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Integrated Nutrient Management for Sustainable Production of Cassava in Konkan Region

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Abstract

Integrated nutrient management (INM) is basically the complementary use of organic, inorganic and biological sources of plant nutrients to maintain and sustain soil fertility and enhance crop productivity. For standardization of INM package for cassava under Konkan region, field experiments were conducted at AICRP on Tuber Crops Centre at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during 2008 to 2011. The experiment was laid out in randomized block design with three replications. Cassava var. Sree Jaya was used for the study. The thirteen treatments comprised recommended dose of FYM + NPK and combinations of 3/4th recommended dose of FYM + NK with vermicompost @ 200 kg ha^{-1}, dhaincha @ 20 kg ha^{-1}, *Glyricidia* green leaf manure @ 25 t ha^{-1} and cowpea @ 20 kg ha^{-1} and FYM alone. All the above treatments were supplemented with panchagavya drenching @ 3% and without drenching of panchagavya. The pooled analysis revealed that significantly highest tuber yield of 45.67 t ha^{-1} was obtained in the treatment combination 3/4th recommended dose of FYM+ NK + *Glyricidia* green leaf manure @ 25 t ha^{-1} with drenching of panchagavya. Application of 3/4th recommended dose of FYM+ NK + dhaincha @ 20 kg ha^{-1} as green manure with drenching of panchagavya also yielded well (42.43 t ha^{-1}) and gave highest net returns of ` 90, 462 ha^{-1} and B: C ratio of 1.88. Besides the major nutrient status of the soil was also improved due to this treatment.

Key words: Cassava, integrated nutrient management, productivity, sustainability

Introduction

Cassava (*Manihot esculenta* Crantz), forms an important alternate source of energy to meet the demand of the geometrically increasing population and serves as an important staple or subsidiary food for about one fifth of the world's population (Sasankan et al., 2008). It can also be used as alternative source of feed for livestock in both tropical and subtropical countries (Edison, 2006). India acquires significance in the global cassava production scenario due to its high productivity in the world (34.0 t ha^{-1}) with an area of 0.24 m ha producing 8.1 m t (James George et al., 2012). The climatic conditions of Konkan region of Maharashtra are suitable for cassava cultivation as a sole as well as an intercrop. For promoting cassava cultivation under Konkan region as well as rest of Maharashtra, a standard production technology is essential. The standardization of nutrient management is one of the aspects of production technology. Though cassava is adapted to soils with marginal fertility, it is proved beyond doubt that high rates of nutrients can enhance its productivity (Susan John, 2010). By adopting proper nutrient management practices, it is possible to realize high productivity from cassava. Integrated nutrient management is a concept where macro and micro nutrients are supplied to crops with combinations of organic and inorganic sources of nutrients. This maintains the soil health and sustains crop productivity. The objective of this study was to develop integrated nutrient management package with different organic and inorganic sources of nutrients for cassava in the Konkan region.

Materials and Methods

Field experiment was conducted at the Central Experiment Station, Wakawali, Dapoli, Maharashtra during 2008 to 2011. The soil of experimental site was lateritic in nature having acidic soil reaction with a pH of 5.3. The soil was rated as low for available N (188.16 kg ha^{-1}), available P (8.78 kg ha^{-1}) and available K (127.68 kg ha^{-1}). The experimental location experiences a warm humid climate with mean annual rainfall of 3500 mm. The experiment was laid out in randomized block design with three replications. A short-duration cassava variety, Sree Jaya, released from the Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, was the test variety. There were 13 treatments:

T_1 : Recommended dose of FYM + NPK

T_2 : ¾ RD of FYM + NK + vermicompost @ 200 kg ha^{-1} + 3% panchagavya

T_3 : ¾ RD of FYM + NK + dhaincha @ 20 kg ha^{-1} (green manure) + 3% panchagavya

T_4 : ¾ RD of FYM + NK + green leaf manure (*Glyricidia* @ 25 t ha^{-1}) + 3% panchagavya

T_5 : ¾ RD of FYM + NK + cowpea @ 20 kg ha^{-1} (green manure) + 3% panchagavya

T_6 : FYM (12.5 t ha^{-1}) + 3% panchagavya

T_7 : Recommended dose of FYM + NPK (RDF)

T_8 : ¾ RD of FYM + NK + vermicompost @ 200 kg ha^{-1}

T_9 : ¾ RD of FYM + NK + dhaincha @ 20 kg ha^{-1} (green manure)

T_{10} : ¾ RD of FYM + NK + green leaf manure (*Glyricidia* @ 25 t ha^{-1})

T_{11} : ¾ RD of FYM + NK + cowpea @ 20 kg ha^{-1} (green manure)

T_{12} : FYM (12.5 t ha^{-1})

T_{13} : Absolute **c**ontrol (without FYM, NPK and panchagavya)

Well decomposed FYM @ 12.5 t ha^{-1} and NPK @ 100:50:100 kg ha^{-1} were applied as the recommended nutrient dose. Full dose of P and half dose of N and K were applied as basal dose at the time of planting. The remaining half dose of N and K were applied as top dressing at 60 days after planting during intercultural operations and earthing up. The organic manures and inorganic fertilizers were applied at different doses as per the treatment requirements. The FYM and vermicompost were incorporated in the plot as per the treatments before preparation of ridges. The dhaincha and cowpea seeds were sown at the time of planting and were incorporated in the soil before flowering (at 40 DAS) in the respective plots. The green matter contribution from dhaincha and cowpea were 18.4 and 13.8 t ha^{-1} respectively. The *Glyricidia* green leaf manure @ 25 t ha^{-1} was incorporated at the time of planting in soil as per the respective treatments. The panchagavya stock solution was prepared by using cow dung, cow urine, cow ghee, cow curd and cow milk as per the procedure given by Asangla et al. (2005) and applied @ 3% to respective treatments. The disease free, fully mature stem cuttings having diameter of 2-3 cm and length of 15-20 cm was planted at a spacing of 90 cm x 90 cm. Planting was done during first fortnight of June. The plot size was 2.7 m x 2.7 m. The intercultural operations were done as and when necessary. Plant growth, yield attributes and yield were recorded. Soil samples were collected initially and at the end of season for analysis of available N, P and K contents as per standard procedures. The economic parameters with respect to different treatments were worked out based on the prevailing market price of 2010-2011. Data of each character collected from the experiment was analyzed statistically using standard procedures of analysis of variance (Gomez and Gomez, 1984).

Results and Discussion

Growth parameters

Growth characters viz., plant height, main and sub branches, leaf length, leaf breadth and fresh total biomass (stems and leaves) were significantly influenced by combined application of organic manure, green manure and inorganic fertilizers. Data presented in Table 1 indicated that the treatment T_3 (¾ RD of FYM + NK + dhaincha @ 20 kg ha^{-1} (green manure) + 3% pancha gavya) resulted in significantly tallest plant (183.11 cm) over rest of the treatments, except treatments T_4, T_9, T_{10}, T_1 and T_7, which were on par. All the treatment combinations produced on an average two main branches per plant, which was significantly superior to T_{13} (1.0). The treatment T_4 resulted in significantly highest sub

Table 1. Effect of integrated nutrient management on growth parameters of cassava

Treatments	Height (cm)	Number of main branches	Number of sub branches	Leaf length (cm)	Leaf breadth (cm)	Fresh total biomass (t ha^{-1})
T_1	171.33	2.00	12.00	27.56	22.00	22.70
T_2	165.11	2.00	11.00	21.33	20.11	18.73
T_3	183.11	2.00	11.00	27.89	21.61	23.78
T_4	182.89	2.00	12.00	27.00	22.72	23.19
T_5	164.22	2.00	11.00	26.56	21.72	19.21
T_6	145.89	2.00	8.00	22.22	20.33	11.45
T_7	170.22	2.00	12.00	23.50	20.39	21.40
T_8	162.11	2.00	11.00	20.54	18.22	16.84
T_9	173.11	2.00	11.00	24.39	24.50	20.31
T_{10}	172.67	2.00	11.00	26.17	23.44	19.36
T_{11}	151.11	2.00	9.00	23.11	20.56	18.28
T_{12}	120.56	2.00	6.00	19.90	17.56	10.20
T_{13}	99.44	1.00	5.00	16.17	15.44	6.14
CD (0.05)	13.57	0.24	2.24	4.19	2.26	2.63

branches per plant (12), which was on par with the treatments T_1, T_7, T_9, T_5, T_3, T_8, T_2 and T_{10} (10-12 per plant). The maximum leaf length of 27.89 cm and leaf breadth of 24.50 cm was obtained due to the treatments T_3 and T_9, respectively. With regard to fresh biomass production, T_3 resulted in significantly greatest biomass (23.78 t ha^{-1}), which was on par with the treatments, T_4, T_1 and T_7. The control treatment T_{13} resulted in significantly lowest values of all the growth parameters. The promotion of growth parameters clearly indicates the positive response to combined application of nutrient sources. The *Glyricidia* green leaf manure and dhaincha green manure contains nutrients and decomposes very fast. Ultimately it improves the soil physico-chemical properties, which imparts favorable soil structure for root growth and thereby promotes plant growth. The results are in conformity with the findings of Sharma and Bhalla (1998) in okra, Jadhav et al. (1998) in sweet potato and Saikia et al. (2010) in taro.

Yield attributes

The integration of green manure with organic and inorganic sources of nutrients could bring about significant difference in tuber yield and yield attributes viz., length and girth of tuber, number of tubers, average tuber weight and tuber yield per plant (Table 2). The integrated nutrient management treatments, T_4 and T_3, resulted in significantly greatest length and girth of tuber, 29.98 cm and 17.64 cm, respectively. The average data of two years revealed that the number of tubers per plant was significantly higher (7.0) in the treatment T_3 (¾ RD of FYM + NK + dhaincha @ 20 kg ha^{-1} as green manure with 3% panchgavya) which was on par with most other treatments, except T_6, T_{12} and T_{13}. The treatments T_4 and T_3 were superior in the case of tuber characteristics mainly due to maximum availability of soil nutrients and production of

Table 2. Effect of integrated nutrient management on yield attributes of cassava (mean of two years)

Treatments	Tuber length (cm)	Tuber girth (cm)	Number of tubers per plant	Tuber yield (kg plant^{-1})	Mean weight of tuber (g)
T_1	29.20	16.84	7.00	2.73	405.29
T_2	25.38	16.31	7.00	2.45	381.90
T_3	29.76	17.64	7.00	2.87	413.76
T_4	29.98	16.60	7.00	2.91	441.41
T_5	28.71	17.44	7.00	2.57	377.50
T_6	21.11	15.84	4.00	1.44	325.46
T_7	27.20	17.33	7.00	2.59	397.47
T_8	22.69	15.98	6.00	1.97	333.23
T_9	26.31	16.49	7.00	2.38	351.33
T_{10}	26.56	16.04	6.00	2.34	372.62
T_{11}	24.47	15.84	6.00	2.21	363.48
T_{12}	18.62	15.56	4.00	1.14	274.23
T_{13}	14.91	13.36	3.00	0.55	208.52
CD (0.05)	3.80	1.15	0.86	0.33	37.82

growth hormones. The increase in uptake of nutrients from the soil might have resulted in enough production of carbohydrate in the leaves for translocation to the sink which might have contibuted to maximum tuber number and mean weight of tuber. This is in agreement with the report of Pathak et. al. (2005). The treatment T_4 resulted in significantly highest yield of 2.91 kg per plant which was significantly superior to rest of the treatments, except T_3, T_1 and T_7. The same treatment resulted in significantly maximum tuber weight of 441.41 g, which was on par with T_3 and T_1 and superior to rest of the treatments. The increase in average tuber weight per plant and tuber yield per plant in T_4 was presumably due to the greater availability of nutrients in soil leading to better nutrient uptake by plant, which in turn increased the photosynthetic area. Similar findings were also reported by Kandaswamy et al. (1988)

Tuber yield

The tuber yield of cassava was influenced significantly by the different nutrient management treatments during individual years as well as in pooled analysis (Table 3). The pooled mean of tuber yield for four consecutive years (2008-2012) showed that the maximum tuber yield 45.67 t ha^{-1} was obtained in the treatment T_4 (¾ RD of FYM + NK with *Glyricidia* green leaf manure @ 25 t ha along with panchagavya), which was on par with T_3 (42.43 t ha^{-1}) and significantly superior over the rest of the treatment combinations. This may be due to the cumulative effects of vigorous plant growth and yield attributes, which resulted in higher accumulation of carbohydrates, increased photosynthetic activity and translocation to the tuber. This finding is in accordance with Jena et al. (1999). Precise application of nutrients in right quantity, at right time to match the crop need, enhanced the nutrient uptake, biochemical activities, which consequently led to better growth and yield. These results are in conformity with the findings of Maheswari et al. (2000) in Ashwagandha.

Table 3. Effect of integrated nutrient management on tuber yield of cassava

Treatments	Tuber yield (t ha^{-1})				
	2008-09	2009-10	2010-11	2011-12	Pooled mean
T_1	32.74	52.53	33.77	33.64	38.17
T_2	36.17	45.45	30.35	30.10	35.52
T_3	43.14	55.66	35.86	35.08	42.43
T_4	51.00	59.94	36.65	35.09	45.67
T_5	49.07	47.92	32.09	31.28	40.09
T_6	39.02	45.12	16.85	18.81	29.95
T_7	38.97	43.97	31.61	32.37	36.73
T_8	33.78	49.24	22.50	26.10	32.90
T_9	44.30	44.46	26.92	31.96	36.91
T_{10}	55.78	46.93	26.01	31.88	40.15
T_{11}	47.79	40.84	25.85	28.77	35.81
T_{12}	39.23	43.64	13.84	14.33	27.78
T_{13}	26.49	26.02	6.27	7.28	16.52
CD (0.05)	6.151	10.95	7.07	4.61	3.46

Chemical properties of soil

The treatment T_3 (¾ RD of FYM + NK + dhaincha @ 20 kg ha^{-1} as green manure along with panchagavya) resulted in higher available N (324.05 kg ha^{-1}) in soil followed by T_9 (303.15 kg ha^{-1}), which was significantly superior over the rest of the nutrient combinations (Table 4). The available P status in soil was the maximum (19.42 kg ha^{-1}) in the treatment T_3 which was significantly superior over the rest of the treatments. The same treatment was superior in the case of available K (254.24 kg ha^{-1}) and on par with the treatments, T_9, T_5, T_1, T_6 and $T_{11,}$ while significantly superior over the rest of the treatments under study. The treatments where FYM @ 12.5 t ha^{-1} was applied with and without panchagavya and control treatment resulted in net negative available N and P in soil over initial N and P status, whereas in the case of available K only the control treatment showed net negative balance over initial status of available K.

Nanda et al. (2012) reported that the incorporation of organic manures and biofertilizers along with inorganic fertilizers (75% of recommended dose of fertilizer) and micro nutrients promoted soil quality by enhancing the availability of N, P and K status of soil in turmeric.

Economics

The economics of different nutrient management treatments evaluated at cost C level revealed that the treatment T_3 (i.e. ¾ RD of FYM + NK + dhaincha @ 20 kg ha^{-1} with panchagavya) realized the highest net returns of ` 90,462 ha^{-1} and B: C ratio of 1.88. This might be due to maximum productivity (42.43 t ha^{-1}) as well as the lowest cost of cultivation (Table 5). Even though the treatment T_4 produced highest tuber yield, due to

Table 4. Effect of integrated nutrient management on chemical properties of soil

Treatments	pH	EC (dS m^{-1})	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1	5.33	0.087	198.61	11.44	206.83
T_2	5.30	0.087	188.16	10.11	171.36
T_3	5.33	0.087	324.05	19.42	254.24
T_4	5.33	0.087	229.97	10.91	214.67
T_5	5.33	0.087	261.33	15.16	234.08
T_6	5.30	0.087	156.80	7.18	144.85
T_7	5.33	0.087	188.16	10.91	204.59
T_8	5.30	0.087	177.71	8.78	159.41
T_9	5.33	0.087	303.15	15.43	244.91
T_{10}	5.33	0.087	209.07	9.31	191.52
T_{11}	5.33	0.087	250.88	14.10	202.72
T_{12}	5.30	0.087	146.35	6.92	129.17
T_{13}	5.30	0.087	135.89	5.85	111.63
CD (0.05)	NS	NS	25.73	2.14	65.60
Initial	5.30	0.087	188.16	8.78	127.68

Table 5. Economic analysis of different nutrient management treatments in cassava

Treatment	Tuber yield (t ha^{-1})	Gross income (` ha^{-1})	Cost of cultivation (` ha^{-1})	Net returns (` ha^{-1})	B:C ratio
T_1	38.17	176680	103801	72879	1.70
T_2	35.52	166080	97352	68728	1.71
T_3	42.43	193720	103258	90462	1.88
T_4	45.67	206680	116526	90154	1.77
T_5	40.09	184360	102207	82153	1.80
T_6	29.95	143800	100041	43759	1.44
T_7	36.73	170920	102060	68860	1.67
T_8	32.90	155600	94688	60912	1.64
T_9	36.91	171640	98796	72844	1.74
T_{10}	40.15	184600	112064	72536	1.65
T_{11}	35.81	167240	98571	68669	1.70
T_{12}	27.78	135120	97813	37307	1.38
T_{13}	16.52	90080	63254	26826	1.42
CD (0.05)	3.46	-	-	-	-

FYM: ` 1800 $t^{-1}$; Planting material: ` 1 set^{-1}; Labour cost: ` 120 $day^{-1}$: Urea: ` 5.60 kg^{-1}; Single super phosphate: ` 3.60 $kg^{-1}$; Muriate of Potash: ` 5.20 kg^{-1}; Cowpea seed: ` 56 $kg^{-1}$; Dhaincha seed: ` 33.50 kg^{-1}; *Glyricidia*: ` 180 $t^{-1}$; Vermicompost : ` 5 kg^{-1} ; Panchagavya: ` 450 $l^{-1}$; Price of tuber: ` 3.5 $kg^{-1.}$

its higher cost of cultivation it was not economical than treatment T_3.

Conclusion

It is concluded from the pooled results that the application of ¾ RD of FYM+ NK + *Glyricidia* green leaf manure @ 25 t ha^{-1} with 3% panchagavya (T_4) produced significantly highest tuber yield of 45.67 t ha^{-1}. However it was on par with the treatment T_3 (42.43 t ha^{-1}) i.e. sowing of dhaincha @ 20 kg ha^{-1} as green manure with ¾ RD of FYM + NK with 3% panchagavya. However the treatment T_3 resulted in maximum net return of ` 90,462 ha^{-1} and B: C ratio of 1.88. The nutrient status of soil under treatment T_3 was also higher

with respect to available major nutrients N, P and K. Hence, the treatment combination, sowing of dhaincha @ 20 kg ha^{-1} as green manure with ¾ RD of FYM, N and K with 3% panchagavya is recommended for cassava cultivation in Konkan region of Maharashtra.

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