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Influence of integrated nutrient management practices on growth, yield, soil fertility, seed quality and economics of Moth bean in shallow black soil of northern dry zone, Karanataka

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Abstract
The study was conducted during *kharif 201*8 at Regional Agricultural Research Station, College of Agriculture, Vijayapur to know the effect of organic, inorganic and integrated nutrient management practices on soil fertility, seed quality and economics of mothben cultivation. Results revealed that significantly higher available nitrogen, phosphorous, potassium, sulphur, exchangeable calcium and exchangeable magnesium was found with combined application of 12.5:25:0 N: P_2O_5: K_2O kg ha^{-1} + Vermicompost at 1.0 t ha^{-1} followed by FYM at 2.5 t ha^{-1} + 12.5 : 25 : 0 N: P_2O_5: K_2O kg ha^{-1} as compared to control. Significantly higher crude protein content was also observed with above said treatments. Significantly higher B: C was found with FYM at 2.5 t ha^{-1} + 12.5: 25: 0 N: P_2O_5: K_2O kg ha^{-1}

Keywords: Vermicompost, FYM and crude protein content

Introduction
Pulses play a vital role in human diet mainly to the fact that the group constitutes the major source of protein for the bulk of the world population. In addition, pulses are also good sources of Carbohydrates, minerals and vitamins. In India, pulses cover an average of 26.23 million hectares with a production of about 15.23 million tonnes with a productivity of 568 Kg per ha. (Anon., 2004). In Karnataka pulses is grown in an area of 1.81 million hectares with a production of 0.52 million tonnes (Anon., 2013). The minimum pulse in take as per FAO / WHO recommendations is 80 g per day per capita. But in India it is low as 45 g per day per capita. This is attributed to the fact that pulses are being gradually replaced by cereals both in diet and in net cropped area. Mothbean (*Vigna aconitifolia* (Jacq.) Marechal) is widely grown in arid and semiarid part of the country, mostly as a dry crop either sole or in mixture for grain or fodder. It is minor *kharif* pulse crop and considered as one of the most drought tolerant among the grain legumes. In India, it is grown in an area of 1.65 million hectares, mostly confined to Gujarat, Rajasthan, Haryana, Maharashtra and north Karnataka with a production of 0.48 million tonnes. The lower productivity of this crop is attributed to several factors viz., growing the crop under moisture stress, late sowing, no recommended fertilizer doses and lack of knowledge about nutrient management. This clearly shows that it is necessary to overcome these constraints to get higher yield and to restore the soil fertility. The transition tract of Karnataka with an annual rainfall of 750 – 800 mm fairly well distributed from June to October offers a good scope for the cultivation of mothbean on both red and black soils. Besides farmers are interested to cultivate mothbean in *rabi*/summer with available/residual moisture left after harvesting *kharif* crops. Moth been is also credited with the fixation of atmospheric nitrogen through symbiotic process. In addition, it sheds, its leaves after physiological maturity and thus enhances soil fertility and productivity

Although organic manures contain plant nutrients in small quantities as compared to the fertilizer, the presence of growth promoting principles like enzyme and hormones besides plant materials make them essential for improvement of soil fertility and productivity. Integrated use of organic and inorganics through FYM and vermicompost improved the organic carbon and cation exchange capacity. Available N, P_2O_5, K_2O, S, exchangeable calcium, exchangeable magnesium and micronutrients status of soil increased significantly with organic sources of nutrients over their initial (Sharma *et al*., 2001) [6]. Pandey *et al*. (2006) [8] reported that application of manures, irrespective of sources and rates recorded significantly higher soil organic carbon, N, P_2O_5 and K_2O compared to control. The application of organic and chemical fertilizers is another crucial component of arable crop production system. Integrating chemical fertilizers with organic manures has been found to be quite promising not only in maintaining higher productivity but also in providing greater stability in crop production. Use of organic manures to meet nutrient requirement of crop would be an inevitable practice in the years to come for sustainable agriculture, since these manures generally improve the physical, chemical and biological properties along with conserving and improving the moisture and nutrient holding capacity of the soil and thereby resulting in enhanced crop productivity along with maintaining the quality of crop produce. The concept of INM for sustaining the soil fertility is not being followed by most of the farmers, leading to poor soil fertility status of Karnataka. Therefore, an attempt was made to find out a sustainable INM package for mothbean in the cropping system.

Material and Methods

Field experiment was laid out at Regional Agricultural Research Station (RARS), Vijayapura during *kharif* 2018, which comes under Northern Dry Zone of Karnataka (Zone 3), located at a latitude 160 491 North, longitude 750431 East and an altitude of 593 m above mean sea level (MSL). Experiment was laid out in split plot design with four main plot (Organic manures) *viz*., no organics(M_1); vermicompost @ 0.5 t ha^{-1}(M_2); vermicompost @ 1.0 t ha^{-1} (M_3)and FYM @ 2.5 t ha^{-1} (M_4) and five sub plots (Fertilizer levels) *viz*, no inorganics(S_1) ; 7.5:15:0 N: P_2O_5 : K_2O kg ha^{-1} (S_2); 10:20:0 N: P_2O_5 : K_2O kg ha^{-1}(S_3); 12.5:25:0 N: P_2O_5: K_2O kg ha^{-1}(S_4); 15:30:0 N: P_2O_5 : K_2O kg ha^{-1}(S_5) and replicated three times. Soil samples were randomly taken from various points at the depth of 0-15 cm using soil auger and the samples were analysed for soil texture, pH, organic carbon, organic matter, Available Nitrogen, Available Phosphorus, Available potassium, Available sulphur, Exchangeable calcium and Exchangeable magnesium using standard procedure as described by Sparks (1996) [12] in the Laboratory of Soil Science Department, university of agricultural science Dharwad, college of agriculture vijayapur. The data collected from the experimental field and laboratory analysis were subjected to statistical analysis by adopting Fischer's method of analysis of variance. The level of significance used in 'F' and't' test was P=0.05. Critical difference was calculated wherever 'F' test was significant.

Result and Discussion

Influence of integrated nutrient management practices on soil nutrient status

Significantly highest available nitrogen (Table 1) was reported with combined application of fertilizer at 12.5:25:0 N: P_2O_5: K_2O kg ha^{-1} + Vermicompost at 1.0 t ha^{-1}(M_3S_4, 268.00 kg ha^{-1}) as compared to vermicompost 1.0 t ha^{-1}+ 15:30:0 N: P_2O_5: K_2O kg ha^{-1} (M_3S_5,258.33 kg ha^{-1}), FYM 2.5 t ha^{-1}+ 15:30: 0 N: P_2O_5: K_2O kg ha^{-1} (M_4S_5, 253.33 kg ha^{-1}) and control (Table 1). It was found on par with the combined application of FYM at 2.5 t ha^{-1} + 12.5: 25: 0 N: P_2O_5: K_2O kg ha^{-1}(M_4S_4, 260.67 kg ha^{-1}). Continuous application of manures increases the level of N, P, K, S, Ca and Mg in the soil over the years (Ginting *et al*., 2003) [3]. Thus creating a reservoir of soil nutrients for several years after application, Use of FYM and vermicompost might have attributed to the mineralization of N in soil and due to high enzyme activities in the soil amended with organic manures might have increased the transformation of nutrients to available form. Role of FYM and vermicompost in releasing N and improving N availability in soil was reported by Singh *et al.* (2008). These findings are in concordant with Rajkhowa *et al*. (2003) [9] and Kumawat *et al.* (2006) [6] and Yadav *et al.* (2015) [16].

Significantly maximum available phosphorous (Table 1) was reported with combined application of fertilizer at 12.5:25:0 N: P_2O_5: K_2O kg ha^{-1} + Vermicompost at 1.0 t ha^{-1} (M_3S_4, 36.17 kg ha^{-1}) followed by combined application of FYM at 2.5 t ha^{-1} + 12.5: 25: 0 N: P_2O_5: K_2O kg ha^{-1}(M_4S_4, 34.33 kg ha^{-1}), vermicompost 1.0 t ha^{-1}+ 15:30:0 N: P_2O_5: K_2O kg ha^{-1} (M_3S_5,35.20 kg ha^{-1}), FYM 2.5 t ha^{-1}+ 15:30 : 0 N: P_2O_5: K_2O kg ha^{-1} (M_4S_5, 33.43 kg ha^{-1}). Application of organics increased the phosphorous availability due to decomposition of organic manure; various organic acids will be produced which solubilize phosphatase and other phosphate bearing minerals and thereby lowers the phosphate fixation and increase its availability. Manna *et al.* (2006) [7] reported that available phosphorus content increased with the addition of FYM over initial and control. Combined application of fertilizer at 12.5:25:0 N: P_2O_5: K_2O kg ha^{-1} + Vermicompost at 1.0 t ha^{-1} (M_3S_4, 429.67 kg ha^{-1}) recorded significantly highest available potassium compared to vermicompost 1.0 t ha^{-1}+ 15:30:0 N: P_2O_5: K_2O kg ha^{-1} (M_3S_5, 414.27 kg ha^{-1}), FYM 2.5 t ha^{-1}+ 15:30 : 0 N: P_2O_5: K_2O kg ha^{-1} (M_4S_5, 413.00 kg ha^{-1}) and control(M_1S_1,235.60). It was found on par with the combined application of FYM at 2.5 t ha^{-1} + 12.5: 25: 0 N: P_2O_5: K_2O kg ha^{-1}(M_4S_4, 425.0 kg ha^{-1}). This increment due to application of FYM and vermicompost, resulted in decomposition of organic matter and also the solubilizing action of certain organic acids produced during the decomposition of FYM and vermicompost and its greater capacity to hold K in the available form.

Significantly highest available sulphure (Table 1) in soil was reported with conjunctive use of fertilizer at 12.5:25:0 N: P_2O_5: K_2O kg ha^{-1} + Vermicompost at 1.0 t ha^{-1}(M_3S_4, 20.63 kg ha^{-1}) followed by combined application of FYM at 2.5 t ha^{-1} + 12.5 : 25 : 0 N: P_2O_5: K_2O kg ha^{-1}(M_4S_4, 20.20 kg ha^{-1}), vermicompost 1.0 t ha^{-1}+ 15:30:0 N: P_2O_5: K_2O kg ha^{-1} (M_3S_5, 20.40 kg ha^{-1}), FYM 2.5 t ha^{-1}+ 15:30 : 0 N: P_2O_5: K_2O kg ha^{-1} (M_4S_5,19.97 kg ha^{-1}) as compared to control (M_1S_1, 8.97 kg ha^{-1}). This increment due to mineralization of nutrients in soil by decomposition of organic matter of FYM or Vermicompost which stimulated the growth, rapid multiplication and activity of microorganisms as supply of organics maintain soil moisture and temperature to optimum level which was conducive for growth and development of beneficial microorganisms. Similarly, significantly maximum Exchangeable calcium and Exchangeable magnesium was reported with combined application of fertilizer at 12.5:25:0 N: P_2O_5: K_2O kg ha^{-1} + Vermicompost at 1.0 t ha^{-1}(M_3S_4, 47.33 and 28.63 c mol (p +) kg^{-1}, respectively) followed by combined application of FYM at 2.5 t ha^{-1} + 12.5 : 25 : 0 N: P_2O_5: K_2O kg ha^{-1}(M_4S_4, 46.37 and 28.13 c mol (p +) kg^{-1}, respectively) as compared to control (M_1S_1,24.03 and 14.70 c mol (p +) kg^{-1}, respectively). This increment attributed due to native dissolution of nutrients. The present results are in line with Rajkhowa *et al.* (2003) [9] and Sutaria *et al.* (2010) [14].

The results of DTPA - extractable Fe, Zn, Cu and Mn (Table 2) as subjected to different combinations of nutrients are furnished in Table 2. DTPA - extractable Fe, Zn, Cu and Mn in soil was not substantially influenced by different levels of fertilizers and organic manures. However, considerably higher DTPA - extractable Fe, Zn, Cu and Mn was reported with combined incorporation of VC @ 1.0 t ha^{-1} and supply of fertilizer @ 12.5 :25:0 kg of N: P2O5: K2O ha^{-1} (M3S4, 3.07, 0.51, 0.65 and 2.37 mg kg^{-1}, respectively) as contrast to control (M1S1, 2.83, 0.44, 0.55 and 2.23 mg kg^{-1}, respectively).

Table 1: Influence of integrated nutrient management practices on soil macro-nutrient status

Treatments	Nitrogen	Phosphorous	Potassium	Sulphur	Calcium	Magnesium
	kg ha^{-1}				cmole (P^{+ve}) kg^{-1}	
Organic manures (M)						
M1	129.03	25.01	291.98	12.49	24.75	16.57
M2	184.27	28.09	365.07	15.24	29.41	17.87
M3	254.67	32.59	403.16	19.15	41.25	23.85
M4	242.73	31.30	383.49	18.63	40.45	23.62
S.Em.±	5.80	0.59	5.99	0.50	0.50	0.82
CD (5%)	20.09	2.06	20.73	1.74	1.74	2.83
Inorganic fertilizer levels (S)						
S1	179.33	24.13	320.97	14.25	28.40	17.01
S2	193.63	27.74	349.45	15.23	30.10	19.50
S3	207.42	30.21	367.45	16.67	36.53	20.45
S4	219.13	32.27	387.63	18.07	38.03	22.93
S5	213.88	31.90	379.13	17.67	36.77	22.50
S.Em.±	3.28	0.55	5.75	0.28	0.47	0.54
CD (5%)	9.45	1.60	16.55	0.82	1.36	1.56
Interactions(M×S)						
M1S1	121.67	16.33	235.60	8.97	24.03	14.70
M1S2	127.67	25.33	265.60	10.47	24.50	16.43
M1S3	131.00	26.00	307.27	14.23	25.00	16.47
M1S4	133.00	28.83	326.83	14.97	25.37	16.90
M1S5	131.83	28.57	324.60	13.83	24.87	18.37
M2S1	131.67	25.83	359.33	14.13	26.07	17.13
M2S2	159.83	27.37	364.67	14.23	26.53	17.50
M2S3	203.00	28.00	367.67	14.86	32.80	17.40
M2S4	214.83	29.73	369.00	16.49	33.03	18.03
M2S5	212.00	29.50	364.67	16.50	28.60	19.27
M3S1	233.67	28.00	363.00	17.50	32.00	18.20
M3S2	253.33	29.77	406.27	18.33	35.07	21.97
M3S3	260.00	33.83	402.60	18.90	44.73	24.07
M3S4	268.00	36.17	429.67	20.63	47.33	28.63
M3S5	258.33	35.20	414.27	20.40	47.10	26.37
M4S1	230.33	26.33	325.93	16.42	31.50	18.00
M4S2	233.67	28.50	361.27	17.87	34.30	22.10
M4S3	235.67	32.99	392.27	18.70	43.60	23.87
M4S4	260.67	34.33	425.00	20.20	46.37	28.13
M4S5	253.33	34.33	413.00	19.97	46.50	26.00
S.Em.±	8.25	1.16	11.90	0.71	0.98	1.27
CD (5%)	26.14	3.51	36.02	2.26	2.98	3.96

Quality parameter

Significantly higher crude protein content was reported with the combined incorporation of vermicompost @ 1.0 t ha^{-1} + 12.5:25:0 N: P2O5: K2O kg ha^{-1} (M_3S_4, 24.96 %) followed by followed by combined application of FYM at 2.5 t ha^{-1} + 12.5: 25: 0 N: P_2O_5: K_2O kg ha^{-1} (M_4S_4, 24.73%) which might be due increased supply of nitrogen from both the source of nutrients (Table 2). Present findings are in conformity with the reports of Vasanthi and Subramanian (2004) [15] in blackgram.

Table 2: Influence of integrated nutrient management practices on soil micro-nutrient status

Treatments	Crude protein (%)	Fe	Zn	Mn	Cu
		mg kg^{-1}			
Organic manures (M)					
M1	18.28	2.95	0.47	2.27	0.57
M2	21.98	2.97	0.47	2.28	0.59
M3	24.05	3.02	0.49	2.35	0.62
M4	23.80	3.01	0.48	2.33	0.60
S.Em.±	0.38	0.04	0.02	0.03	0.02
CD (5%)	1.30	NS	NS	NS	NS
Inorganic fertilizer levels (S)					
S1	20.11	2.90	0.45	2.27	0.56
S2	21.57	2.98	0.46	2.29	0.59
S3	22.16	3.00	0.48	2.31	0.60

S4	23.10	3.04	0.50	2.33	0.62
S5	23.20	3.03	0.49	2.32	0.61
S.Em.±	0.31	0.04	0.01	0.03	0.01
CD (5%)	0.88	NS	NS	NS	NS
Interactions(M×S)					
M1S1	14.38	2.83	0.44	2.23	0.55
M1S2	17.96	2.94	0.46	2.26	0.57
M1S3	18.96	2.97	0.47	2.27	0.58
M1S4	19.58	3.01	0.48	2.29	0.59
M1S5	20.54	2.99	0.47	2.28	0.58
M2S1	20.83	2.86	0.45	2.26	0.56
M2S2	21.15	2.97	0.46	2.27	0.58
M2S3	21.17	2.98	0.47	2.28	0.59
M2S4	23.13	3.03	0.50	2.31	0.61
M2S5	23.60	3.02	0.49	2.29	0.60
M3S1	23.06	2.95	0.45	2.31	0.58
M3S2	23.54	3.00	0.47	2.33	0.61
M3S3	24.31	3.02	0.49	2.35	0.62
M3S4	24.96	3.07	0.51	2.37	0.65
M3S5	24.40	3.05	0.50	2.36	0.63
M4S1	22.17	2.94	0.44	2.29	0.57
M4S2	23.63	2.99	0.46	2.31	0.60
M4S3	24.19	3.01	0.49	2.33	0.61
M4S4	24.73	3.05	0.50	2.36	0.63
M4S5	24.27	3.04	0.49	2.35	0.62
S.Em.±	0.66	0.07	0.03	0.06	0.03
CD (5%)	2.04	NS	NS	NS	NS

Growth and Yield Attributes

The integrated use of inorganic and organic manure as a source of nutrients significantly influenced the different growth attributes of mothbean (Table 3).

Table 3: Influence of integrated nutrient management practices on economics of mothbean cultivation

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	B:C
Organic manures (M)			
M_1	391.00	1468.00	1.55
M_2	462.60	1718.40	1.57
M_3	572.73	2124.87	1.71
M_4	570.13	2081.13	1.89
S.Em.±	16.95	59.39	0.05
C.D 5%	58.66	205.52	0.17
Fertilizer levels (S)			
S_1	437.75	1632.50	1.58
S_2	484.92	1800.25	1.65
S_3	501.25	1828.83	1.67
S_4	536.67	1982.58	1.76
S_5	535.00	1996.33	1.73
S.Em.±	6.62	30.47	0.02
C.D 5%	19.06	87.77	0.06
Interaction (M×S)			
M_1S_1	296.33	1143.33	1.35
M_1S_2	413.33	1553.33	1.64
M_1S_3	414.33	1543.33	1.61
M_1S_4	416.00	1503.33	1.58
M_1S_5	415.00	1596.67	1.56
M_2S_1	431.33	1650.00	1.56
M_2S_2	452.00	1690.00	1.55
M_2S_3	460.00	1688.67	1.55
M_2S_4	485.33	1766.67	1.60
M_2S_5	484.33	1796.67	1.58
M_3S_1	513.33	1866.67	1.62
M_3S_2	537.67	2021.00	1.62
M_3S_3	566.00	2103.33	1.68
M_3S_4	625.00	2340.00	1.83

M_3S_5	621.67	2293.33	1.79
M_4S_1	510.00	1870.00	1.80
M_4S_2	536.67	1936.67	1.80
M_4S_3	564.67	1980.00	1.86
M_4S_4	620.33	2320.33	2.02
M_4S_5	619.00	2298.67	1.98
S.Em.±	20.68	80.61	0.06
C.D 5%	67.62	257.58	0.20

Application of 12.5:25:0 N: P_2O_5: K_2O kg ha^{-1} + Vermicompost at 1.0 t ha^{-1}(M_3S_4) recorded highest seed yield (625.0 kg ha^{-1}) and straw yield (2340 kg ha^{-1}) which were superior by 31.7 and 30.0 per cent, respectively (Table 3) over control and was on par with combined application of FYM at 2.5 t ha^{-1} + 12.5 : 25 : 0 N: P_2O_5: K_2O kg ha^{-1}(M_4S_4). This increment in yield due to the amplified growth probably as a consequence of effective use of nutrients absorbed through ramified root system and productive shoot growth due to amended nourishment through organic fertilization and it also might be due to application of organics which improved the physicochemical and biotic properties of soil which in turn benefited plant by providing balanced nutrition to crop as and when needed which helped in production of a greater number of yield parameters (pod length, pod numbers per plant and test weight) and ultimately increased the mothbean yield. Rajkhowa *et al*. (2003) [9] also opined that incorporation of vermicompost @ 2.5 t ha^{-1} noticed the supreme grain and straw yield of mungbean. These results were in line with the reports of Krishna Jagadish (2002) in blackgram and Sadashivanagowda *et al.* (2017 a) in mothbean. Significantly lowest pod numbers (27.60 plant $^{-1}$), pod length (4.04 cm), 100 seed weight (1.57 g), seed yield (296.33 kg ha^{-1}) and straw yield (1143 kg ha^{-1}) was recorded with control (M_1S_1).

Significantly highest B:C was reported with conjunctive use of FYM at 2.5 t ha^{-1} + 12.5 : 25 : 0 N: P_2O_5: K_2O kg ha^{-1}(2.02, M_4S_4) followed by combined application of FYM at 2.5 t ha^{-1} + 12.5 : 25 : 0 N: P_2O_5: K_2O kg ha^{-1} (1.89, M_4S_5) and fertilizer at 12.5:25:0 N: P_2O_5: K_2O kg ha^{-1} + Vermicompost at 1.0 t ha^{-1}(1.82, M_3S_4). This was because of higher cost incurred for vermicompost than FYM. These outcomes are in concordant with the reports of Subbarayappa *et al.* (2009) in green gram and Sutaria *et al.* (2010) [14] in cowpea.

Conclusion

From above results, it can be concluded that integrated nutrient management practice in mothbean crop was found beneficial for sustaining soil health in terms of build-up of macro and micronutrient content in soil after harvest of crop. Thus, integrated approach of nutrient supply by chemical fertilizers along with organic manures and biofertilizers is gaining importance as this system not only reduces the use of inorganic fertilizers but sustaining the crop productivity by improving soil health and is also an environment-friendly approach.

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