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Performance of *Valeriana jatamansi* in Hill Zone of West Bengal Concerning Manure Sources

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The organic source of nutrients would be a promising practice for *Valeriana jatamansi* cultivation which maintains its curative value. A set of experiments was conducted at Hill Zone of West Bengal, Kalimpong for two consecutive cycles to standardize organic nutrient management in *V. jatamansi* for optimum growth and economic yield. Different organic sources of nutrients such as farm yard manure (FYM), bio-fertilizer (BF), and vermicompost (VC) were applied at various doses along with a recommended dose. We applied the treatments as follows: T_1= FYM (5 t.ha^{-1}), T_2= VC (2 t.ha^{-1}), T_3= FYM (5 t.ha^{-1}) + VC (2 t ha^{-1}), T_4= FYM (5 t.ha^{-1}) + PSB, T_5= VC (2 t.ha^{-1}) + PSB, T_6= FYM (5 t.ha^{-1}) + VC (2 t.ha^{-1}) + PSB, T_7= Control, T_8= RDF through inorganic fertilizers (50:25:25 kg.ha^{-1} as N, P_2O_5, and K_2O). The use of organic manures and PSB significantly ($P<0.05$) increased the rhizome yield and soil-available macronutrients in *V. jatamansi* due to the release of nutrients from the decomposition of organic manures. The addition of T_6 resulted in a maximum canopy height (18.28 cm), plant fresh biomass (16.42 t.ha^{-1}), dry biomass (3.19 t.ha^{-1}), rhizome

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fresh weight (3.16 $t.ha^{-1}$), and dry weight (1.16 $t.ha^{-1}$), as well as highest organic carbon content (0.75%), nitrogen (221 $kg.ha^{-1}$), phosphorus (46.70 $kg.ha^{-1}$), and potassium (201 $kg.ha^{-1}$). Applying FYM, vermicompost, and PSB combination would be a promising strategy for growing *V. jatamansi*.

Keywords: Bio-fertilizer; FYM; nutrient availability; Valeriana jatamansi; vermicompost.

1. INTRODUCTION

More than 250 species of the genus *Valeriana* belong to the Valerianaceae family. Concerning the geographic range, it lives in temperate parts of the planet. There are around 16 species in India, of which two subspecies and five species are found in the high-altitude area of the central Himalayas [1]. According to Patan et al. [2], the herbaceous Valerian *jatamansi* is known as Indian Valerian, Sugandhbala, and Tagar in Hindi and Sanskrit, respectively. Since ancient times, it has been utilized in Indian healthcare [3,4]. *V. jatamansi* became apparent due to its various uses. More than 50% of the use was for basic healthcare. The results of past studies support its use to treat respiratory conditions, as well as pain and inflammation [5,6]. In India, *V. jatamansi* is used locally as an antihypertensive, laxative, carminative, aphrodisiac, and for mental disorders [7,8]. According to Zhang and Ding [9], it has been used in China to treat dermatitis, eye problems, sleeplessness, obesity, epilepsy, mental disorders, and snake poisoning. According to Bhattacharyya et al. [10] it is used in Nepal to lessen stress, anxiety, and depression.

The enormous pharmacological importance of *V. jatamansi* and its widespread use are factors contributing to its rising demand daily [11]. Rhizomes and seeds are the conventional methods for propagating *V. jatamansi*. The traditional farming system has never produced enough material to satisfy industrial demands and is time-consuming. Nevertheless, approximately 80% of Indians continue to use herbal medications. As a result, with an expanding population, there is an increasing concern about herb production and sustainable use. Currently, there is a 40,000 tonnes estimated gap between the supply and demand for medicinal plants. Thus plant cultivation under ex-situ conditions can meet growing demand. For its cultivation, there is no specific program has been developed. It would be preferable to cultivate the crop organically rather than using chemical fertilizers because they may cause a decline in its therapeutic value. Applying organic manures might increase soil fertility by providing vital nutrients which promote crop growth. Manures can replace mineral fertilizer and benefit the environment, soil structure, productivity, and carbon sequestration. The physicochemical and biological characteristics of the soil such as pH, bulk density, enzymatic activity, aggregation, organic carbon, and both macro and micronutrients were well-reported to be greatly improved by manure fertilization [12,13]. Manure fertilization can enhance the physical structure of the soil, enabling it to hold more water and nutrients, increasing crop productivity and having a lasting impact on succeeding crops [14]. Vermicompost, poultry manure, and farmyard manure increased crop yield and concentrations of essential nutrients in Indian soil when used in various cropping systems.

Since the development of the organic farming package of practices, there has been a lack of research on the organic cultivation of *V. jatamansi*. Therefore our objective is to maximize it's productivity with the available organic sources. We carried out a set of experiments at Hill Zone of West Bengal, Kalimpong for two consecutive cycles to standardize organic nutrient management in *V. jatamansi* for optimum growth and economic yield.

2. MATERIALS AND METHODS

2.1 Experimental Site Description

The experiments were conducted at the experimental farm at Regional Research Station (Hill Zone), Uttar Banga Krishi Viswavidyalaya, Kalimpong, West Bengal (latitude 27°31' N, longitude 88°28' E, and altitude 1097 m) during 2017-20. The climate of the area belongs to subtropical and humid, and the soils are moderately shallow to deep (80–120cm), dark yellowish brown to yellowish brown. The details of the soil nutrient status before starting the experiments were listed in Table 1. The region receives an average annual rainfall of 2231 mm. The air temperature varies between 8 and 27℃. Mean monthly weather parameters for the study region are presented in Fig. 1.

Table 1. Soil nutrient status before the start of the experiment

Properties	Characteristic value
Soil type	Sandy loam
Soil pH	Acidic (Value 5.32)
EC (d S m^{-1})	0.012
Available N (Kg ha^{-1})	210
Available phosphorus (Kg ha^{-1})	54.7
Available potassium (Kg ha^{-1})	183.5
Soil organic carbon (%)	0.72

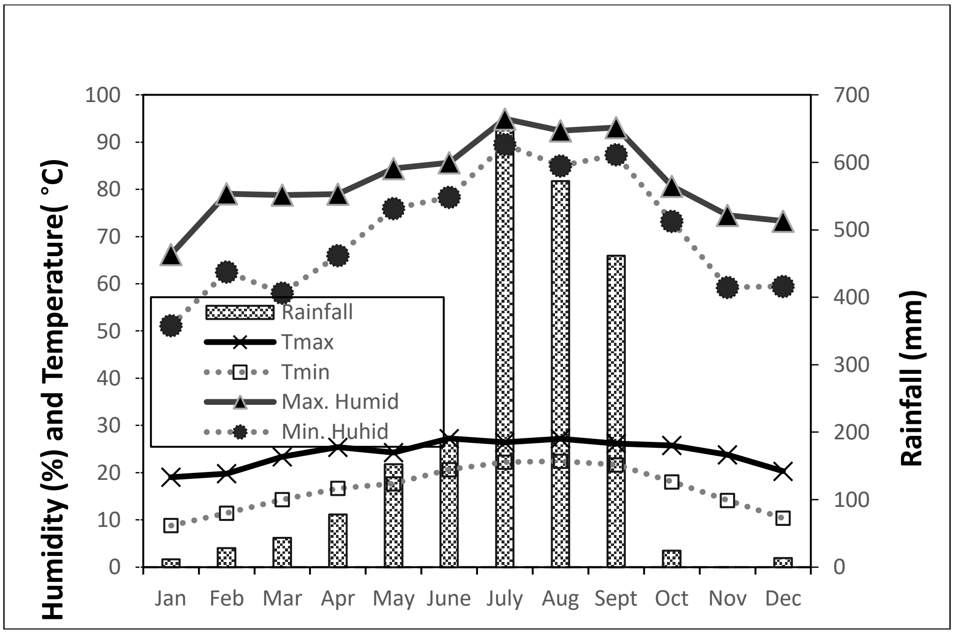

Fig. 1. Meteorological observations during the entire crop growth period

2.2 Treatment Details

A Randomized Block design was used to construct eight treatment combinations with four replications. i.e. T_1= FYM (5 t.ha^{-1}), T_2= VC (2 t.ha^{-1}), T_3= FYM (5 t.ha^{-1} + VC (2 t.ha^{-1}), T_4= FYM (5 t.ha^{-1} + PSB), T_5= VC (2 t.ha^{-1} + PSB), T_6= FYM (5 t.ha^{-1} + VC (2 t.ha^{-1}) + PSB, T_7= Control, and T_8= RDF through inorganic fertilizers (50:25:25 kg ha^{-1} as N, P_2O_5 and K_2O). At the time of the land preparation, FYM and VC were applied. Rhizome seed treatment was used to apply bio-fertilizer at the time of sowing. Two ploughings and one harrowing were used to prepare the field. Chemical fertilizers such as urea, single super phosphate (SSP), and muriate of potash (MoP) were employed. Rhizomes were sown with a spacing of 30 cm × 30 cm in each experimental plot (6 m × 2 m).

2.3 Harvesting and Plant Data Collection

Five randomly chosen plants were used to determine the yield-attributing characteristics, such as canopy height (cm), whole fresh weight (t.ha^{-1}), whole dry weight (t.ha^{-1}), rhizome fresh weight (t.ha^{-1}), and rhizome dry weight (t.ha^{-1}).

2.4 Soil Analysis

A composite soil sample (four random sample were mixed) was collected from each experimental plot (15 cm soil depth) after harvesting the crop in each season. The soil was air-dried in a shed and passed through a 2mm sieve for chemical analysis. Soil pH was determined by the glass electrode method in 1:2.5 water suspension using a Systronics pH meter (pH system 361) Jackson (1973). Soil organic carbon was determined by the wet digestion method of Walkley and Black (1934) Jackson (1973). The available phosphates were extracted with Bray and Kurtz No. 1 extractant (Bray and Kurtz, 1945). Potassium was determined by the neutral normal ammonium acetate (Jackson, 1973).

2.5 Statistical Analysis

Randomized block design with four replication were employed. The data gathered was compiled and tabulated. Statistical analysis was performed to determine the importance of variance caused by experimental treatments. The data was analysed using the analysis of variance (ANOVA) approach and SPSS 10 (software).

3. RESULTS AND DISCUSSION

3.1 Effect of Organic Manure on Yield Attributing Characters

The effects of different organic manure on yield-attributing characters are presented in Table 2. A significant ($P<0.05$) difference was recorded in canopy height. The significantly ($P<0.05$) highest canopy height (18.28 cm) was found with T6 and the lowest canopy heights (14.83 cm) were achieved with T3. Plant fresh weight and plant dry were also observed. Among treatments, the highest whole fresh and dry biomass were recorded with the T6. The lowest whole fresh and dry biomass were recorded with the T7 treatment (control).

Rhizome is the main economic part and its fresh was recorded highest with the T6 treatment and it was at par with the T3 and T5 treatments. The lowest rhizome fresh weight was recorded with the T7 control. The highest rhizome dry weight was achieved with the T6 treatment and it was at par with the T3 and T5 treatments. The lowest rhizome fresh weight was recorded with the T7 control.

3.2 Effect of Organic Manure on Soil Chemical Properties

The performance of any crop depends on nutrient supplying capacity of soil and the quality and quantity of added nutrients. Different combinations of organic sources of nutrients were applied for the performance of *V. jatamansi*. The changes in soil chemical properties and nutrient availability are presented in Table 3.

Table 2. Effect of organic practices on growth parameters of *Valeriana jatamansi*

Treatments	Canopy height (cm)	Plant fresh wt. (t/ha)	Plant dry wt. (t/ha)	Rhizome fresh wt. (t/ha)	Rhizome dry wt. (t/ha)
T1	16.15	13.45	2.40	2.28	0.81
T2	17.44	14.59	2.64	2.84	0.95
T3	17.94	16.13	3.03	3.09	1.02
T4	16.91	14.91	2.55	2.83	0.87
T5	17.73	15.11	2.82	3.03	1.03
T6	18.28	16.42	3.19	3.16	1.16
T7	14.83	11.83	2.02	2.04	0.67
T8	16.70	15.13	2.58	2.72	0.89
SEm(±)	0.44	1.45	0.19	0.27	0.8
CD (0.05%)	1.30	NS	0.6	0.8	0.23

Table 3. Soil chemical properties after completion of the experiment

Treatments	pH	EC(d S m^{-1})	Organic carbon (%)	Available N(Kg ha^{-1})	Available P (Kg ha^{-1})	Available K(Kg ha^{-1})
T1	5.39	0.01	0.69	211	51.40	184
T2	5.40	0.01	0.66	212	52.06	183
T3	5.33	0.01	0.74	218	54.20	196
T4	5.41	0.01	0.71	213	56.80	195
T5	5.44	0.01	0.68	217	52.70	188
T6	5.37	0.01	0.75	221	58.40	201
T7	5.64	0.01	0.61	207	46.70	182
T8	5.46	0.01	0.64	215	47.30	184
Sem (±)	0.3	0.001	0.08	2.38	3.18	3.36
CD(0.05%)	NS	NS	NS	7.39	10.01	9.73

The results showed that there was no significant response of organic manures to the soil pH of the soil. Results showed that a little decrease in pH was associated with organic manure application over control. These might be due to organic acid production from VC and FYM which decrease the soil pH. The electrical conductivity revealed no significant changes.

The organic carbon contents act as an indicator of soil structure, stability, nutrient retention, and soil erosion [15]. It is used as a proxy for soil fertility and nutrient availability. Results showed a significantly ($P<0.05$) higher organic carbon content in the soil under organics application over control and chemical fertilizer treatment. Results also revealed that the highest organic carbon content was obtained with the application of T6. The lowest organic carbon was found in both control and T8. FYM and VC applications had a modifying influence on the local edaphic environment like reducing bulk density, enhancing pore size distribution, and alteration of water and air regime that might also restrict soil organic carbon biodegradation.

The available nitrogen, phosphorus, and potassium contents among the different treatments varied significantly ($P<0.05$). The highest available nitrogen was found with the T6 treatment. The highest available N in T6 treatment was probably due to both application of FYM and VC and its mineralization. The decomposition of FYM and VC produces some organic ligands which help to increase their availability to plants and at the same time due to mineralization of such organics, N is released in the soil. The lowest available nitrogen content was found in the control.

The highest and lowest contents of available phosphorus were associated with the T6 and T7 control. Organic amendments on decomposition released organic acids which increased the P availability by blocking P adsorption sites on soils or through the anion exchange phenomenon [16-18], and the organic acid produced through the application of PSB caused the dissolution of P-bearing minerals in the soil and thus cause an increase in P availability.

Results also revealed that the application of T6 significantly ($P<0.05$) increased the available K over T7 control and T8. This might be due to the application of FYM and VC increasing the cumulative non-exchangeable potassium release and could maintain a large amount of potassium in soil solution and on exchange sites by re-establishing the equilibrium among different forms of potassium. Many researchers reported a significant increase in available K content in soil upon continuous application of FYM with inorganic fertilizer.

4. CONCLUSION

The release of nutrients from the breakdown of organic manures led to a considerable increase in the rhizome yield and soil-accessible macronutrients in *V. jatamansi* when organic manures and PSB were used. The addition of FYM (5 $t.ha^{-1}$) + VC (2 $t.ha^{-1}$) + PSB resulted in the highest organic carbon contents (0.75%), plant fresh biomass (16.42 $t.ha^{-1}$), plant dry biomass (3.19 $t.ha^{-1}$), rhizome fresh weight (3.16 $t.ha^{-1}$), nitrogen (221 $kg.ha^{-1}$), phosphorus (46.70 kg.ha-1), and potassium (201 $kg.ha^{-1}$). Thus the study concluded that applying FYM, vermicompost, and PSB together would be a promising strategy for growing *V. jatamansi* because it enhances soil fertility.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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