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Research Article
Effect of Different Manure on the Plant Growth and Yield of *Gymnema sylvestre* R. Br.

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Abstract

Background and Objective: *Gymnema sylvestre* is a perennial climber, well known for its pharmaceutical value. Despite of several studies on chemical composition and biological activities, there is a meagre information available on agronomical trails on this species. To analyze the effect of organic, bio and NPK fertilizers on the plant growth and leaf yield. **Materials and Methods:** Four treatments viz. T_1: Application of 100 kg of Farm Yard Manure; T_2: Application of 1.2 kg nitrogen, 0.8 kg phosphorus and 0.4 kg potassium, T_3: Application of 6.75 kg well decomposed coco peat, T_4: Application of 0.10:0.10:0.08 kg of Azospirillum:Phosphate Solubilizing Bacteria (PSB):Vesicular Arbuscular Mycorrhizal (VAM) in each replicate having unit area of 100 m^2. Data on plant height, number of branches per plants, dry weight of leaf yield per plant and per unit leaf yield was recorded in 12, 18 and 24 months after transplantation (MAT). **Results:** Maximum plant height of 188.96 cm was recorded in T_2 for 12 MAT. For 18 and 24 MAT, maximum plant height of 293.29 and 326.65 cm, respectively was recorded in T_4. Likewise, average number of branches per plant was recorded maximum of 7.85 in T_2 for 12 MAT, 19.36 and 22.46 for T_4, respectively in 18 and 24 MAT. Highest dry leaf yield of 124.84 kg per acre was achieved in T_2 for 12 MAT, while for 18 and 24 MAT, highest yield of 348.84 and 381.44 kg was achieved in T_4. **Conclusion:** Combine application of bio-fertilizers (Azospirillum, VAM and PSB), significantly improves the growth and yield in *Gymnema sylvestre*.

Key words: VAM, PSB, azospirillum, farm yard manure, *Gymnema sylvestre*

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Gymnema sylvestre (family Asclepiadaceae; abbreviated as GS) is a perennial climber thrives naturally in most part of India. The leaves of the plants possesses anti-diabetic, anti-sweetener and anti-inflammatory activities[1]. Traditionally, the leaf extract is used as a remedy for stomach ache, diabetes, rheumatism, cough, ulcer, dyspepsia, jaundice, haemorrhoids, asthma, bronchitis, conjunctivitis, leucoderma etc.[2,3]. The wide varieties of biological activities of GS is due to the presence of biologically active compounds such as acidic glycosides and anthroquinones[1]. The GS is recognized by natural products industry in north America and Europe and various commercial products has been developed from the species[2]. Leaves of GS is in high demand due to the presence of hypoglycemic property. Most of the supply was met through illegal and unsustainable harvesting from natural population and thus causing rapid depletion in natural habitat[1]. Moreover, the poor seed germination and very slow growth rate of the species also restrict its natural multiplication[2].

Cultivation of economic, rare and threatened species is considered the ultimate way to mitigate the pressure of dwindling population[4]. Moreover, getting optimum yield per unit area is another concern. It is well established fact that using chemical fertilizer can improves the yield but has adverse effect on the soil structure, soil fertility and environment. Furthermore, substantial use of chemical fertilizer in crops including medicinal plants and their use by human beings, may cause cancer and other lethal diseases. Application of organic, bio-fertilizers and NPK improves and maintain soil fertility and hence, plays a crucial role in growth, development and yield production. It is reported that, the consortium organic and bio-fertilizer can influence the plant growth directly through the production of phyto-hormones and indirectly through nitrogen fixation and production of bio-control agents against soil-borne phyto-pathogen[5]. Many studies has been carried out pertaining to propagation technique[1,3,6], however, very meagre information is available on yield improvement of this important species[5]. Yield improvement studies are important especially for those species, whose leaves are used for the medicinal purpose. Application of organic, bio-fertilizer and NPK should be preceded by proper evaluation of the plant for their ability to produce the optimum yield. Keeping above views in mind, the present study was design to understand the effect of different fertilizers on growth and yield production in GS.

MATERIALS AND METHODS

Study area: The field experiment was conducted at the research station of Zandu Foundation for Health Care, Ambach, Gujarat, India during June, 2016-May, 2018. Soil was collected from the study area at 0-10, 10-20 and 20-30 cm depth and composited for soil analysis. Soil texture class was determined by following textural triangle and the soil colour was determined through Munsell's soil colour chart (Munsell Color Division, Kollmorgen Corporation, Baltimore, MD 24218, USA, 1971). Soil pH was analyzed by an electro-metric pH meter. The details of the physico-chemical characteristics of the soil of the study area is presented in Table 1. Climatic data such as temperature, relative humidity (%) and rainfall of the study area during the study period is presented in the Fig. 1.

Experiment: The experiment was laid down in Randomized Block Design with 3 replications each having 100 m^2 area. There were four treatments i.e. T_1: application of 100 kg of Farm Yard Manure (abbreviated as FYM) per replicate, T_2: Application of 1.2 kg nitrogen, 0.8 kg phophorus and 0.4 kg potassium per replicate, T_3: Application of 6.75 kg well decomposed coco peat per replicate, T_4: Application of 0.10:0.10:0.08 kg of Azospirillum: Phosphate Solubilizing Bacteria (PSB):Vesicular Arbuscular Mycorrhizal (VAM) per replicate (Table 1). In each treatment, one fourth of the fertilizer were applied at four time i.e., at the stage of transplanting, 6 months after transplanting (abbreviated as MAT), 12 MAT and at 18 MAT. The seedling were planted with the spacing of 1 × 1 m line by line and plant by plant. Irrigation was provided every week except for rainy seasons.

Table 1: Geography and soil characteristic of the study area

Parameters	Characteristics
Mean elevation (m a.s.l.)	24
Location	20°24'09" N-72°59'04" E
Soil characteristics	
Colour	Brown
Texture	Sandy Loam
pH	7.88
WHC (%)	68.57
Total N/organic carbon (%)	0.86
P (Kg ha^{-1})	12.50
K (Kg ha^{-1})	130.00
S (ppm)	18.80
Zn (ppm)	1.08
Fe (ppm)	20.80
Mn (ppm)	24.86
Cu (ppm)	1.86

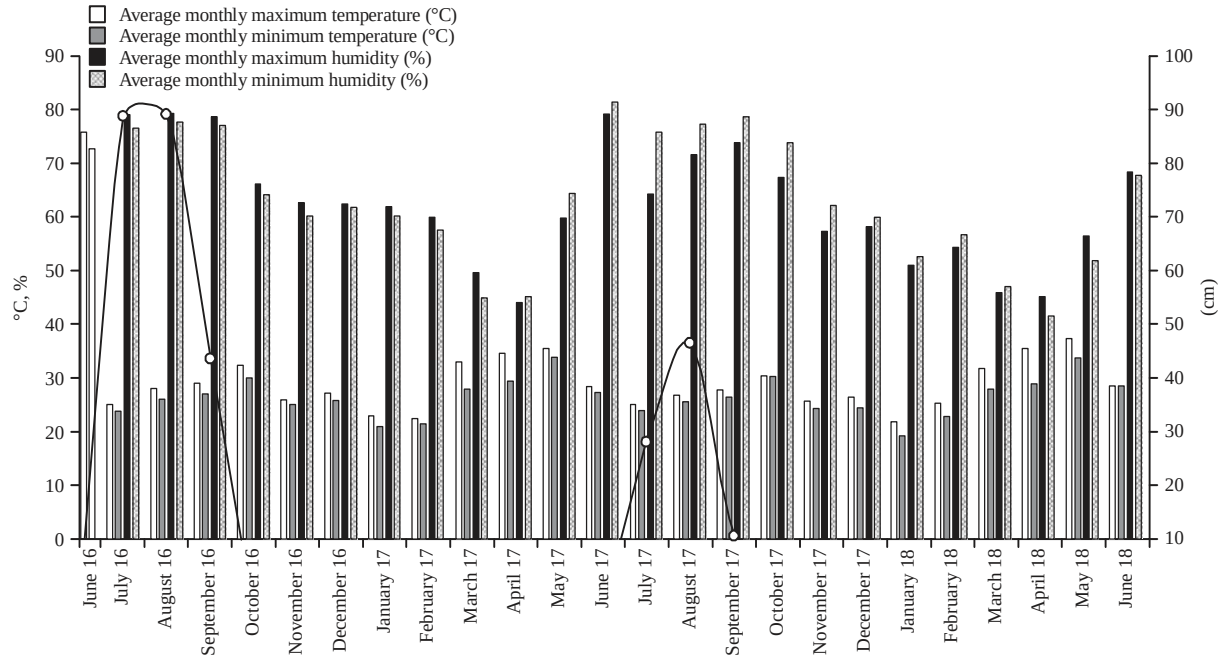

Fig. 1: Climatic data of the study area during study period

Table 2: Applications of organic, bio and NPK fertilizers in different treatment

Treatments	Fertilizers applied	Type of fertilizer	Quantity per application	Total fertilizers applied	Unit area
T_1	FYM	Organic	25 Kg	100 kg	100 m^2
T_2	NPK	Chemical	300:200::100 gm each	1.2 kg N, 0.8 Kg P, 0.4 kg K	
T_3	Well decomposed coco peat	Organic	2 kg	8 kg	
T_4	Azospirillum: PSB:VAM	Bio	50:25:20 gm each	100 g azospirillum, 100 g PSB and 80 g VAM	

Data collection: Observations on morphological parameters like plant height, number of branches per plant, dry weight of leaves at 12, 18 and 24 MAT were recorded. Harvesting was done by hand plucking and the harvested leaves was dried under shade to get yield per plant and yield are unit area. Obtained data were subjected to analysis of variance (ANOVA) between time interval (harvesting) and treatments by calculating the respective F-value and the critical difference at p = 0.05 following Panse and Sukuhatme[7].

RESULTS

Growth parameters: In present study, the applications of organic, bio-fertilizers and NPK resulted in increased plant height, number of branches per plant, dry weight of leaves per plants and total yield per unit area. Variation in plant height among different treatment and different harvesting time was found significant (p = 0.05). Likewise, variation for number of branches per plant was also found significant for both treatments and harvesting time (p = 0.05). Data pertaining to application of organic, bio-fertilizer and NPK on plant growth and number of branches per plants in all the stages i.e., after 12, 18 and 24 MAT is presented in Table 2. In 12 MAT, maximum plant height of 188.96 cm was recorded for treatment T_3. Likewise, number of branches per plant was recorded maximum of 7.85 for treatment T_2. Minimum plant height and minimum number branches was recorded in T_1 (Fig. 2a).

In 18 MAT, maximum plant height of 293.29 cm and maximum number of branches per plants was observed in treatment T_4. While, T_1 showed minimum plant height and minimum number of branches per plants (Fig. 2a). In 24 MAT, treatment T_4 showed best results for plant height and number of branches per plants followed by T_2 and T_3. In this harvesting time too, minimum plant height and minimum number of branches per plants was recorded for T_1 (Fig. 2a). Effect of different manure on plant height and number of leaves per plants was found significant (p = 0.05).

Yield parameters: Production of dry leaves per plant at harvesting done at 12 MAT was recorded highest of 31.21 g for T_2 (Fig. 2b). However, in 18 and 24 MAT, it was recorded maximum for T_4. Minimum production of dry leaves per plant was recorded in T_1 for harvesting done at 12, 18 and 24 MAT.

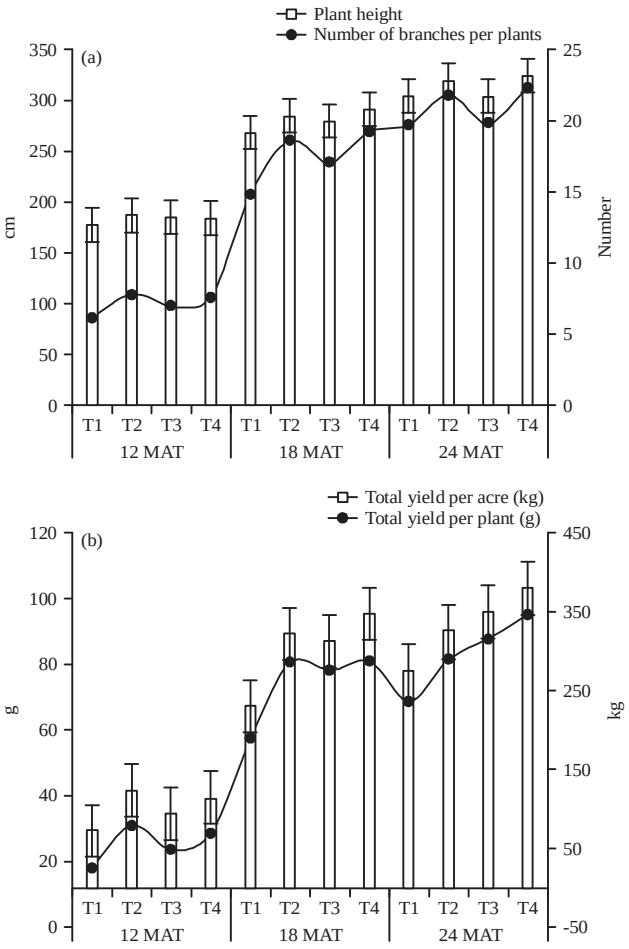

Fig. 2(a-b): Effect of different treatments on (a) Plant height and number of branches in different harvesting seasons and (b) Yield per plant and yield per acre in different harvesting seasons

Highest yield production of 124.84 kg per acre was achieved in T_2 (Fig. 2b). While, it was highest in T_4 for other two harvesting time i.e., in 18 and 24 MAT with the value of 348.84 kg and 381.44 kg per acre, respectively (Fig. 2b). Minimum yield production of dry leaves was recorded in T_1 for all the harvesting seasons. Variation in leaf yield per plant and per unit area among different treatment and different harvesting time was found significant ($p = 0.05$).

DISCUSSION

Achieving maximum yield with high quality produce is the ultimate goal of any crop management program. The organic, bio-fertilizer and NPK provides additional nutrients and increases availability of native soil nutrients with increased microbial activities. Organic and bio-fertilizer improves the humic substances in soil which improves the yield of the crops[8]. In present study, maximum plant height was obtained in T_2 in 12 MAT and T_4 in 18 and 24 MAT. Increase in plant height in T_2 in 12 MAT may be attributed to the fact that adequate supply of readily available nitrogen from NPK in the soil and its absorbance by plants leads to improved physiological activities in the plant thus making plant to grow fast. While, in 18 and 24 MAT, increased plant growth in T_4 indicated that application of bio-fertilizer (Azospirillum, PSB and VAM) promotes plant growth at later stages. El-Sayed *et al.*[9] also reported that application of Phosphate Solubilizing Bacteria (PSB) has positive effect on plant height. Bio-fertilizers boost the activity of micro-organisms in the soil and make the unavailable micronutrients available for the plant growth[10]. Significant variation in plant height among different treatments irrespective of different MATs may be attributed to chemistry and physical properties of different manure applied.

Number of branches per plant was also observed highest in T_2 for 12 MAT and in T_4 for 18 and 24 MAT. Branching pattern in a crop is also influenced by the physical and chemical properties of the soil[11] besides plants genetic makeup and diseases. Proper and timely application of appropriate fertilizers also prevent occurrence of diseases in plants, thus not only help the plant to blooms but also increases the yield. Pandey[3] reported that application of FYM produces highest number of leaves per plant. In contrast, application of FYM (T_1) has least impact on the plant growth and number of leaves per plant in present study. However, the variation in plant height and number of leaves per plants were comparable.

Yield is a complex phenomenon which is influenced by number of factor such as genetic makeup, environment, available soil moisture, available soil nutrients etc. Besides this, management of soil fertility and proper timing of fertilization also play vital role in plant growth and yield production. Present study clearly indicated that, plant growth and yield in GS were considerably increased by the application of various fertilizers. It is interesting to note that, in 12 MAT, T_2 gave 40.98% higher production than T_1, 23.84% higher production than T_3 and 7.46% higher production than T_4. While, in 18 MAT, T_4 gave 33.65, 7.27 and 10.13% higher production than T_1, T_2 and T_3, respectively. Likewise, in 24 MAT, T_4 gave 27.54% higher production than T_1, 14.13% than T_2 and 7.86% higher than T_3. Effect of different manure on leaf yield per plants and leaf yield per unit area was found significant ($p = 0.05$). Significant variation in leaf yield per plant among different MATs and treatments may be attributed to functioning pattern of the manures applied.

Better leaf yield production in T_2 at harvesting done at 12 MAT may be attributed to the fact that, NPK is readily available to plant as soon as it is applied to the soil. Subbaraj and Thamburaj[12] also reported that, application of nitrogen significantly stimulate the growth in GS. However, excessive use of NPK may increase soil erosion, decrease soil fertility and also hamper the local environment[13]. Increased yield in T_4 in harvesting done at 18 and 24 MAT is attributed to the fact that, Azospirillum, PSB and VAM may take some time to carry out their functions. Moreover, GS requires 18 months to fully develop its root system, thus, able to use optimum benefits from bio-fertilizers. Nitrogen fixing bacteria, such as Azospirillum helps plant to synthesize vitamins, auxins and gibberellins, which stimulates plant growth[9]. Likewise, PSB is well known for producing organic acids like malic, succinic, fumaric, citric, tarteric and acetic acids when applied in soil. Application of PSB in soil also improves availability of micro-nutrients to the plants. The PSB needs some time to releases the acids and help in plant growth. VAM, the other important component of treatment T_4 is a fungus that penetrates the roots of plants in order to help them to capture nutrients from the soil. This fungus also needs some time to enter the plant root. The root system in GS is fully developed and established in 18 months and application of VAM at 18 MAT gives this fungus ample space to enter the fully established roots and making mycorrhizal colonies. This fungus retain moisture and produce powerful enzymes that naturally locks mineral nutrients in the soil for natural root absorption. Therefore, higher yield production in 18 and 24 MAT may be attributed to higher N accumulation by Azospirillum, N_2 fixation and better root growth which in turn would provide ample time to VAM to enter roots and hence helped roots to uptake higher water and nutrients. In the meantime, PSB also releases acids to the soils, which further helps in plant growth and higher yield production. Bhalla *et al.*[14] also reported that, the secretion of plant growth promoting substances such as auxins, gibberellins and cytokinins by these micro-organisms seem to be responsible for beneficial effects in plants inoculated with organic-fertilizers. Bio-fertilizers (Azospirillum, PSB and VAM) improve plant growth and yield by providing micro-nutrients, converting other nutrients from unavailable form to available form during the biological process[15].

CONCLUSION

It is observed that, combine application of bio-fertilizers (Azospirillum, VAM and PSB) containing bacteria and fungus, have positive effect on plant growth and leaf yield production in GS.

SIGNIFICANT STATEMENT

This study discovered that combine use of Azospirillum, Phosphate Solubilizing Bacteria (PSB) and Vesicular Arbuscular Mycorrhizal (VAM) have significant impact of plant growth and leaf yield production in *Gymnema sylvestre*. The findings of this study will help the researchers to uncover the critical area of applications of bio-fertilizer and its relationship with plant growth and yield production for better understanding.

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