Plant Spd– Plant spread, Duration- Duration of flowering (darker the colour greater the correlation intensity)

Conclusion

The findings of this analysis revealed that SMG-II White with Blotch variety achieved the most commendable results in terms of vegetative development, flowering and potting compost quality.

The findings underscore that Ghanjeevamrit at 80 g per pot plus 10% Jeevamrit foliar spray treatment produced optimal growth and flowering, accompanied by a significant accumulation of beneficial microorganisms. Therefore, this framework is recommended for enhancing nutrient availability and fostering a robust microbial ecosystem in the soil, thereby augmenting the performance of potted pansies. This innovative technology is viable for large-scale commercial potted plant production,enhancing aesthetic quality and contributing to healthful living environments.

Future scope of study: To improve the application and effectiveness of natural farming practices, future research should include long-term, field-based investigations of various crops and agro-climatic zones. Standardized preparation and application processes for natural inputs will improve consistency and scalability. Integrating mechanization and investigating market access tactics helps promote natural farming methods to a larger farmer base.

Funding: No funding was received.

Author contribution

ST, JSW, SB, PK, VB: idea creation, data collection and analysis, manuscript preparation, editionof the manuscript.

Acknowledgements: Authors are thankful to theDepartment of Floriculture and Landscape Architecture, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India (173230) for providing necessary facilities to execute this study.

Conflicts of Interest: The author(s) declare no conflict of interest.

References

1. John DA and Babu GR (2021) Lessons from the aftermaths of green revolution on food system and health. Front Sustain Food Syst5:644559. https://doi.org/10.3389/fsufs.2021.644559

2. Pingali PL(2012) Green revolution: impacts, limits, and the path ahead. Proc. Natl. Acad. Sci. U. S. A. 109, 12302–12308. https://doi.org/10.1073/pnas.0912953109

3. Vetter SH, Sapkota TB, Hillier J, Stirling CM, Macdiarmid JI, Aleksandrowicz L, Green R, Joy EJ, Dangour AD and Smith P (2017) Greenhouse gas emissions from agricultural food production to supply Indian diets: Implications for climate change mitigation. Agric Ecosyst Environ 237, pp.234-241.

4. Craswell E(2021) Fertilizers and nitrate pollution of surface and ground water: an increasingly pervasive global problem. SN Appl. Sci. 3:518. https://doi.org/10.1007/s42452021045218

5. Kabiraj S, Duraisekaran E and Ramaswamy M (2022) Combination of remote sensing spectral indices to classify the areas of land degradation in west Burdwan district. India. Environ Earth Sci81:218. https://doi.org/10.1007/s12665-022-10388-4

6. Gupta GS(2019) Land degradation and challenges of food security. Rev. Eur. Stud. 11:63. https://doi.org/10.5539/res.v11n1p63

7. Nicolopoulou-Stamati P, Maipas S, Kotampasi C and Stamatis P(2016) Chemical pesticides and human health: the urgent need for a new concept in agriculture. Front Public Health4:148. https://doi.org/10.3389/fpubh.2016.00148

8. Duddigan S, Collins CD, Hussain Z, Osbahr H, Shaw LJ, Sinclair F, Sizmur T, Thallam V and Ann Winowiecki L (2022) Impact of zero budget natural farming on crop yields in Andhra Pradesh, SE India. Sustainability 14: 1689. https://doi.org/10.3390/su14031689

9. Laishram C, Vashishat R, Sharma S, Rajkumari B, Mishra N, Barwal P, Vaidya MK, Sharma R, Chandel RS, Chandel A, Gupta RK and Sharma N(2022) Impact of natural farming cropping system on rural households-evidence from Solan district of Himachal Pradesh, India. Front Sustain Food Syst6: 878015. https://doi.org/10.3389/fsufs.2022.878015

10. Chandel RS, Gupta M, Sharma S and Chandel A(2023) Economic analysis of natural farming-based apple orchards in Himachal Pradesh. Indian J Ecol 50(1): 119–23. http://dx.doi.org/10.55362/IJE/2023/3863

11. Palekar S(2006)*The principles of spiritual farming II*. 2nd ed. Amravati: Zero Budget Natural Farming Research, Development & Extension Movement, Amravati, Maharashtra, India. http://www.vedicbooks.net/principles-spiritual-farming-volume p-14779.html.

12. Rosset PM and Martínez-Torres ME(2012) Rural social movements and agroecology: context, theory, and process. Ecol Soc17:17. https://doi.org/10.5751/ES-05000-170317

13. Gandolfo E, Hakim G, Geraci J, Feuring V, Giardina E and Benedetto A(2016) Responses of Pansy (*Viola × wittrockiana* Gams.) to the Quality of the Growing Media. Am J ExpAgric 12(3), 1–10. https://doi.org/10.9734/ajea/2016/26144

14. Chandler SF and Tanaka Y(2018) Transgenic research in floricultural crops. In: Rout G, Peter K (eds) Genetic engineering of horticultural crops. Academic Press, Cambridge, pp 121–136.

15. Gonçalves J, Ferreira Borges JC, de Almeida CL(2019) Bioactive compounds in edible flowers of garden pansy in response to irrigation and mycorrhizal inoculation. Revista Ceres, 66:407–415. https://doi.org/10.1590/0034-737x201966060001

16. Fernandes L, Casal S, Pereira JA, Pereira EL, Saraiva JA and Ramalhosa E(2019) Physicochemical, antioxidant and microbial properties of crystallized pansies (*Viola × wittrockiana*) during storage. Food Sci Technol Int 25(6) 472–479. https://doi.org/10.1177/1082013219833234

17. Jackson M L (1973) Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

18. Walkey A and Black TA(1934) An experimentation of vegetative method for determining soil organic matter and proposed modification of the chromic acid titration method. Soil Sci 37:38-39.

19. Subbiah BV and Asija GL(1956) Rapid procedure for the estimation of the available nitrogen in soils. Curr Sci 25:259-260.

20. Olsen SR, Cole CU, Wattannable F and Sandean DA (1954) Estimation of available phosphorus in soil by extraction with sodium bicarbonate. USDA circulation. 939p.

21. Merwin HD and Peech M (1951) Exchange ability of soil potassium in the sand, slit and clay fractions as influenced by the nature and complementary exchangeable cations. Soil Sci Am Proc15:125-128.

22. Conover CA (1986) Quality. Acta Hortic 181:201-205.

23. Subba Rao NS(1999) Soil microorganisms and plant growth. Oxford & IBH publishing Company, New Delhi. 1-333p

24. Gomez KA and Gomez AA (1984)*Statistical procedure for Agricultural Research*. 2nd ed. Jhon Wiley and Sons Inc, New York. 680p.

25. Kachave TR, Dhamak AL, Shinde VN andGajbhiye BR (2021) Effect of organic formulations and inorganic fertilizer on yield attributes, yield and quality of tomato. Int J Curr Microbiol and Appl Sci10:223–235.

26. Chadha S, Saini JP, Paul YS(2012) Vedic Krishi: Sustainable livelihood option for small and marginal farmers. Indian J TraditKnowl 11 483–486.

27. Bisht AS, Dilta BS, Sharma KM, Baweja HS, Sharma BP and Kuma P(2022) Influence of various natural farming modules on available npk, viable microbial count and economics of seed production on african marigold (*Tagetes erecta* L.) Cv.'PusaNarangiGainda'. Int J Food and Nutr Sci 11(1), pp.2320-7876.

28. Pathania S, Dilta BS and Kumar A(2023) Response of biostimulants on growth, flowering, seed yield and quality of China aster (*Callistephuschinensis* (L.) Nees). IJBSM *14*(8), pp.1108-1115. http://dx.doi.org/10.23910/1.2023.3552

29. Sharma R, Bhatia S and Dhiman SR(2023) Production of potted petunias (*Petunia× hybrida*Vilm) as affected by growing media and Jeevamrit application. J Farm Sci 13(2) pp.87-93.doi: 10.5958/2250-0499.2023.00038.1

30. Pathania S, Dhiman SR, Kashyap B, Kumar A, Kaushal R, Gupta RK, Saleh IA, Okla MK and Elshikh MS (2024) Influence of planting dates and fertilizer modules on yield of chrysanthemum and soil health. BMC Plant Biol 24(1), p.510. https://doi.org/10.1186/s12870-024-05241-y

31. Choudhary R, Kumar R, Sharma G and Sharma P(2022) Effect of natural farming on yield performances, soil health and nutrient uptake in wheat+ gram inter cropping system in sub-temperate regions of Himachal Pradesh. JCrop Weed 18, 1–8. https://doi.org/10.22271/09746315

32. Rautela S, Bains G, Singh DK, Jahan S and Thi T(2022) Effect of organic, inorganic and integrated nutrient amendments on growth parameters of basmati rice (*Oryza sativa* L.). Pharm Innov J 11, 321–325.

33. Hu Q, Liu T, Ding H, Li C, Tan W, Yu M, Liu J and Cao C(2023) Effects of nitrogen fertilizer on soil microbial residues and their contribution to soil organic carbon and total nitrogen in a rice-wheat system. Appl Soil Ecol 181, p.104648. https://doi.org/10.1016/j.apsoil.2022.104648

34. Yadav N, Thakur KS, Mehta DK(2022) A practice to enhance soil physico-chemical properties and viable microbial count as effected by organic nutrient sources in garden pea under mid hill zone of Himachal Pradesh. Indian J Agric Res, 56, 626–628. https://doi.org/10.18805/IJARe.A-5979

35. Darjee S, Pooja LR, Khandelwal A, Dhar S, Shrivastava Mand Singh R (2022) Integrated application of inorganic and bio-fertilizers affects nitrogen losses and yield of wheat (*Triticum aestivum* L.). Ann Agric Res 43, 127–133.

36. Kaur P and Saini JP(2021) Optimization of Jeevamrit doses and application time for enhancing productivity of wheat under natural farming system. J PharmacognPhytochem10, 405–408.

37. Naresh RK, Kumar M, Kumar S, Chowdhary U, Kumar Y, Mahajan NC, Malik M, Singh S, Rathi RC and Tomar SS (2018) Zero budget natural farming viable for small farmers to empower food and nutritional security and improve soil health: A review. J PharmacognPhytochem7 (2), pp.1104-1118.

38. Saharan BS, Tyagi S, Kumar R, Vijay Om H, Mandal BS and Duhan JS(2023) Application of Jeevamrit improves soil properties in zero budget natural farming fields. Agric13:196. https://doi.org/10.3390/agriculture13010196

39. Sharma R and Chadak S(2022) Residual soil fertility, nutrient uptake, and yield of okra as affected by bioorganic nutrient sources. Commun Soil Sci Plant Anal, 53, 2853–2866. https://doi.org/10.1080/00103624.2022.2094397

40. Al-Jabori JSJ, Al-Obaed BSO and Al-Amiri AHF(2011) Effect of soil gypsum content and kind of organic matter on status and behavior of potassium. TJAS 11, 299–310.

41. Kumari S, Meena L, Raghavendra KJ and Karwal, M(2022)Jeevamrit/ Jeevamrutha: organic concoctions for natural farming. Agric Food e-Newsletter. 4, 40–42.

42. Dhiman M, Rana N and Ghabru A(2023) Isolation and screening of agriculturally important Bacteria (PGPR) from organic sources of nutrient (Panchgavya, Jeevamrit and farm yard manure) for future use. Asian J Agric22, 43–52. https://doi.org/10.9734/ajaar/2023/v22i3443

43. Rathore G, Kaushal R, Sharma V, Sharma G, Chaudhary S, Dhaliwal SS, Alsuhaibani AM, Gaber A and Hossain A(2023) Evaluation of the usefulness of fermented liquid organic formulations and manures for improving the soil fertility and productivity of brinjal (Solanum melongena L.). Agric 13(2), p.417.

