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Realization of Bhumyamalaki (*Phyllanthus amarus* Schum and Thonn.) growth, yield and nutrient balance through integrated nutrient management

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Abstract
The field experiment with different combinations of organic manures and inorganic fertilizers was undertaken to elicit information on integrated nutrient management in *Phyllanthus amarus* under Northern Dry Zone of Karnataka at Main Horticultural Research and Extension Centre (MHREC), UHS, Udyanagiri, Bagalkot, during 2018-19. Among different treatment combinations, application of $M_2V_1F_2$ (15 tonnes FYM, 2 tonnes vermicompost and fertilizer combination of 100: 45: 45 kg NPK per hectare) had recorded significantly maximum growth attributing parameters like plant spread (75.47 cm^2/plant), leaf area (497.67cm^2/plant), leaf area index (3.32), Cumulative growth rate (11.53 g/m^2/day), Absolute growth rate (0.23 g/day) and the yield parameters like total dry matter accumulation (16.17 g/plant),fresh herbage yield (22.19 g/plant and 14.79 t/ha) and dry herbage yield (9.92 g/plant and 6.61 t/ha). Whereas, the maximum nutrient availability in soil after harvest (P_2O_5-52.00 and K_2O-924.33 kg/ha) was recorded with treatment $M_2V_0F_0$ (15 tonnes FYM, 0 tonnes vermicompost along with 0 kg NPK per hectare).

Keywords: *Phyllanthus amarus*, INM, growth, yield, nutrient balance in soil

Introduction
Phyllanthus amarus Schum and Thonn. Is an important annual medicinal herb belongs to Euphorbiaceae family. It is popularly known as "Bhumyamalaki" having pronounced hepatoprotective property in the Indian system of medicine. It is native to America and widely distributed in humid tropical and subtropical countries in the world. It is *Kharif* season crop found abundantly throughout the hotter parts of India upto 1000 m altitude (George, 1892)[6]. It has obtained a place in the secondary list of the pharmacopoeia of India because of having medicinally important organic compounds having different classes including alkaloids, steroids, flavonoids, terpenoids, lipids, lignins and coumarins. Among all the compounds, the important lignans *i.e.,* phyllanthin (a bitter constituent) and hypophyllanthin (a non bitter constituent) (Row *et al.,* 1967) [17]. These compounds are gaining importance in the recent years in Indian system of medicine because of its novel antiviral activity against Hepatitis - B virus (Unander *et al*., 1993) [22], where it inactivates the virus and further prevents its multiplication by inhibiting the polymerase activity and suppressing the virulence of viruses (Thyagarajan *et al*., 1988) [21]. This herb is used in traditional medicine for more than 3,000 years. The whole plant has been used in medicine in Central and South America and Asia (including India and Indonesia) (Calixto *et al.,* 1998) [3]. It has many curing properties against numerous human ailments such as diuretic kidney and gallbladder stones (Foo and Wong, 1992) [5], cold, flu, tuberculosis, geinto-urinary infections and also acts against liver cell toxicity and improves the immune system of patients and found effective against Hepatitis - A (Jayarama *et al*., 1997) [9].
Because of its high potential, it is gaining great demand. So, it needs commercial cultivation to meet its demand. Since, this drug has wide role in both *Ayurvedic* and pharmaceutical industries. There is need to reduce the chemicals in cultivation to lower the residue. Hence, proper blending of chemical fertilizers with organic manures is important to get sustainable yield, good quality drug and the desired crop productivity and to improve soil health through optimization of benefit from all possible sources of plant nutrients in an integrated manner.

So, the present investigation entitled "Realization of Bhumyamalaki (*Phyllanthus amarus* Schum and Thonn.) growth, yield and nutrient balance" proposed to evaluate the best combination of inorganic fertilizers and organic manures for maximum growth, yield and nutrient balance in soil of *P. amarus.*

Material and Methods

The field experiment was carried out with mutant variety CIM Jeevan during *Kharif* 2018-19 at University of Horticultural Sciences, Bagalkote, which is situated in Northern Dry Zone of Karnataka (Zone-3) located at 542.0 m above the mean sea level. The investigation was conducted on sandy loam soil with pH 8.14, available nitrogen (238 kg/ha), phosphorus (34.36 kg/ ha) and potassium (821.76 kg/ha). The experiment was laid out in Factorial randomized block design with three replications and there were 24 treatments consisting of different levels. The three levels of FYM, *viz*., M_0, M_1& M_2 (0, 7.5 & 15 t/ha), vermicompost *viz*., V_0& V_1 (0 & 2 t/ha) and chemical fertilizers, *viz*., F_0, F_1, F_2& F_3 (0: 0: 0, 50: 30: 30, 100: 45: 45 and 150: 60: 60 kg NPK/ha respectively). Full dose of FYM (farm yard manure) and vermicompost were applied one week before sowing and mixed well, Phosphorus in the form of single super phosphate (P_2O_5) and potash in the form of muriate of potash (K_2O) and 50 per cent nitrogen in the form of urea (N) as per the treatments were applied just before sowing of seeds and remaining 50 per cent of nitrogen was top dressed at 35 days after sowing (DAS). Seeds were line sown at a depth of 1-2 cm using 1 kilogram seeds per hectare with row to row spacing of 15 cm and intra-row spacing of 10 cm. Immediately after sowing light irrigation was provided. The observations were recorded on five randomly selected plants from three replications at harvest (100 DAS). The observations like plant spread was measured along the East-West and North-South direction with the help of meter scale, leaf area was determined with digital leaf area meter (LI-3100 Area Meter) and LAI was calculated by applying the formula as suggested by Sestak *et al*. (1971)[19]. Whereas, total dry matter production, Cumulative growth rate (CGR) and Absolute growth rate (AGR) were recorded between different stages and intervals of crop growth and calculated using the formula suggested by Watson (1952) [23] for CGR and for AGR by Reford (1967) [16]. The harvesting was done using sickel by cutting whole herb at crown region and weighed for fresh herbage yield. They were dried in the shade to retain the color and weighed for dry herbage yield. The soil samples were collected before and after cropping at a depth of 0-30 cm from each plot and a composite soil sample was drawn and analyzed for N, P, and K content. Where, available nitrogen by using alkaline potassium permanganate method given by Subbiah and Asija, (1956) [20], available phosphorus by chlorostannus reduced molybdo-phosphoric blue colour method and available potassium by flame photometer method as suggested by Jackson (1973) [8] were determined. The data recorded during the crop period were statistically analyzed using the Fischer's method of analysis of variance technique as outlined by Panse and Sukhatme (1967) [14] and the results have been discussed at 5% probability level.

Result and discussion

Growth and yield attributing parameters were increased with increasing level of FYM (15 t/ha), vermicompost (2 t/ha) and second highest level of NPK (100: 45: 45 kg/ha). The results of the experiment on integrated nutrient management with use of organic and chemical fertilizers showed significant effect on growth attributing parameters. Among different nutrients combinations, $M_2V_1F_2$ (15 t FYM/ha + 2 t vermicompost/ha + 100: 45: 45 kg NPK/ha) showed significantly maximum plant spread represented in Table 1.1 (75.47 cm^2) which was on par with $M_2V_0F_3$ (15 t FYM/ha + 0 t vermicompost/ha + 150: 60: 60 kg NPK/ha). Significantly, the maximum leaf area (497.67 cm^2) and LAI (3.32) was recorded with $M_2V_1F_2$ (15 t FYM/ha + 2 t vermicompost/ha + 100: 45: 45 kg NPK/ha) which was on par with $M_2V_1F_3$ (15 t FYM/ha + 2 t vermicompost/ha + 150: 60: 60 kg NPK/ha) followed by $M_2V_0F_3$ (15 t FYM/ha + 0 t vermicompost/ha + 150: 60: 60 kg NPK/ ha). This might be due to higher nutrient released from both organic manures and inorganic fertilizers would have resulted in the increased nutrient availability of both macro and micro nutrients, along with improvement in soil health where it enhanced the translocation of photosynthates from source to sink and improved vegetative growth parameters. The similar results were reported by Sadhashiv (2010)[18] in ashwagandha, Nadukeri (2006) [13] in coleus, Konnur (2018) [11] in garden rue and Balakumbahan *et al*. (2011)[2] in *Phyllanthus amarus.*

The CGR and AGR found significantly maximum (Table 1.2 & 1.3 respectively) at 30-60 DAS compared to 60-100 DAS with treatment combination of $M_2V_1F_2$ (15 t FYM/ha + 2 t VC/ha + 100: 45: 45 kg NPK/ ha). This might be due to fact that Bhumyamalaki being short duration crop, its vegetative phase will be maximum at initial stages (30-60 DAS) when compared to later stages. Because, at later stages (60-100 DAS) it enters into reproductive stage hence hinders the vegetative growth. Significantly maximum CGR and AGR (11.53 g/m^2/day and 0.23 g/day, respectively) was observed with $M_2V_1F_2$ (15 t FYM/ha + 2 t VC/ha + 100: 45: 45 kg NPK/ ha) at 60-100 DAS followed by $M_2V_0F_3$ (15 t FYM/ha + 0 t VC/ha + 150: 60: 60 kg NPK/ ha). This increased CGR and AGR might be due to fact that nutrient released from both organic and fertilizers would have resulted in synergistic effect in terms of improved nutrient availability for longer period, water holding capacity, beneficial microbial activity which intern enhanced photosynthetic rate and also translocation of photosynthates from source to sink resulted in more dry matter accumulation and thereby increased CGR and AGR. Similar results were reported by Sadashiva (2010) [18] in ashwagandha, Kattimani (1999)[10] in Japanese mint and Nadukeri (2006) [13] in *C. forskohlii.*

The combined application of M × V × F had significant effect on total dry matter accumulation (Table 2.1 & Fig.1). Significantly, maximum dry matter production was observed with $M_2V_1F_3$ (15 t FYM/ha + 2 t vermicompost/ha + 150: 60: 60 kg NPK/ ha) at 30 and 60 DAS (3.70 and 11.05 g/plant respectively). Whereas, at harvest maximum dry matter production (16.17 g/plant) was observed with $M_2V_1F_2$ (15 t FYM/ha + 2 t vermicompost/ha + 100: 45: 45 kg NPK/ ha) followed by $M_2V_1F_3$ (15 t FYM/ha + 2 t vermicompost/ha + 150: 60: 60 kg NPK/ha). This might be due to fact that increase in availability of nutrients by both the amendments *viz.*, organic manures and inorganic fertilizers has increased the growth attributing factors like plant height, number of leaves, number of branches, plant spread, leaf area etc which inturn led to increase in total dry matter production. This result was in line with Sadashiva (2010) [18] reported in ashwagandha.

The fresh and dry herbage yield (Table 2.2, Fig. 2 and Table 2.3, Fig. 3 respectively) also showed significant effect. Where, the maximum fresh herbage yield (22.19 g/plant & 14.79 t/ha) and dry herbage yield (9.92 g/plant & 6.61 t/ha, respectively) were observed in $M_2V_1F_2$ (15 t FYM/ha + 2 t vermicompost/ha + 100: 45: 45 kg NPK/ ha) which was on par with$M_2V_1F_3$ (15 t FYM/ha + 2 t vermicompost/ha + 150: 60: 60 kg NPK/ha)

followed by $M_2V_0F_3$ (15 t FYM/ha + 0 t vermicompost/ha + 150: 60: 60 kg NPK/ha). This increase in yield parameters might be due to increased uptake of major and minor nutrients by the plants through FYM, vermicompost and chemical fertilizers in the presence of beneficial microbes and growth promoting substances. These results are in the line with the findings of Rajamanickam *et al*. (2011) [15] in mint, Ajimoddin *et al*. (2005) [1] in sweet basil and Gupta *et al*. (2011) [7] in black henbane.

Soil available nitrogen content after harvest did not show any significant difference with the application of different levels of organic manures and inorganic fertilizers. Whereas, it recorded significant impact on soil available P and K contents (Table 3). Highest available P and K (52.00 and 924.33 kg/ha respectively) was recorded with the application of $M_2V_0F_0$ (15 tonnes FYM, 0 tonnes vermicompost along with 0 kg NPK per hectare) where P was *on par with* $M_2V_1F_0$ (15 tonnes FYM, 2 tonnes vermicompost along with 0 kg NPK per hectare) and K was on par with $M_2V_0F_1$ (15 tonnes FYM, 0 tonnes vermicompost along with 50: 30: 30 kg NPK per hectare). The higher P content in $M_2V_0F_0$ might be due to the slow release of phosphorous by FYM, which lead to fixation and poor uptake by the plants. As a result, more amount of phosphorous was fixed in the soil. There was also decrease in equilibrium of K_2O in the soil and also reduced leaching loss. As a result more amount of K_2O was found in the soil. Similar results were observed in stevia by Kumar *et al.* (2013) [12] and Chand *et al*. (2001) [4] in mint.

Conclusion

From the present investigation, it can be concluded that the integrated application of 15 tonnes FYM + 2 tonnes vermicompost + 100: 45: 45 kg NPK per hectare ($M_2V_1F_2$) recorded the highest growth and yield attributing parameters and also maintained proper nutrient balance in soil of Bhumyamalaki under northern dry zone of Karnataka.

Table 1: Growth and developmental parameters of Bhumyamalaki (*Phyllanthus amarus* Schum and Thonn.) as influenced by integrated nutrient management.

Table 1.1 Growth parameters

Treatment		Plant spread (cm^2)					Leaf area (cm^2)					Leaf area index				
		F_0	F_1	F_2	F_3	Mean	F_0	F_1	F_2	F_3	Mean	F_0	F_1	F_2	F_3	Mean
M_0	V_0	21.63	26.97	32.27	39.17	30.01	175.33	207.33	277.67	343.33	250.92	1.17	1.38	1.85	2.29	1.67
	V_1	25.73	31.48	37.80	43.20	34.55	189.33	256.00	335.00	389.00	292.33	1.26	1.71	2.23	2.59	1.95
	Mean	23.68	29.22	35.03	41.18	32.28	182.33	231.67	306.33	366.17	271.63	1.22	1.54	2.04	2.44	1.81
M_1	V_0	27.10	36.43	46.83	56.00	41.59	234.67	335.33	378.67	402.67	337.83	1.56	2.24	2.52	2.68	2.25
	V_1	33.83	40.30	51.67	61.00	46.70	307.00	351.00	388.67	457.00	375.92	2.05	2.34	2.59	3.05	2.51
	Mean	30.47	38.37	49.25	58.50	44.15	270.83	343.17	383.67	429.83	356.88	1.81	2.29	2.56	2.87	2.38
M_2	V_0	35.10	48.10	58.00	72.33	53.38	336.33	381.33	442.33	483.67	410.92	2.24	2.54	2.95	3.22	2.74
	V_1	45.00	51.87	75.47	67.00	59.83	377.33	432.67	497.67	493.00	450.17	2.52	2.88	3.32	3.29	3.00
	Mean	40.05	49.98	66.73	69.67	56.61	356.83	407.00	470.00	488.33	430.54	2.38	2.71	3.13	3.26	2.87
Mean of (F)		31.40	39.19	50.34	56.45	44.34	270.00	327.28	386.67	428.11	353.01	1.80	2.18	2.58	2.85	2.35
Mean of (V)	V_0	27.94	37.17	45.70	55.83	41.66	248.78	308.00	366.22	409.89	333.22	1.66	2.05	2.44	2.73	2.22
	V_1	34.86	41.21	54.98	57.07	47.03	291.22	346.56	407.11	446.33	372.81	1.94	2.31	2.71	2.98	2.49

For comparing means of	Plant spread (cm^2)		Leaf area (cm^2)		Leaf area index	
	S.Em ±	C.D @ 5%	S.Em ±	C.D @ 5%	S.Em ±	C.D @ 5%
FYM (M)	0.81	2.32	4.16	11.85	0.03	0.08
Vermicompost (V)	0.66	1.89	3.40	9.67	0.02	0.06
Fertilizer (F)	0.94	2.67	4.81	13.68	0.03	0.09
M x V	1.15	NS	5.89	NS	0.04	NS
M x F	1.63	4.63	8.32	23.69	0.06	0.16
V x F	1.33	3.78	6.80	NS	0.05	NS
M x V x F	2.30	6.55	11.77	33.51	0.08	0.22

Farm yard manure (M)
M_0= 0 t ha^{-1}
M_1= 7.5 t ha^{-1}
M_2= 15 t ha^{-1}

Vermicompost (V)
V_0= 0 t ha^{-1}
V_1= 2 t ha^{-1}

Fertilizer (F)
F_0= 0:0:0 NPK (kg ha^{-1})
F_1= 50:30:30 NPK (kg ha^{-1})
F_2= 100:45:45 NPK (kg ha^{-1})
F_3= 150:60:60 NPK (kg ha^{-1})

NS= Non significant

Table 1.2: Growth attributing physiological parameter Cumulative Growth Rate (CGR)

Cumulative growth rate (g m^{2-1} day^{-1})											
Treatment		30-60 DAS					60-100 DAS				
		F_0	F_1	F_2	F_3	Mean	F_0	F_1	F_2	F_3	Mean
M_0	V_0	4.13	3.55	7.24	9.31	6.06	1.72	2.84	3.30	4.04	2.98
	V_1	4.23	6.30	8.02	10.63	7.30	2.58	2.99	3.60	4.68	3.46
	Mean	4.18	4.93	7.63	9.97	6.68	2.15	2.92	3.45	4.36	3.22
M_1	V_0	4.29	8.04	8.64	11.48	8.11	2.84	3.28	4.31	4.71	3.79
	V_1	4.86	6.51	9.31	11.94	8.15	3.00	5.19	5.55	6.17	4.98
	Mean	4.57	7.27	8.98	11.71	8.13	2.92	4.24	4.93	5.44	4.38
M_2	V_0	6.22	7.91	9.32	12.44	8.97	3.28	4.96	6.93	7.61	5.69
	V_1	7.08	8.28	12.84	16.33	11.13	3.74	6.05	11.53	7.03	7.09
	Mean	6.65	8.09	11.08	14.38	10.05	3.51	5.50	9.23	7.32	6.39
Mean of (F)		5.14	6.76	9.23	12.02	8.29	2.86	4.22	5.87	5.71	4.66
Mean of (V)	V_0	4.88	6.50	8.40	11.08	7.71	2.61	3.69	4.85	5.45	4.15
	V_1	5.39	7.03	10.06	12.97	8.86	3.11	4.75	6.89	5.96	5.18

For comparing means of	S.Em ±	C.D @ 5%	S.Em ±	C.D @ 5%
FYM (M)	0.15	0.43	0.10	0.29
Vermicompost (V)	0.12	0.35	0.08	0.24
Fertilizer (F)	0.17	0.49	0.12	0.33
M x V	0.21	0.35	0.14	0.41
M x F	0.30	0.86	0.20	0.58
V x F	0.25	0.70	0.17	0.47
M x V x F	0.43	1.21	0.29	0.82

Farm yard manure (M) **Vermicompost (V)** **Fertilizer (F)**

M_0= 0 t ha^{-1} V_0= 0 t ha^{-1} F_0= 0:0:0 NPK (kg ha^{-1}) DAS=Days after sowing

M_1= 7.5 t ha^{-1} V_1= 2 t ha^{-1} F_1= 50:30:30 NPK (kg ha^{-1}) NS= Non significant

M_2= 15 t ha^{-1} F_2= 100:45:45 NPK (kg ha^{-1})

F_3= 150:60:60 NPK (kg ha^{-1})

Table 1.3: Growth attributing physiological parameter Absolute Growth Rate (AGR)

Absolute growth rate (g day^{-1})											
Treatment		**30-60 DAS**					**60-100 DAS**				
		F_0	**F_1**	**F_2**	**F_3**	**Mean**	**F_0**	**F_1**	**F_2**	**F_3**	**Mean**
M_0	V_0	0.06	0.05	0.11	0.14	0.09	0.03	0.06	0.07	0.08	0.06
	V_1	0.06	0.09	0.12	0.16	0.11	0.05	0.06	0.07	0.09	0.07
	Mean	0.06	0.07	0.11	0.15	0.10	0.04	0.06	0.07	0.09	0.06
M_1	V_0	0.06	0.12	0.13	0.17	0.12	0.06	0.07	0.09	0.09	0.08
	V_1	0.07	0.10	0.14	0.18	0.12	0.06	0.10	0.11	0.12	0.10
	Mean	0.07	0.11	0.13	0.18	0.12	0.06	0.08	0.10	0.11	0.09
M_2	V_0	0.09	0.12	0.14	0.19	0.13	0.07	0.10	0.14	0.15	0.11
	V_1	0.11	0.12	0.19	0.24	0.17	0.07	0.12	0.23	0.14	0.14
	Mean	0.10	0.12	0.17	0.22	0.15	0.07	0.11	0.18	0.15	0.13
Mean of (F)		0.08	0.10	0.14	0.18	0.12	0.06	0.08	0.12	0.11	0.09
Mean of (V)	V_0	0.07	0.10	0.13	0.17	0.12	0.05	0.07	0.10	0.11	0.08
	V_1	0.08	0.11	0.15	0.19	0.13	0.06	0.09	0.14	0.12	0.10
For comparing means of		S.Em ±		C.D @ 5%			S.Em ±		C.D @ 5%		
FYM (M)		0.00		0.01			0.00		0.01		
Vermicompost (V)		0.00		0.01			0.00		0.00		
Fertilizer (F)		0.00		0.01			0.00		0.01		
M x V		0.00		0.01			0.00		0.01		
M x F		0.00		0.01			0.00		0.01		
V x F		0.00		0.01			0.00		0.01		
M x V x F		0.01		0.02			0.01		0.02		

Farm yard manure (M) **Vermicompost (V)** **Fertilizer (F)**

M_0= 0 t ha^{-1} V_0= 0 t ha^{-1} F_0= 0:0:0 NPK (kg ha^{-1}) DAS=Days after sowing

M_1= 7.5 t ha^{-1} V_1= 2 t ha^{-1} F_1= 50:30:30 NPK (kg ha^{-1}) NS= Non significant

M_2= 15 t ha^{-1} F_2= 100:45:45 NPK (kg ha^{-1})

F_3= 150:60:60 NPK (kg ha^{-1})

Table 2: The yield attributing parameters of Bhumyamalaki (*Phyllanthus amarus* Schum and Thonn.) as influenced by integrated nutrient management.

Table2.1: Total dry matter accumulation (g/plant) at different different stages of crop growth.

Treatment		**30 DAS**					**60 DAS**					**100 DAS (At harvest)**				
		F_0	**F_1**	**F_2**	**F_3**	**Mean**	**F_0**	**F_1**	**F_2**	**F_3**	**Mean**	**F_0**	**F_1**	**F_2**	**F_3**	**Mean**
M_0	V_0	0.36	0.60	0.84	1.11	0.73	2.22	2.20	4.10	5.30	3.45	3.25	3.90	6.08	7.72	5.24
	V_1	0.52	0.72	1.00	1.47	0.93	2.42	3.56	4.61	6.25	4.21	3.97	5.36	6.77	9.06	6.29
	Mean	0.44	0.66	0.92	1.29	0.83	2.32	2.88	4.35	5.77	3.83	3.61	4.63	6.43	8.39	5.76
M_1	V_0	0.61	0.91	1.38	1.88	1.20	2.54	4.53	5.27	7.05	4.85	4.25	6.50	7.85	9.87	7.12
	V_1	0.71	1.24	1.61	2.51	1.52	2.89	4.17	5.80	7.88	5.19	4.69	7.29	9.13	11.59	8.18
	Mean	0.66	1.08	1.50	2.20	1.36	2.72	4.35	5.54	7.47	5.02	4.47	6.89	8.49	10.73	7.65
M_2	V_0	0.86	1.36	2.34	3.00	1.89	3.66	4.92	6.53	8.60	5.93	5.63	7.89	10.69	13.16	9.34
	V_1	1.03	2.15	3.47	3.70	2.59	4.22	5.87	9.25	11.05	7.60	6.47	9.50	16.17	15.27	11.85
	Mean	0.95	1.75	2.91	3.35	2.24	3.94	5.39	7.89	9.83	6.76	6.05	8.70	13.43	14.22	10.60
Mean of (F)		0.68	1.16	1.77	2.28	1.47	2.99	4.21	5.93	7.69	5.20	4.71	6.74	9.45	11.11	8.00
Mean of (V)	V_0	0.61	0.96	1.52	2.00	1.27	2.81	3.88	5.30	6.98	4.74	4.38	6.10	8.21	10.25	7.23
	V_1	0.75	1.37	2.03	2.56	1.68	3.18	4.54	6.56	8.40	5.67	5.04	7.38	10.69	11.97	8.77
For comparing means of		S.Em ±		C.D @ 5%			S.Em ±		C.D @ 5%			S.Em ±		C.D @ 5%		
FYM (M)		0.02		0.06			0.06		0.18			0.08		0.24		
Vermicompost (V)		0.02		0.05			0.05		0.15			0.07		0.19		
Fertilizer (F)		0.02		0.07			0.07		0.21			0.10		0.27		
M x V		0.03		0.09			0.09		0.25			0.12		0.34		
M x F		0.04		0.12			0.12		0.36			0.17		0.47		
V x F		0.04		0.10			0.10		0.29			0.14		0.39		

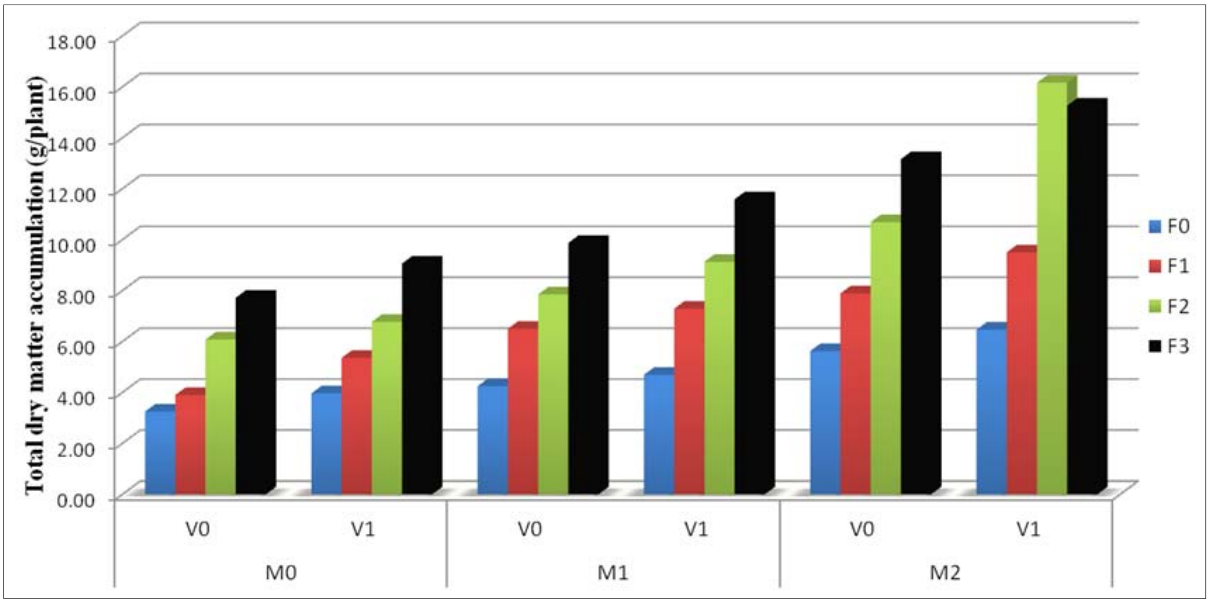
M x V x F	0.06	0.17	0.18	0.50	0.24	0.67

Farm yard manure (M)
M_0= 0 t ha^{-1}
M_1= 7.5 t ha^{-1}
M_2= 15 t ha^{-1}

Vermicompost (V)
V_0= 0 t ha^{-1}
V_1= 2 t ha^{-1}

Fertilizer (F)
F_0= 0:0:0 NPK (kg ha^{-1})
F_1= 50:30:30 NPK (kg ha^{-1})
F_2= 100:45:45 NPK (kg ha^{-1})
F_3= 150:60:60 NPK (kg ha^{-1})

DAS=Days after sowing
NS= Non significant



Farm yard manure (M)
M_0= 0 t ha^{-1}
M_1= 7.5 t ha^{-1}
M_2= 15 t ha^{-1}

Vermicompost (V)
V_0= 0 t ha^{-1}
V_1= 2 t ha^{-1}

Fertilizer (F)
F_0= 0:0:0 NPK (kg ha^{-1})
F_1= 50:30:30 NPK (kg ha^{-1})
F_2= 100:45:45 NPK (kg ha^{-1})
F_3= 150:60:60 NPK (kg ha^{-1})

Fig 1: Total dry matter accumulation (g/plant) at harvest in Bhumyamalaki (*Phyllanthus amarus* Schum and Thonn.) as influenced by integrated nutrient management.

Table 2.2: Fresh herbage yield per plant and per hactare

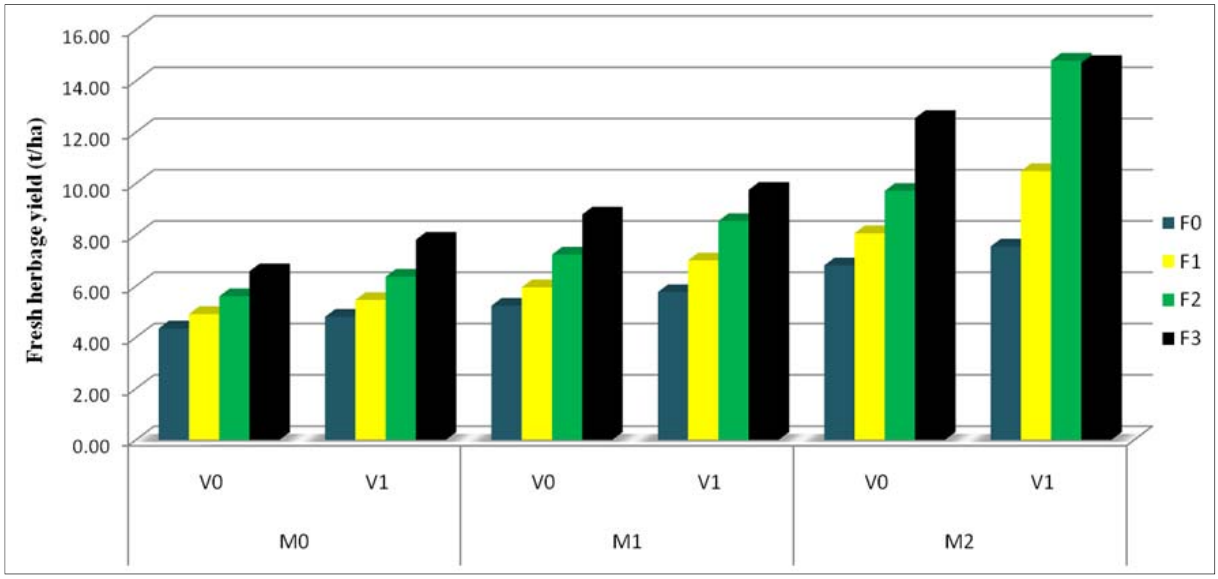
Treatment		Fresh herbage yield									
		Per plant (g)					Per hectare (t)				
		F_0	F_1	F_2	F_3	Mean	F_0	F_1	F_2	F_3	Mean
M_0	V_0	6.52	7.36	8.40	9.86	8.03	4.35	4.91	5.60	6.58	5.36
	V_1	7.20	8.18	9.54	11.71	9.16	4.80	5.45	6.36	7.81	6.10
	Mean	6.86	7.77	8.97	10.79	8.60	4.57	5.18	5.98	7.19	5.73
M_1	V_0	7.85	8.93	10.84	13.19	10.20	5.23	5.95	7.23	8.79	6.80
	V_1	8.64	10.50	12.80	14.62	11.64	5.76	7.00	8.53	9.75	7.76
	Mean	8.24	9.71	11.82	13.90	10.92	5.50	6.47	7.88	9.27	7.28
M_2	V_0	10.20	12.08	14.57	18.82	13.92	6.80	8.05	9.71	12.55	9.28
	V_1	11.31	15.72	22.19	22.04	17.82	7.54	10.48	14.79	14.69	11.88
	Mean	10.76	13.90	18.38	20.43	15.87	7.17	9.27	12.25	13.62	10.58
Mean of (F)		8.62	10.46	13.06	15.04	11.79	5.75	6.97	8.70	10.03	7.86
Mean of (V)	V_0	8.19	9.46	11.27	13.96	10.72	5.46	6.30	7.51	9.30	7.14
	V_1	9.05	11.47	14.84	16.12	12.87	6.03	7.65	9.90	10.75	8.58

For comparing means of	S.Em ±	C.D @ 5%	S.Em ±	C.D @ 5%
FYM (M)	0.13	0.36	0.08	0.24
Vermicompost (V)	0.10	0.29	0.07	0.19
Fertilizer (F)	0.14	0.41	0.10	0.28
M × V	0.18	0.51	0.12	0.34
M × F	0.25	0.71	0.17	0.48
V × F	0.21	0.58	0.14	0.39
M × V × F	0.36	1.01	0.24	0.67

Farm yard manure (M)
M_0= 0 t ha^{-1}
M_1= 7.5 t ha^{-1}
M_2= 15 t ha^{-1}

Vermicompost (V)
V_0= 0 t ha^{-1}
V_1= 2 t ha^{-1}

Fertilizer (F)
F_0= 0:0:0 NPK (kg ha^{-1})
F_1= 50:30:30 NPK (kg ha^{-1})
F_2= 100:45:45 NPK (kg ha^{-1})
F_3= 150:60:60 NPK (kg ha^{-1})



Farm yard manure (M)
M_0= 0 t ha^{-1}
M_1= 7.5 t ha^{-1}
M_2= 15 t ha^{-1}

Vermicompost (V)
V_0= 0 t ha^{-1}
V_1= 2 t ha^{-1}

Fertilizer (F)
F_0= 0:0:0 NPK (kg ha^{-1})
F_1= 50:30:30 NPK (kg ha^{-1})
F_2= 100:45:45 NPK (kg ha^{-1})
F_3= 150:60:60 NPK (kg ha^{-1})

Fig 2: Fresh herbage yield (t/ha) of Bhumyamalaki (*Phyllanthus amarus* Schum and Thonn.) as influenced by integrated nutrient management

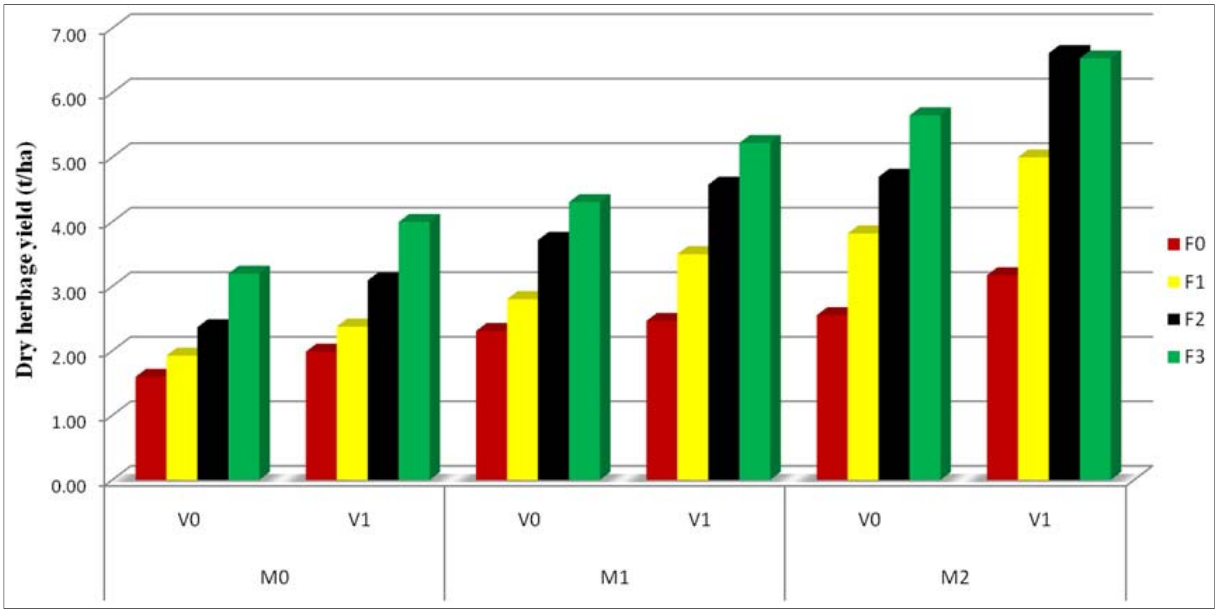
Table 2.3: Dry herbage yield per plant and per hactare

Treatment		Dry herbage yield									
		Per plant (g)					Per hectare (t)				
		F_0	F_1	F_2	F_3	Mean	F_0	F_1	F_2	F_3	Mean
M_0	V_0	2.40	2.89	3.55	4.79	3.41	1.60	1.93	2.37	3.20	2.27
	V_1	2.98	3.56	4.64	6.00	4.29	1.99	2.38	3.09	4.00	2.86
	Mean	2.69	3.23	4.09	5.40	3.85	1.79	2.15	2.73	3.60	2.57
M_1	V_0	3.46	4.20	5.58	6.46	4.92	2.31	2.80	3.72	4.30	3.28
	V_1	3.70	5.25	6.86	7.83	5.91	2.46	3.50	4.58	5.22	3.94
	Mean	3.58	4.72	6.22	7.14	5.42	2.39	3.15	4.15	4.76	3.61
M_2	V_0	3.83	5.73	7.05	8.47	6.27	2.55	3.82	4.70	5.65	4.18
	V_1	4.76	7.50	9.92	9.80	7.99	3.17	5.00	6.61	6.53	5.33
	Mean	4.29	6.61	8.48	9.14	7.13	2.86	4.41	5.66	6.09	4.75
Mean of (F)		3.52	4.85	6.27	7.22	5.47	2.35	3.24	4.18	4.82	3.64
Mean of (V)	V_0	3.23	4.27	5.39	6.57	4.87	2.15	2.85	3.59	4.38	3.24
	V_1	3.81	5.44	7.14	7.88	6.07	2.54	3.62	4.76	5.25	4.04
For comparing means of		S.Em ±		C.D @ 5%			S.Em ±		C.D @ 5%		
FYM (M)		0.07		0.19			0.04		0.12		
Vermicompost (V)		0.05		0.15			0.04		0.10		
Fertilizer (F)		0.08		0.21			0.05		0.14		
M × V		0.09		0.26			0.06		0.17		
M × F		0.13		0.37			0.09		0.25		
V × F		0.11		0.30			0.07		0.20		
M × V × F		0.18		0.52			0.12		0.35		

Farm yard manure (M)
M_0= 0 t ha^{-1}
M_1= 7.5 t ha^{-1}
M_2= 15 t ha^{-1}

Vermicompost (V)
V_0= 0 t ha^{-1}
V_1= 2 t ha^{-1}

Fertilizer (F)
F_0= 0:0:0 NPK (kg ha^{-1})
F_1= 50:30:30 NPK (kg ha^{-1})
F_2= 100:45:45 NPK (kg ha^{-1})
F_3= 150:60:60 NPK (kg ha^{-1})



Farm yard manure (M)
M_0= 0 t ha^{-1}
M_1= 7.5 t ha^{-1}
M_2= 15 t ha^{-1}

Vermicompost (V)
V_0= 0 t ha^{-1}
V_1= 2 t ha^{-1}

Fertilizer (F)
F_0= 0:0:0 NPK (kg ha^{-1})
F_1= 50:30:30 NPK (kg ha^{-1})
F_2= 100:45:45 NPK (kg ha^{-1})
F_3= 150:60:60 NPK (kg ha^{-1})

Fig 3: Dry herbage yield (t/ha) of Bhumyamalaki (*Phyllanthus amarus* Schum and Thonn.) as influenced by integrated nutrient management

Table 3: Nutrient availability in soil (kg ha^{-1}) after harvest in Bhumyamalaki (*Phyllanthus amarus* Schum and Thonn.) as influenced by integrated nutrient management

Treatment		Nitrogen (kg ha^{-1})					Phosphorous (kg ha^{-1})					Potassium (kg ha^{-1})				
		F_0	**F_1**	**F_2**	**F_3**	**Mean**	**F_0**	**F_1**	**F_2**	**F_3**	**Mean**	**F_0**	**F_1**	**F_2**	**F_3**	**Mean**
M_0	V_0	138.04	126.00	119.67	102.33	121.51	15.33	25.00	22.67	18.63	20.41	358.00	330.00	311.00	303.67	325.67
	V_1	185.50	145.00	107.00	73.00	127.63	37.33	27.33	22.33	17.67	26.17	846.00	713.00	597.67	498.33	663.75
	Mean	161.77	135.50	113.33	87.67	124.57	26.33	26.17	22.50	18.15	23.29	602.00	521.50	454.33	401.00	494.71
M_1	V_0	298.00	273.67	252.33	154.67	244.67	43.33	32.67	28.00	20.00	31.00	907.53	815.07	736.17	615.17	768.48
	V_1	245.33	193.67	149.33	101.00	172.33	31.30	26.79	19.03	16.67	23.45	663.00	594.67	509.33	475.33	560.58
	Mean	271.67	233.67	200.83	127.83	208.50	37.32	29.73	23.52	18.33	27.22	785.27	704.87	622.75	545.25	664.53
M_2	V_0	315.33	263.33	203.33	186.33	242.08	52.00	46.00	33.33	28.00	39.83	924.33	869.67	775.00	617.33	796.58
	V_1	304.33	235.00	163.00	172.67	218.75	49.00	30.67	21.33	27.33	32.08	713.73	624.13	458.33	548.00	586.05
	Mean	309.83	249.17	183.17	179.50	230.42	50.50	38.33	27.33	27.67	35.96	819.03	746.90	616.67	582.67	691.32
Mean of (F)		247.76	206.11	165.78	131.67	187.83	38.05	31.41	24.45	21.38	28.82	735.43	657.76	564.58	509.64	616.85
Mean of (V)	V_0	250.46	221.00	191.78	147.78	202.75	36.89	34.56	28.00	22.21	30.41	729.96	671.58	607.39	512.06	630.24
	V_1	245.06	191.22	139.78	115.56	172.90	39.21	28.26	20.90	20.56	27.23	358.00	330.00	311.00	303.67	325.67

For comparing means of	S.Em ±	C.D @ 5%	S.Em ±	C.D @ 5%	S.Em ±	C.D @ 5%
FYM (M)	5.61	15.98	0.76	2.16	10.75	30.59
Vermicompost (V)	4.58	13.05	0.62	1.76	8.78	24.98
Fertilizer (F)	6.48	18.45	0.88	2.49	12.41	35.33
M x V	7.94	22.60	1.07	3.05	15.20	43.27
M x F	11.23	NS	1.52	4.32	21.49	NS
V x F	9.17	NS	1.24	3.53	17.55	NS
M x V x F	15.88	NS	2.15	6.11	30.40	86.53

Farm yard manure (M)
M_0= 0 t ha^{-1}
M_1= 7.5 t ha^{-1}
M_2= 15 t ha^{-1}

Vermicompost (V)
V_0= 0 t ha^{-1}
V_1= 2 t ha^{-1}

Fertilizer (F)
F_0= 0:0:0 NPK (kg ha^{-1})
F_1= 50:30:30 NPK (kg ha^{-1}) NS= Non significant
F_2= 100:45:45 NPK (kg ha^{-1})
F_3= 150:60:60 NPK (kg ha^{-1})

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