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Gauthami Kayarga
Department of Agronomy, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Naveen NE
Scientist (Agronomy), ICAR-Krishi Vigyan Kendra, Brahmavara, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Rudragouda FC
Junior Agronomist, AICRP on IFS, Kathalagere, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Chaitanya HS
Scientist (Horticulture), ICAR-Krishi Vigyan Kendra, Brahmavara, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Jayaprakash SM
SFS and Associate Professor, ZAHRS- Brahmavara, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Corresponding Author:
Gauthami Kayarga
Department of Agronomy, College of Agriculture, Shivamogga, Karnataka, India

Effect of varied levels of *Salvinia molesta* vermicompost on yield, post-harvest soil nutrient status and economics of paddy-groundnut cropping system in Udupi district of coastal Karnataka

Gauthami Kayarga, Naveen NE, Rudragouda FC, Chaitanya HS and Jayaprakash SM

Abstract
A field experiment was conducted during *kharif* and *rabi* 2021-22 at Zonal Agricultural and Horticultural Research Station, Brahmavara, Udupi, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, on sandy loam soil to study the effect of varied levels of *Salvinia molesta* vermicompost on yield, post-harvest soil nutrient status and economics of paddy-groundnut cropping system in Udupi district of Coastal Karnataka. The experiment was laid out in RCBD (Randomized Complete Block Design) with five treatment combinations, replicated four times. The study revealed that application of 13.2 t ha^{-1} *Salvinia molesta* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1} achieved maximum grain yield (5231 kg ha^{-1}), straw yield (6657 kg ha^{-1}) in paddy during *kharif* and pod yield (1598 kg ha^{-1}), kernel yield (1134 kg ha^{-1}) in groundnut during *rabi* due to the residual effect of added treatment and it was at par with the application of 9.9 t ha^{-1} *Salvinia molesta* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1}. With respect to post-harvest soil nutrient status higher available nutrients (N- 293.67 kg ha^{-1}, P_2O_5- 37.59 kg ha^{-1} and K_2O- 201.64 kg ha^{-1} were recorded in the treatment 13.2 t ha^{-1} *Salvinia molesta* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1}. Due to the impact of the above factors, treatment application of 9.9 t ha^{-1} *Salvinia molesta* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1} achieved maximum net returns (₹ 113511 ha^{-1}) and economic efficiency (₹ 732 ha^{-1}day^{-1}) in paddy-groundnut cropping system under coastal ecosystem of Udupi, Karnataka.

Keywords: Economic efficiency, Groundnut, Paddy, *Salvinia molesta* vermicompost

Introduction
In parts of the Udupi district of Coastal Karnataka, *Salvinia molesta* became an exceedingly invasive and dominant aquatic weed found naturally as wild plants in lakes, ponds, paddy cultivated areas, *etc*. It is capable of multiplying and growing at a faster rate. It doubles in abundance within two days, forming thick, floating mats that block light, reduce the oxygen content and degrade the field leading to the destruction of the other plants due to competition for nutrients, sunlight and other physicochemical factors. The physical, chemical, and mechanical means of removing weeds may not be effective because these methods are highly labour-based and time-bound. Moreover, the weeds may develop resistance when exposed continuously to the chemicals. So the next best option of control is the cultural method. It includes composting, vermicomposting, anaerobic digestion, *etc*. Of these, vermicomposting is considered most important for the reason that it is advantageous over composting in terms of the time taken for processing the biomass and the quality of the end product obtained (Gajalakshmi, 2015) [1].

Paddy-legume crop sequence plays a significant role in the food security of India. Growing two crops in a year involves heavy removal of plant nutrients, which diminishes soil fertility. Therefore, it is necessary to manage the inflow of nutrients by integrating fertilizers with organic sources such as vermicompost, which can be produced by utilizing available phytomass such as *Salvinia*. Moreover, it has been reported in several studies that vermicompost is better and preferred over fertilizers. The reason is due to the growth-stimulating hormones and enzymes secreted by the earthworms in their vermicast. It keeps the soil alive by bringing qualitative changes in physical, chemical and biological properties. Applying organic materials along with inorganic fertilizers leads to increased productivity of the system and sustained soil health for a more extended period (Gawai and Pawar, 2006) [2].

Though many nutrient management studies have been carried out in the paddy-groundnut cropping system, the study on the effect of *Salvinia* vermicompost in paddy-groundnut cropping system in the Coastal zone of Karnataka was carried out for the first time. Keeping the above points in view, to overcome the problem of the aquatic weed *Salvinia molesta* in the Udupi district, vermicomposting and its application based on the nutrient level is found to be one appropriate method at the farmer's level.

Material and Methods

A field experiment was conducted during *kharif* and *rabi* 2021-22 at Seed Farm, Zonal Agricultural and Horticultural Research Station, Brahmavara, Udupi, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga.

The experiment was conducted in two seasons, transplanted paddy during *kharif* 2021 and groundnut raised on residual nutrients during *rabi* 2021. Geographically an experimental site is situated at 12º 54′ N latitude and 74º 54′ E longitude at an altitude of 10 m above mean sea level. The soil was sandy loam in texture with 1.20% organic carbon and a pH of 5.10. With respect to initial available nutrients, N (336 kg ha^{-1}) was medium, high P_2O_5 (59.10 kg ha^{-1}) and low K_2O (106.80 kg K_2O ha^{-1}) was noticed in the soil. The treatments include the application of recommended dose of fertilizers (10 t ha^{-1} FYM + 60: 30: 75 kg N: P_2O_5: K_2O ha^{-1}) and in the remaining treatments *Salvinia molesta* vermicompost is applied at the rate of 3.3, 6.6, 9.9 and 13.2 t ha^{-1}, respectively along with 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1} in paddy [Nitrogen (N) content has been reduced to 75% from RDF in these treatments]. Nitrogen content in FYM: 0.45% and *Salvinia molesta* vermicompost: 1.49%. In applied N, 50% N was applied at the time of transplanting, 25% N top dressed at 30 Days after transplanting (DAT) and 25% N at 55 DAT. Whereas, residual study was conducted on groundnut which was raised after the harvest of paddy during *rabi* 2021.

The paddy variety used was '*BMR-MS-1-2-1*' (Sahyadri Brahma) sown with a spacing of 20 cm × 15 cm. It is a heavy tillering variety with a duration of 130 to 135 days. G-2-52 groundnut variety was sown with the spacing of 30 cm × 10 cm. It has a bunchy plant stature with a duration of 110 days. The experiment was laid out in a randomized complete block design comprising five treatments replicated four times and having a net plot size of 3.8 m × 3.6 m.

Composite soil samples were drawn at a depth of 0 to 15 cm soil layer and a representative sample was obtained by standard procedures. The soil was analyzed for its chemical properties *viz*., pH, EC, OC, available nitrogen, phosphorus and potassium,

Data on different parameters of paddy and groundnut were recorded at different growth stages were subjected to analysis of variance (ANOVA) appropriate to the experimental design as described by Gomez and Gomez (1984).

Rice equivalent yield, Production efficiency, Net returns and Economic efficiency were calculated using the formula given below.

$$\text{Crop equivalent yield} = \text{Yield of main crop} + \frac{\text{Yield of sequence crop} \times \text{Price of sequence crop}}{\text{Price of main crop}}$$

$$\text{Production efficiency} = \frac{\text{Crop equivalent yield}}{\text{Duration of cropping system}}$$

$$\text{Economic efficiency} = \frac{\text{Net returns of cropping system}}{\text{Duration of cropping system}}$$

Results and discussion

Yield of paddy-groundnut cropping system as influenced by varied levels of *Salvinia molesta* vermicompost

Rice grain yield is the product of the number of filled grains per unit area under a given environment. The highest grain yield and straw yield (5231 and 6657 kg ha^{-1}, respectively) were recorded with the application of 13.2 t ha^{-1} *Salvinia* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1}, which was closely followed by the application of 9.9 t ha^{-1} *Salvinia* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1} (5025 and 6646 kg ha^{-1}, respectively) and the treatment with the RDF (10 t FYM + 60: 30: 75 kg N: P_2O_5: K_2O ha^{-1}) recorded the least grain yield and straw yield (4274 kg ha^{-1} and 6150 kg ha^{-1} respectively). [Table 1]. Higher yield with the application of *Salvinia* vermicompost might be due to the increased availability of nutrients for a prolonged period that mitigates the deficiency of nutrients and improves the soil physical condition. The presence of micro flora in *Salvinia molesta* vermicompost such as nitrogen fixers and presence of biologically active metabolites like gibberllins, cytokinins, auxins, group B vitamins and also high humic substances such as humines, humic acids, and fulvic acids may also favoured in increasing the crop yield. The results are in line with the research findings of Vasanthi and Kumaraswamy (1999) [5]. The higher yield might be due to the better growth environment created by higher soil microbial population and higher moisture content prevailed in soil due to improvement in soil physical properties resulted in higher water holding capacity as influenced by the application of higher levels of *Salvinia molesta* vermicompost, which favoured in mineralisation, solubilisation and translocation of nutrients (N, P_2O_5, K_2O & S) resulted in higher yield and yield components. Better yield is also due to higher dry matter production, better translocation of photosynthetic materials from source to sink.

Post-harvest soil nutrient status at the end of the experiment as influenced by the varied levels of *Salvinia molesta* vermicompost

Maximum available N (293.67 kg ha^{-1}), P_2O_5 (37.59 kg ha^{-1}) and K_2O (201.64 kg ha^{-1}) was noticed with application of 13.2 t ha^{-1} *Salvinia* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1} which was on par with 9.9 t ha^{-1} *Salvinia* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1} [Table 2]. This is mainly because the weedy vermicompost usually contains major, secondary and micronutrients required for plant growth and, therefore can be a good source of these plant nutrients. When *Salvinia molesta* vermicompost is applied to soil, the plant availability of nutrients may increase due to mineralization and solubilisation by the higher soil microbial population. These results are in line with Prakash *et al*. (2018) [4].

Combined economics of paddy-groundnut cropping system as influenced by varied levels of *Salvinia molesta* vermicompost

Rice Equivalent Yield (REY) was calculated to determine the performance of cropping system by converting yield of non-rice crops into equivalent rice yield on a price basis. Higher REY (9627 kg ha^{-1}) was recorded in 13.2 t *Salvinia* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1}**.** Higher REY is due to higher grain and pod yield. The greater

production efficiency (38 kg ha^{-1} day^{-1}) was noticed in the mentioned treatment due to higher REY obtained with the application of higher levels of *Salvinia molesta* vermicompost. These findings are in accordance with Kundu and Mahapatra (2014) [3]. However, highest economic efficiency (₹ 732 ha^{-1} day^{-1}) was achieved with the application of 9.9 t *Salvinia* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1} in the paddy-groundnut cropping system mainly because of higher net returns (₹ 113511 ha^{-1}).

Table 1: Yield of paddy-groundnut cropping system as influenced by varied levels of *Salvinia molesta* vermicompost

Treatments		Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Pod yield (kg ha^{-1})	Kernel yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1	RDF (10 t FYM + 60: 30: 75 kg N: P_2O_5: K_2O ha^{-1})	4274.00	1092.00	709.00	2490.00	6150.00
T_2	3.3 t *Salvinia* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1}	4511.00	1127.00	755.00	2537.00	6229.00
T_3	6.6 t *Salvinia* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1}	4832.00	1319.00	897.00	2698.00	6364.00
T_4	9.9 t *Salvinia* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1}	5025.00	1550.00	1100.00	2880.00	6646.00
T_5	13.2 t *Salvinia* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1}	5231.00	1598.00	1134.00	2908.00	6657.00
S.Em. ±		70.26	94.69	20.15	14.00	64.05
CD (P=0.05)		216.51	291.78	62.09	42.09	197.37

RDF: Recommended dose of fertilizers
FYM: Farm yard manure

Table 2: Post harvest available soil nutrient status [N, P_2O_5, K_2O (kg ha^{-1})] as influenced by the varied levels of *Salvinia molesta* vermicompost

Treatments		Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
T_1	RDF (10 t FYM + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1})	265.88	24.14	155.73
T_2	3.3 t *Salvinia* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1}	271.58	29.98	166.28
T_3	6.6 t *Salvinia* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1}	279.35	33.69	181.04
T_4	9.9 t *Salvinia* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1}	285.64	36.39	193.86
T_5	13.2 t *Salvinia* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1}	293.67	37.59	201.64
S.Em. ±		4.10	0.48	2.65
CD (P=0.05)		12.65	1.48	8.18

RDF: Recommended dose of fertilizers
FYM: Farm yard manure

Table 3: Combined economics of paddy – groundnut cropping system as influenced by varied levels of *Salvinia molesta* vermicompost

Treatments		REY (kg ha^{-1})	Production efficiency (kg ha^{-1} day^{-1})	Net returns of CS ₹ ha^{-1}	Economic efficiency (₹ ha^{-1} day^{-1})
T_1	RDF (10 t FYM + 60: 30: 75 kg N: P_2O_5: K_2O ha^{-1})	7277	29	91649	591
T_2	3.3 t *Salvinia* vermicompost + 45 :30 :75 kg N: P_2O_5: K_2O ha^{-1}	7612	30	109070	704
T_3	6.6 t *Salvinia* vermicompost + 45 :30 :75 kg N: P_2O_5: K_2O ha^{-1}	8460	33	112257	724
T_4	9.9 t *Salvinia* vermicompost + 45 :30 :75 kg N: P_2O_5: K_2O ha^{-1}	9289	36	113511	732
T_5	13.2 t *Salvinia* vermicompost + 45 :30 :75 kg N: P_2O_5: K_2O ha^{-1}	9627	38	102901	664

REY: Rice Equivalent Yield, CS: Cropping System, RDF: Recommended dose of fertilizers, FYM: Farmyard manure

Conclusion

The application of 9.9 t *Salvinia* vermicompost + 45: 30: 75 kg N: P_2O_5: K_2O ha^{-1} is found more beneficial to improve grain yield and pod yield (5025 kg ha^{-1} and 1100 kg ha^{-1}, respectively) and economically advantageous with higher net returns (₹ 113511 ha^{-1}) and economic efficiency (₹ 732 ha^{-1} day^{-1}).

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