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Effect of integrated nutrient management on yield and uptake of nutrients by mothbean (*Vigna acontifolia*) in northern dry zone of Karnataka

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Abstract
Field experiment was conducted during *kharif* season 2018 at Regional Agricultural Research Station, Dry Land Agriculture, College of Agriculture, Vijayapur to study the effect of integrated nutrient management on yield and uptake of nutrients by mothbean in shallow black soils. The results revealed that highest yield and nutrient uptake by mothbean was recorded by application of 100% RDF of green gram (12.5:25:0 N: P_2O_5: K_2O kg ha^{-1}) + vermicompost at 1.0 t ha^{-1}. The conjunctive use of vermicompost with 100% RDF significantly improved the status of primary and secondary nutrient content over the inorganic fertilizer alone. The combined use of inorganic and organic sources of nutrients improves soil fertility and productivity.

Keywords: Vermicompost, Soil fertility and Productivity

Introduction
Mothbean [*Vigna aconitifolia* (Jacq.) Marechal] is an important pulse crop of the desert region and is remarkably well suited to arid and semi-arid areas of India and some other countries of Asia. In India, it is grown on an area of 13.19 lakh ha, mostly confined to Rajasthan, Gujarat, Maharashtra, Karnataka, Uttar Pradesh and Haryana with a production of 1,753 lakh t and productivity of 133 kg ha^{-1} (Rajendra Prasad, 2013) [11]. It can very well withstand drought conditions and is probably the most drought resistant crop among the grain legumes. Mothbean is a short duration, deep rooted legume recognized for its twin benefits of tolerance for drought and heat. It has ability to grow under harsh climate, low rainfall and poor soil conditions and considered as most significant arid pulse of Rajasthan (Sharma and Ratnoo, 2014) [14]. The crop has spreading growth habit forming a mat like covering on the soil surface. It thus helps greatly in the conservation of soil, water and serves as a very efficient and suitable cover crop for checking soil erosion. The lower productivity of this crop is attributed to several factors *viz*., growing the crop under moisture stress, marginal lands with very low inputs, without proper nutrient management and other agronomical practices, without pest and disease management, non-availability of high yielding varieties and late sowing. This clearly shows that it is necessary to overcome these constraints to get higher yields. Yield is a complex character resulting from the interplay of nutrient management with the environmental variables and other factors. Balanced fertilization is necessary to increase the productivity of pulses. Regular and judicious use of fertilizers not only helps in raising good crop yield, but also can help farmers to gain consistently higher profit. But even today, a great number of farmers are not smearing recommended dose of fertilizers. As a consequence of technological dissemination farmers have realised importance of use of nitrogen, phosphorus, secondary or trace elements and organic manures. Price escalation of fertilizers has also been a factor that prevents the farmers from using optimum quantities of fertilizers.

Vasanthi and Subramanian (2004) [20] observed the maximum nitrogen, phosphorous and potassium concentration and their uptake with the incorporation of vermicompost @ 2 t ha-1 + 100% RDF. Indoria *et al.* (2005) [4] preached that supply of nitrogen 10 kg ha^{-1} and phosphorous 40 kg ha^{-1} resulted in momentous upsurge in uptake of nitrogen (49.3 and 46.7 kg ha-1) and phosphorous (7.57 and 7.19 kg ha-1, respectively) by grain and straw of cowpea as contrast to control. However, Yadav *et al*. (2015) at Udaipur, revealed that highest uptake of nutrient was recognised with combined supply of RDF 100% + VC @ 4 t per ha. The combined incorporation of vermicompost with 100% RDF significantly improved the status of nitrogen, phosphorous and potassium content over the chemical fertilizer alone. With the increasing demand of pulses, there is an urgent need to increase their productivity, so combined use of fertilizers and organic manure not only give the great promise in crop production but also control the emergence of multiple nutrient deficiencies and maintain good soil health. Keeping this in view, an effort was made to investigate the effect of integrated nutrient management on yield and uptake of nutrients by mothbean (*Vigna acontifolia*) in northern dry zone of Karnataka

Material and methods

The experiment was laid out in split plot design replicated thrice with four main plots (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). The Mothbean variety 'KBMB-1' was sown at spacing 30 cm row to row and 10 cm plant to plant. Seed were treated with rhizobium just before sowing. The FYM and Vermicompost were incorporated about 20 and 4 days before sowing respectively and inorganic fertilizers was applied at the time of sowing as per treatments. All other operations were performed as per recommendations of the crop. The data on various growth attributes, yield attributes, and seed and straw yields were recorded under various treatments. The representative dry samples of seed and straw were analysed for ascertaining the nutrient (N, P, K, Ca, Mg and S) content. Seed and straw samples were digested in H_2SO_4 for determination of nitrogen (AOAC, 1995) and in di-acid mixture (HNO3: HClO4, 9:4 v/v) for other nutrient estimation (Bhargava and Raghupathi, 1984) [2]. The nutrients uptake by seed and straw were calculated by multiplying nutrient content with seed and straw yield (kg ha^{-1}) respectively and data analysed statistically to draw suitable inference as per standard ANOVA technique described by Gomez and Gomez (1984) [3].

Result and discussion

Growth attributes

The integrated use of inorganic and organic manure as a source of nutrients significantly influenced the different growth attributes of mothbean (Table 1). Significantly greater plant height (45cm), Dry matter accumulation (20.43g $plant^{-1}$) at harvest was recorded with combined 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) and being 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) as compared to vermicompost 1.0 t ha^{-1}+ 15:30:0 N: P_2O_5: K_2O kg ha^{-1} (M_3S_5), FYM 2.5 t ha^{-1}+ 15:30 : 0 N: P_2O_5: K_2O kg ha^{-1} (M_4S_5) and other nutrient combinations. Significantly lowest plant height (22 cm), Dry matter accumulation (13.18 g $plant^{-1}$) at harvest of mothean was recorded with control (M_1S_1). The increase in plant height and DMA might be due to conjunctive application of vermicompost and readily available nutrients through fertilizer which produced vigorous seedling as vermicompost contains the growth hormones and enzymes, essential nutrients and organic matter which favours rapid cell elongation and division and favours better growth and development and gave higher germination of mothbean as contrast to the control. Similar finding has reported by Netwal (2003) [9] in cowpea, Rajkhowa *et al*. (2003) [12] and Watisenla and Lanunola (2016) [21] in green gram, Raghawendra and Kedar (2008) [10] in chickpea.

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 2) 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). Significantly maximum pod numbers (61.47 plant $^{-1}$), pod length (8.67 cm),100 seed weight (1.96 g), was recorded with combined 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) as compared to vermicompost 1.0 t ha^{-1}+ 15 :30 : 0 N: P_2O_5: K_2O kg ha^{-1} (M_3S_5), FYM 2.5 t ha^{-1}+ 15 :30 : 0 N: P_2O_5: K_2O kg ha^{-1} (M_4S_5) and other nutrient combinations and being 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 and yield attributes 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) [12] 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) [5] in blackgram and Sadashivanagowda *et al.* (2017a) [13] 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) [15] in green gram and Sutaria *et al.* (2010) [16] in cowpea.

Table 1: Effect Integrated nutrient management on growth and yield attributes of mothbean

Treatments	Plant height at harvest	Dry matter accumulation (DMA) at harvest	Pod numbers	Pod length (cm)	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	B:C
Organic manures (M)								
M_1	28.67	13.44	31.33	4.73	1.59	391.00	1468.00	1.55
M_2	39.10	16.06	47.41	6.14	1.62	462.60	1718.40	1.57
M_3	43.10	18.86	54.60	8.01	1.82	572.73	2124.87	1.71
M_4	41.60	18.39	54.85	7.80	1.74	570.13	2081.13	1.89
S.Em.±	0.54	0.28	0.67	0.09	0.02	16.95	59.39	0.05
C.D 5%	1.87	0.96	2.31	0.32	0.08	58.66	205.52	0.17
Inorganic fertilizer levels (S)								
S_1	34.42	15.65	42.97	5.80	1.62	437.75	1632.50	1.58

S_2	37.46	16.18	45.38	6.36	1.68	484.92	1800.25	1.65
S_3	38.79	16.85	46.84	6.84	1.68	501.25	1828.83	1.67
S_4	40.21	17.56	50.31	7.25	1.76	536.67	1982.58	1.76
S_5	39.71	17.19	49.75	7.09	1.73	535.00	1996.33	1.73
S.Em.±	0.43	0.22	0.67	0.07	0.02	6.62	30.47	0.02
C.D 5%	1.25	0.64	1.94	0.19	0.05	19.06	87.77	0.06
Interaction (M×S)								
M_1S_1	22.00	13.18	27.60	4.04	1.57	296.33	1143.33	1.35
M_1S_2	29.50	13.24	29.80	4.27	1.69	413.33	1553.33	1.64
M_1S_3	29.83	13.37	31.40	4.97	1.50	414.33	1543.33	1.61
M_1S_4	31.33	13.62	31.80	5.17	1.56	416.00	1503.33	1.58
M_1S_5	30.67	13.80	36.07	5.21	1.60	415.00	1596.67	1.56
M_2S_1	37.00	13.80	43.00	5.23	1.64	431.33	1650.00	1.56
M_2S_2	38.83	15.20	45.80	6.15	1.65	452.00	1690.00	1.55
M_2S_3	39.17	16.78	47.73	6.15	1.59	460.00	1688.67	1.55
M_2S_4	40.50	17.21	48.47	6.53	1.65	485.33	1766.67	1.60
M_2S_5	40.00	17.30	52.07	6.64	1.55	484.33	1796.67	1.58
M_3S_1	40.50	17.83	50.27	7.03	1.68	513.33	1866.67	1.62
M_3S_2	41.83	18.17	52.80	7.53	1.73	537.67	2021.00	1.62
M_3S_3	43.50	18.74	54.00	8.37	1.85	566.00	2103.33	1.68
M_3S_4	45.00	20.43	61.47	8.67	1.96	625.00	2340.00	1.83
M_3S_5	44.67	19.10	54.47	8.47	1.90	621.67	2293.33	1.79
M_4S_1	38.17	17.80	51.00	6.92	1.58	510.00	1870.00	1.80
M_4S_2	39.67	18.09	53.13	7.49	1.64	536.67	1936.67	1.80
M_4S_3	42.67	18.50	54.23	7.89	1.77	564.67	1980.00	1.86
M_4S_4	44.00	18.99	59.50	8.63	1.87	620.33	2320.33	2.02
M_4S_5	43.50	18.57	56.40	8.07	1.86	619.00	2298.67	1.98
S.Em.±	0.95	0.48	1.38	0.15	0.04	20.68	80.61	0.06
C.D 5%	2.91	1.49	4.15	0.47	0.12	67.62	257.58	0.20

Table 2: Effect Integrated nutrient management on uptake of nutrients (Primary and Secondary) by mothbean

Treatments	Nitrogen		Phosphorous		Potassium		Sulphur		Calcium		Magnesium	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Organic manures (M)												
M1	11.55	10.11	2.01	1.93	12.77	20.15	1.51	2.72	5.55	8.72	2.97	6.85
M2	16.29	13.78	2.96	2.72	17.69	26.00	2.51	4.06	7.41	11.19	3.88	8.52
M3	22.10	18.76	4.41	5.84	26.17	38.10	6.46	5.84	11.03	15.64	5.26	12.01
M4	21.78	17.57	4.25	5.41	25.29	36.33	6.24	5.32	10.77	15.08	5.14	11.57
S.Em.±	0.62	0.51	0.17	0.31	0.87	1.24	0.16	0.17	0.32	0.53	0.18	0.42
CD (5%)	2.14	1.77	0.59	1.06	3.00	4.29	0.57	0.59	1.10	1.85	0.62	1.46
Inorganic fertilizer levels (S)												
S1	14.54	12.30	2.59	2.66	16.41	24.75	2.22	3.31	6.80	10.56	3.48	7.83
S2	16.93	14.19	3.19	3.24	18.88	28.97	2.68	3.88	7.99	12.04	4.10	8.95
S3	17.99	14.88	3.49	4.15	20.88	29.87	4.39	4.56	8.83	12.54	4.35	9.62
S4	20.13	17.07	3.95	5.06	23.42	33.86	5.89	5.44	9.98	14.13	4.87	11.37
S5	20.07	16.84	3.82	4.78	22.81	33.27	5.72	5.24	9.85	14.01	4.76	10.93
S.Em.±	0.33	0.33	0.06	0.15	0.36	0.68	0.17	0.15	0.18	0.25	0.07	0.18
CD (5%)	0.94	0.96	0.18	0.43	1.03	1.95	0.48	0.42	0.52	0.71	0.21	0.52
Interactions(M×S)												
M1S1	6.63	6.03	0.90	1.14	8.54	13.68	0.91	2.40	3.82	5.94	1.70	4.76
M1S2	11.88	10.22	2.11	1.87	12.81	20.11	1.36	2.44	5.72	9.22	3.20	7.10
M1S3	12.57	10.55	2.29	2.11	13.68	21.44	1.54	2.58	6.01	9.32	3.25	7.31
M1S4	13.03	11.52	2.37	2.15	14.24	21.04	1.97	3.01	6.10	9.31	3.38	7.36
M1S5	13.65	12.21	2.38	2.39	14.57	24.48	1.78	3.17	6.08	9.81	3.33	7.72
M2S1	14.39	12.51	2.62	2.45	15.45	23.45	1.74	2.71	6.51	9.81	3.37	7.48
M2S2	15.28	13.33	2.83	2.53	17.10	24.78	1.95	3.05	7.14	10.60	3.59	7.95
M2S3	15.54	13.60	2.96	2.69	18.36	25.29	2.41	4.39	7.40	11.16	3.85	8.57
M2S4	17.95	14.74	3.29	2.88	19.08	28.44	3.29	5.18	8.05	12.32	4.34	9.31
M2S5	18.30	14.73	3.08	3.05	18.48	28.02	3.16	4.99	7.96	12.07	4.24	9.29
M3S1	18.98	15.63	3.49	3.61	21.07	30.98	3.23	4.33	8.49	13.35	4.52	9.53
M3S2	20.26	16.94	3.96	4.49	23.22	36.50	3.76	5.31	9.61	14.53	4.89	10.70
M3S3	22.00	18.86	4.40	6.26	26.40	39.03	6.92	5.81	11.04	15.44	5.22	11.76
M3S4	24.96	21.51	5.23	7.86	30.92	43.68	9.29	7.08	13.11	17.71	5.92	14.83
M3S5	24.29	20.85	4.97	6.98	29.26	40.33	9.10	6.66	12.88	17.18	5.76	13.26
M4S1	18.16	15.03	3.37	3.42	20.58	30.88	2.98	3.80	8.38	13.15	4.34	9.53
M4S2	20.29	16.27	3.84	4.07	22.40	34.49	3.64	4.71	9.47	13.82	4.73	10.07
M4S3	21.85	16.50	4.31	5.54	25.09	33.73	6.70	5.48	10.85	14.26	5.10	10.82
M4S4	24.56	20.50	4.92	7.34	29.44	42.30	9.02	6.50	12.65	17.19	5.82	13.99
M4S5	24.06	19.56	4.83	6.71	28.93	40.24	8.86	6.13	12.47	16.98	5.70	13.45
S.Em.±	0.85	0.79	0.20	0.41	1.08	1.73	0.34	0.31	0.45	0.69	0.22	0.53
CD (5%)	2.71	2.46	0.67	1.30	3.51	5.51	1.03	0.95	1.43	2.24	0.73	1.72

Nutrient uptake

The significant difference in N, P and K uptake by seed and straw of mothbean was reported under different nutrient combination (Table 3). Combined application of vermicompost at 1.0 t ha^{-1} +12.5:25:0 N: P_2O_5: K_2O kg ha^{-1} (M_3S_4), FYM at 2.5 t ha^{-1} + 12.5 : 25 : 0 N: P_2O_5: K_2O kg ha^{-1}(M_4S_4) has significantly increased the uptake of N, P and K by seed and straw over control (M_1S_1).Combined application of vermicompost at 1.0 t ha^{-1} +12.5:25:0 N: P_2O_5: K_2O kg ha^{-1} (M_3S_4) has recorded highest uptake of N, P and K by seed (22.10, 4.41 and 26.17 kg ha^{-1}, respectively) and by straw (18.76, 5.84 and 38.10 kg ha^{-1}, respectively) as compared to other treatments combination. However it is being 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), vermicompost 1.0 t ha^{-1}+ 15 :30 : 0 N: P_2O_5: K_2O kg ha^{-1} (M_3S_5), FYM 2.5 t ha^{-1}+ 15 :30 : 0 N: P_2O_5: K_2O kg ha^{-1} (M_4S_5) and the lowest uptake of N, P and K was reported with the treatment which was not supplied with any fertilizer and organic manure (M_1S_1). This increment in uptake of N, P and K by mothbean crop was attributed due to increased accessibility of nutrients in soil as mothbean is leguminous in nature, it has got self-atmospheric nitrogen fixing capacity which resulted in enrichment of soil with nutrients and also might be due to synergistic interaction between nitrogen, phosphorous and potassium, increase in levels of nitrogen also increases P and K. Above said superior treatment has also resulted in higher DMA, hence resulted in increased uptake of nutrients under the treatment with combined application of organics and fertilizers. The results are in concordant with the results of Vasanthi and Subramanian (2004) [20] in blackgram and Tyagi *et al.* (2014) [18] in green gram.

Similar trend was noticed with respective to uptake of S, Ca and Mg (Table 2) by seed and straw of mothbean crop. Significantly maximum S, Ca and Mg uptake by seed (M_3S_4, 9.29, 13.11 and 5.92 kg $ha^{-1,}$ respectively) and straw (7.08, 17.71 and 14.83 kg $ha^{-1,}$ respectively) was reported with nutrient combination of vermicompost at 1.0 t ha^{-1} +12.5:25:0 N: P_2O_5: K_2O kg ha^{-1} (M_3S_4) as compared to other treatments but it was found on par with conjunctive use of FYM at 2.5 t ha^{-1} + 12.5 : 25 : 0 N: P_2O_5: K_2O kg ha^{-1}(M_4S_4), vermicompost 1.0 t ha^{-1}+ 15 :30 : 0 N: P_2O_5: K_2O kg ha^{-1} (M_3S_5), FYM 2.5 t ha^{-1}+ 15 :30 : 0 N: P_2O_5: K_2O kg ha^{-1} (M_4S_5). The lowest S, Ca and Mg uptake by seed and straw was reported with treatment without any nutrient source (M_1S_1). This increment in uptake by mothbean might due to native dissolution of Ca and Mg might have solubilized by the production of organic acids from the root region of crop which caused in higher uptake of secondary nutrients by mothbean. The present results are in concordant with the results of Tolanur (2009) [17] in chickpea, Kumar *et al.* (2007) [6] and Kumawat *et al.* (2006) [7, 8].

Conclusion

Studies on integrated nutrient management made on mothbean revealed that the use of organic manures along with inorganic fertilizers had a marked effect in increasing grain and straw yield and uptake of nutrients by mothbean and highest was obtained with conjunctive use of vermicompost at 1.0 t ha^{-1} +12.5:25:0 N: P_2O_5: K_2O kg ha^{-1} (M_3S_4), FYM at 2.5 t ha^{-1} + 12.5 : 25 : 0 N: P_2O_5: K_2O kg ha^{-1}(M_4S_4). These results clearly indicated the need for supply of nutrients through organic manures to soil conjunctive with inorganic fertilizers, which increased the availability of nutrients over a long period, have positive impact on growth and yield attributes of mothbean crop and suggesting as a feasible and viable technology to sustain agriculture ensuring higher crop yields without deterioration of soil quality.

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