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Role of bio-formulations in combination with inorganic and organic nutrient sources in enhancement of morpho-physiological characters and root yield in safed musli (*Chlorophytum borivilianum* Sant. & Fernand.)

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Abstract
A field study was conducted during 2018-19 on "Effect of integrated nutrient management (INM) on morpho-physiological and yield of safed musli" at KRC college of Horticulture, Arabhavi, Gokak, Karnataka. The research results revealed that plant supplied with panchagavya recorded maximum leaf area (581.57 cm^2), leaf area index (1.29), CGR (2.13 g m^2 day^{-1} at 30-60 DAP), fresh root yield (31.15 g $plant^{-1}$ and 33.42 q ha^{-1}), dry root yield (5.77 q ha^{-1}) and fresh peeled root yield (21.34 g $plant^{-1}$). Among inorganic and organic source of nutrients application, 100 per cent RD NPK 50:40:40 kg ha^{-1} recorded significantly maximum leaf area (635.71 cm^2), LAI (1.41), CGR (3.47 g m^2day^{-1}), significantly fresh root yield (36.16 g $plant^{-1}$ and 36.26 q ha^{-1}, respectively), fresh peeled root yield (26.40 g $plant^{-1}$) and dry root yield of 6.33 q ha^{-1}. Among interaction, application of panchagavya (3%) + 100 per cent RD NPK 50:40:40 kg ha^{-1} recorded significantly maximum leaf area (671.05 cm^2), LAI (1.49), CGR (3.70g m^2day^{-1}), significantly highest fresh peeled root yield (30.51g $plant^{-1}$) and fresh root yield (38.34 q ha^{-1}).

Keywords: Vernal keratoconjunctivitis, tacrolimus, immunomodulators, olopatadine

Introduction
Safed musli (*Chlorophytum borivilianum* Sant. & Fernand.) Is one of the fasciculated root yielding medicinal plants, gaining high demand in pharmaceutical sector for its valuable medicinal property? It belongs to the family Liliaceae and it is also known as Swetha musli in Hindi. The crop naturally found in the Arawali hills of India has a great internal demand and export potential. Peeled dry roots are considered as one of the most important drugs in Indian system of medicines *viz.*, *Ayurveda*, *Unani* and *Siddha*. The main content in roots is saponins and alkaloids. It is a medicinal plant indigenous to central India and grows naturally in Madya Pradesh, Chhattisgarh, Gujarat and U.P., in tropical and sub-tropical climates with an altitude up to 1500m (Kothari and Sathi Reddy, 2009) [9]. The foreign demand has been estimated as 300-700 tons annually (Kothari and Singh, 2003) [10].

It is commercially propagated only through the fresh roots. Sexual reproduction is very rare and takes longer duration compared to root propagation. In its natural habitat, the production has been reduced much due to unorganized and destructive harvesting. While in cultivated condition, its production is mainly depends upon agro-climatic conditions and management practices. Due to its wide application in different medicinal sector, their quality roots are in demand. It can be grown commercially in farmer's land to get good quality and quantity of roots. Hence, to increase the root yield, nutrient application has to be standardized by way of integrated nutrient management. In this context, the present research was undertaken to standardize bio-formulations, inorganic and organic source of nutrients for enhanced growth, physiological characters and root yield in safed musli.

Material and Methods
An investigation was carried out to study the effect of bio-formulations, organic and inorganic source of nutrients on growth, physiological characters and dry root yield of safed musli at Kittur Rani Channamma College of Horticulture, Arabhavi, Karnataka, University of Horticultural Sciences, Bagalkot during 2018-19. The experiment was laid out in factorial design with twelve treatments and three replications.

Treatment details
Factor I: Bio-formulations
O_1: Panchagavya (3%)
O_2: Humic acid (1%)
O_3: Jeevamruta (5%)
O_4: Control (No drenching)

Factor II: Inorganic and organic source of nutrients
F_1: 100% RD NPK 50:40:40 kg ha^{-1} (Jat *et al.*, 2015)
F_2: 50% RD NPK 25:20:20 kg NPK ha^{-1}
F_3: 50% Rec. N through FYM (5 t ha^{-1}) + 50% of Rec. N through vermicompost (2.5 t ha^{-1})
F_4: Control (without fertilizer/manure application).

Note: 15 t ha^{-1} of FYM was applied uniformly to all the treatments.

For planting of safed musli raised beds were prepared with a spacing of 1.8 m x 1.2 m and healthy fasciculated roots vertically cut along with sprouting bud weighing of 5-6 gram were selected for planting. Before planting the tubers were treated with fungicide for 40 minutes and planted at a spacing of 30 cm between rows and 15 cm between plants. A spacing of 0.5 m between raised beds was provided for easy cultural operations. Farm yard manure was applied to each plot at the rate of 15 tonnes per hectare. The fertilizers were applied in both organic and inorganic combinations as per the treatment specifications. The bio-inoculants (panchagavya, jeevamrutha and humic acid) were drenched at 15 days interval since planting.

Observations recorded

Observations on growth and physiological parameters were recorded on five randomly selected plants in each replication of different treatments at 30, 60 and 90 days after planting (DAP). The leaf area was calculated on five randomly selected plants by using Biovis instrument at 30, 60 and 90 days after planting. The average was expressed as leaf area in cm^2 per plant. The leaf area index was computed using the formula suggested by Sestak *et al.* (1971) [14]

$$LAI = \frac{\text{Leaf area of the entire plant } (cm^2)}{\text{Spacing provided } (cm^2)}$$

Crop growth rate (CGR) (g m^{-2} day^{-1}) is the rate of dry matter production per unit ground area per unit time. It was calculated by using the formula given by Watson (1952) and expressed as g per m^2 per day.

$$CGR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{1}{A}$$

Where,

W_1 - Dry weight of the plant at time t_1

W_2 - Dry weight of the plant at time t_2

A - Land area (m^2)

The crop was harvested by digging out the fasciculated roots for peeling at two months after complete maturity as indicated by withering and drying up of leaves. Harvested fasciculated roots were cleaned to remove adhered soil and attached roots, then manually peeled and dried in shade. Fresh roots per plant produced by the labeled plants were weighed separately and their average values were expressed in grams per plant and on the basis of fresh root yield per plot the fresh root yield per hectare (q) was estimated. Then, the roots were subjected to peeling and the average peeled roots weight was expressed in gram. After peeling of roots from each labeled plants, they were dried in hot air oven at 60°C and their weight was recorded and expressed the average in gram per plant and the dry root yield per hectare (q) was estimated on the basis of dry root yield per plot.

Result and Discussion

The results obtained from the present experiment and relevant discussions have been summarized here. The data revealed that, increase in all the growth and physiological attributes was noticed with each increasing level of fertilizers combination with bio-formulations. The data on leaf area, leaf area index (LAI) and crop growth rate (CGR) are presented in Table 1. The data revealed that leaf area and leaf area index of safed musli recorded at various stages of crop growth differed significantly due to application of bio-formulations and in-organics and organic source of nutrients. The leaf area and leaf area index increased with advancement of the crop age in all the treatments. Among the bio-formulations at 90 DAP, maximum leaf area (581.57 cm^2) and leaf area index (1.29) was recorded in panchagavya (3%) applied plants and the lowest leaf area (554.69) and leaf area index (1.23) was in control. The maximum leaf area shown in panchagavya (3%) was on par with humic acid and similarly, maximum leaf area index shown in panchagavya (3%) was on par with humic acid and jeevamruta applied plants. With respect to inorganic and organic source of nutrients, significantly maximum leaf area and leaf area index was recorded in F_1 (100% RD NPK *i.e.,* 50:40:40 kg ha^{-1}) throughout the growth stages. Among interaction of treatments, significantly maximum leaf area (671.05 cm^2) and leaf area index (1.49) was recorded in O_1F_1 and minimum was in O_4F_4 (486.79 cm^2 and 0.82, respectively). Increase in physiological parameters might be due to better vegetative growth in the plants supplied with bio-formulations, inorganic and organic source of nutrients. Similar findings were also reported by Nagalakshmi *et al.* (2010) [11] in Anthurium and Ahmad *et al.* (2013) [1] in Gladiolus. Similarly, maximum CGR of 2.13 g m^{-2} day^{-1} was recorded in panchagavya at 30-60 DAP which was on par with humic acid and the minimum CGR was observed in the control. In earlier findings, plants sprayed with panchagavya invariably produced bigger leaves and developed denser canopy (Somusundaram *et al.,* 2007 in green gram). The photosynthetic system is activated for enhanced biological efficiency, enabling synthesis of maximum metabolites and photosynthesis. These results are in line with the findings of Sridhar (2003) [18] in *Solanum nigrum.*

Interaction of bio-formulations and inorganic and organic source of nutrients also showed significant effect on physiological parameters. The maximum CGR was recorded in the early stages of growth (30-60 DAP) in plants applied with O_1F_1 (3.70 g m^{-2} day^{-1}) and minimum was recorded in O_4F_4. This increase in CGR might be due to more dry matter accumulation and translocation of photosynthates from source to sink. These results are in line with the findings of Somanath (2002) [16] and Sadashiv and Kattimani (2012) [12] in *Plectranthus forskohlii.*

Application of bio-formulations, inorganic and organic source of nutrients showed significant effect on root yield (Table 2) in safed musli. The maximum fresh root yield (31.15 g $plant^{-1}$ and 33.42 q ha^{-1}, respectively) was recorded in panchagavya applied plants and the lowest fresh root yield per plant and per hectare was observed in control. Fresh peeled root weight (21.34 g $plant^{-1}$) was highest in panchagavya applied plants. No significant variation in fresh to dry root recovery was observed due to treatments. However, maximum fresh to dry root recovery (17.34%) was observed in humic acid applied plants. The maximum dry root yield (5.77 q ha^{-1}) was recorded in panchagavya and it was on par with humic acid (5.59 q ha^{-1}). The increased yield in panchagavya treated plants might be due to higher leaf area and LAI recorded in panchagavya treatment. Moreover, panchagavya acts as growth promoter (75%) and immunity booster (25%) and exactly fills the missing link to

sustain the organic farming without any yield loss (Vedivel, 2007) [19]. Similar findings are also reported by Kanimozhi (2003) [8] and Sathiyaraj, (2017) [13] in medicinal coleus.

Treatment F_1 :100% RD NPK *i.e.*, 50:40:40 kg ha^{-1} recorded significantly highest fresh root yield (36.16 g plant^{-1} and 36.26 q ha^{-1}, respectively), fresh peeled root yield (26.40 g plant^{-1}) and dry root yield (6.33 q ha^{-1}). The lowest yield was recorded in control. The increased yield in F_1 was mainly because of increased yield attributes and higher available nutrient that resulted from increased availability of nutrient in NPK interaction than control. Chauhan *et al.* (2005) [2] also found that, application of 25:25:25 and 50:50:50 kg NPK per hectare recorded 13.40 and 19.80 per cent increase in fresh yield and 14.10 and 18.10 per cent in dry root yield, respectively over control (FYM at 15t ha^{-1}) in safed musli. The similar results are also presented by Harinkhede *et al.* (2005) [5] in safed musli, Joy *et al.* (2005) [7] in black musli, Sivasankar and Manivannan (2015) [15] in glory lilly, Dhage *et al.* (2008) [3] in ashwagandha. The interaction effect of bio-formulations and inorganic and organic source of nutrients was found significant on fresh peeled root yield and fresh root yield per hectare. Significantly highest fresh root yield (38.34 q ha^{-1}) and fresh peeled root yield (30.51 g plant^{-1}) was recorded in O_1F_1. There was no significant difference in fresh to dry root recovery. The increased trend in fresh root yield might be due to increased photosynthetic rate as a result of highest vegetative growth observed at higher dose of nutrients. The increase in root yield might be due to the fact that organic bio-formulation along with inorganics improved the physical condition of soil and provided better condition for uptake of nutrients which lead to better growth of plant. These results are in conformity with the findings of Chauhan *et al.* (2005) [2] and Gaikwad *et al.* (2011) [4] in safed musli.

Finally, it is summerized that application of panchagavya (3%) and 100 per cent RD NPK *i.e.*, 50:40:40 kg ha^{-1} can be recommended to get the highest dry root yield of safed musli

Table 1: Effect of bio-inoculants, organic and inorganic nutrients on morpho-physiological characters of safed musli.

Treatments	Leaf area (cm^2)			Leaf area index (LAI)			CGR (g m^{-2} day $^{-1}$)	
	30DAP	60DAP	90DAP	30DAP	60DAP	90DAP	30-60 DAP	60-90 DAP
Bio-formulations (O)								
O_1	204.70	553.19	581.57	0.45	1.23	1.29	2.13	0.61
O_2	192.99	545.71	571.41	0.43	1.21	1.27	2.00	0.67
O_3	180.16	537.90	565.73	0.40	1.20	1.26	1.97	0.66
O_4	166.98	520.84	554.69	0.37	1.16	1.23	1.74	0.61
S Em±	7.28	5.42	3.35	0.02	0.012	0.007	0.02	0.02
CD (P=0.05)	24.29	18.09	11.19	0.05	0.040	0.025	0.06	NS
Inorganic and organics (F)								
F_1	218.90	605.99	635.71	0.49	1.35	1.41	3.47	0.65
F_2	191.20	540.90	552.44	0.42	1.20	1.23	1.56	0.62
F_3	192.27	549.91	585.28	0.43	1.22	1.30	1.83	0.74
F_4	142.46	460.83	499.98	0.32	1.02	1.11	0.96	0.54
S Em±	7.28	5.42	3.35	0.02	0.012	0.007	0.02	0.02
CD (P=0.05)	24.29	18.09	11.19	0.05	0.040	0.025	0.06	NS
Interactions (O x F)								
O_1F_1	224.41	631.95	671.05	0.50	1.40	1.49	3.70	0.59
O_1F_2	210.19	544.25	550.13	0.47	1.21	1.22	1.78	0.59
O_1F_3	216.60	565.01	594.89	0.48	1.26	1.32	2.03	0.74
O_1F_4	167.60	471.55	510.23	0.37	1.05	1.13	1.00	0.53
O_2F_1	231.82	612.28	628.25	0.52	1.36	1.40	3.36	0.66
O_2F_2	196.53	541.15	555.21	0.44	1.20	1.23	1.89	0.60
O_2F_3	204.38	565.21	594.83	0.45	1.26	1.32	1.71	0.90
O_2F_4	139.21	464.20	507.35	0.31	1.03	1.13	1.03	0.51
O_3F_1	219.83	611.57	624.31	0.49	1.36	1.39	3.55	0.69
O_3F_2	174.48	540.25	555.19	0.39	1.20	1.23	1.27	0.72
O_3F_3	186.25	562.54	587.88	0.41	1.25	1.31	2.02	0.66
O_3F_4	140.09	437.25	495.57	0.31	0.97	1.10	1.01	0.58
O_4F_1	199.52	568.16	619.25	0.44	1.26	1.38	3.26	0.68
O_4F_2	183.58	537.96	549.22	0.41	1.20	1.22	1.31	0.58
O_4F_3	161.84	506.89	563.50	0.36	1.13	1.25	1.56	0.65
O_4F_4	122.95	470.33	486.79	0.27	1.05	1.08	0.82	0.55
S Em±	16.82	12.52	7.75	0.04	0.03	0.017	0.04	0.05
CD (P=0.05)	NS	36.17	22.37	NS	0.080	0.050	0.13	0.14

Bio-formulations (O)	Inorganic and organics (F)
O_1= Panchagavya (3%)	F_1: 100% RD NPK *i.e.*, 50:40:40 kg ha^{-1}
O_2= Humic acid (1%)	F_2: 50% RD NPK (25:20:20 kg NPK ha^{-1})
O_3= Jeevamruta (5%)	F_3: 50% Rec. N through FYM (5 t ha^{-1}) + 50% of Rec. N through vermicompost (2.5 t ha^{-1})
O_4= Control (No drenching)	F_4: Control
	DAP: Days After Planting
	DAP: Days After Planting

Table 2: Influence of bio-formulations, inorganic and organic nutrients on root yield at harvest in safed musli

Treatments	Fresh root yield (g plant^{-1})	Fresh peeled root yield (g plant^{-1})	Fresh root yield (q ha^{-1})	Dry root yield (q ha^{-1})
Bio-formulations (O)				
O_1	31.15	21.34	33.42	5.77
O_2	30.19	20.07	32.21	5.59
O_3	30.11	19.65	32.51	5.61
O_4	27.91	17.45	31.50	5.34
S Em±	0.26	0.42	0.218	0.06
CD (P=0.05)	0.87	1.39	0.727	0.20
Inorganic and organics (F)				
F_1	36.16	26.40	36.26	6.33
F_2	27.65	17.35	31.23	5.34
F_3	31.85	21.22	32.59	5.62
F_4	23.70	13.53	29.55	5.03
S Em±	0.26	0.42	0.218	0.06
CD (P=0.05)	0.87	1.39	0.727	0.20
Interactions (O x F)				
O_1F_1	38.34	30.51	38.34	6.71
O_1F_2	28.41	17.93	31.48	5.37
O_1F_3	33.60	22.46	33.60	5.82
O_1F_4	24.26	14.46	30.25	5.17
O_2F_1	36.36	26.41	36.28	6.35
O_2F_2	28.11	17.38	30.64	5.33
O_2F_3	32.22	21.75	32.22	5.60
O_2F_4	24.06	14.74	29.68	5.08
O_3F_1	36.39	25.46	36.39	6.34
O_3F_2	27.72	17.08	31.33	5.36
O_3F_3	32.16	20.72	32.55	5.64
O_3F_4	24.17	15.33	29.78	5.10
O_4F_1	33.57	23.24	34.01	5.91
O_4F_2	26.36	17.02	31.47	5.29
O_4F_3	29.40	19.93	32.00	5.40
O_4F_4	22.30	9.59	28.51	4.77
S Em±	0.60	0.96	0.503	0.14
CD (P=0.05)	NS	2.77	1.454	NS

Bio-formulations (O) O_1= Panchagavya (3%) O_2= Humic acid (1%) O_3= Jeevamruta (5%) O_4= Control (No drenching)	Inorganic and organics (F) F_1: 100% RD NPK *i.e.*, 50:40:40 kg ha^{-1} F_2: 50% RD NPK (25:20:20 kg NPK ha^{-1}) F_3: 50% Rec. N through FYM (5 t ha^{-1}) + 50% of Rec. N through vermicompost (2.5 t ha^{-1}) F_4: Control NS: Non-significant DAP: Days After Planting

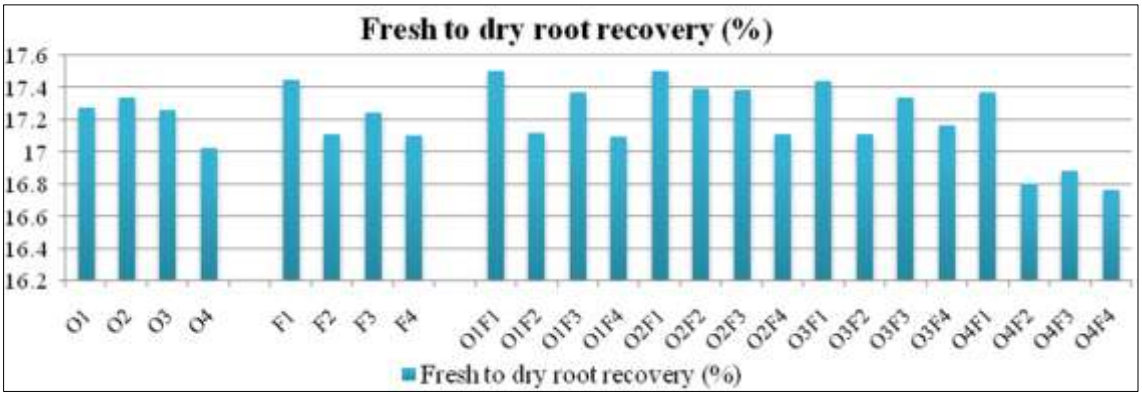

Fig 1: Influence of bio-formulations, inorganic and organic nutrients on fresh to dry root recovery of safed musli

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