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Integrated Nitrogen Management Strategy for Growth and Yield of Cashew (*Anacardium occidentale* L.)

S.V. Patil[1]*, Nagaraja, G.[2], Manjunath R.[3], Rajakumar G.R.[4] and Adiga, J.D.[5]
[1]Professor of Agronomy, Department of NRM,
College of Horticulture, UHS Campus, GKVK, Bengaluru-560065, (Karnataka), India.
[2]Assistant Professor of Agricultural Engineering,
Department of NRM, College of Horticulture, UHS Campus, GKVK, Bengaluru-560065, (Karnataka), India.
[3]Assistant Professor of Agricultural Microbiology, Department of NRM,
College of Horticulture, UHS Campus, GKVK, Bengaluru-560065, (Karnataka), India.
[4]Scientist (Soil Science), KVK, Hanumanamatti, Haveri-581115, (Karnataka), India.
5Principal Scientist (Horticulture), ICAR-DCR, Puttur, Karnataka-574202, (Karnataka), India.

(Corresponding author: S.V. Patil)*
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ABSTRACT: Cashew crop is facing many challenges related to its nutrition and yield. Hence, to address the issue, the present study was carried out at Regional Horticulture and Extension Centre, University of Horticultural Sciences Campus, GKVK, Bengaluru, Karnataka during the years 2016-17, 2017-18 & 2018-19 by employing factorial randomized complete block design with 13 treatments and three replications to the nitrogen management strategies for the growth and yield of cashew nut. The growth parameters like trunk girth, plant height and canopy spread didn't show any significant difference among the sources and different combinations levels, whereas the number of flowering laterals per square meter and cashew nut yield per plant was significantly higher in 100 % RDN through vermicompost. Among levels of applications, 50 % organic and 50% inorganic combination recorded significantly higher number of flowering laterals per square meters and cashew nut yield per plant compared to other levels of combinations whereas, among interaction, 100% vermicompost followed by 75% N vermicompost + 25% N Urea recorded significantly higher yield. The research studies proved that cashew crop responded very well to the integrated nutrient management when compared to the control.

Keywords: Integrated nitrogen management, cashew, vermicompost.

INTRODUCTION

Cashew (*Anacardium occidentale* L.) is a tropical evergreen tree native to the northern region of South America (Ohler, 1979). The cashew tree (*Anacardium occidentale* L.), though native of Brazil, has acclimatized well in India. Cashew was introduced to India by Portuguese travellers during 16th Century for afforestation and soil conservation purpose. In India, cashew is grown along the coastal regions mainly in Maharashtra, Goa, Karnataka and Kerala in the West Coast and Tamil. India is the largest producer, processor, exporter and consumer of cashew in the world. It has the potential to provide source of livelihood for the cashew growers, empower rural women in the processing sector, create employment opportunities and generate foreign exchange through exports (Jena and Panda, 2020). Globally, India is largest processor of raw cashewnut but meets only 50 per cent raw cashewnuts required by processing industries (Saroj and Roopa, 2014). Mostly, cashew is grown in poor and marginal soils in India due to which the cashew productivity has been low. Cashew production can be enhanced by improving productivity in the existing old/new gardens by nutrient management. The cashew tree responds very well to manures and fertilizer application (Babu *et al.*, 2015) and Continuous non application of fertilizers and manures lead to multi-nutrient deficiencies in soil (Mangalassery *et al.*, 2020). The major nutrient requirement of cashew plant has been N followed by K, while P is needed in comparatively lesser quantity. Nitrogen has more influence on tree growth, production and quality of cashew than any other nutrient. Balanced plant nutrition was found essential to achieve economic yields in Australia, with nitrogen (N) of particular importance because of its capacity to modify growth, affect nut yield and cause environmental degradation through soil acidification and off-site contamination (O'Farrell *et al.*, 2010). Like any other crops and organism, cashew too requires additional nutrient inputs for producing potential yield. Being a perennial tree crop, cashew removes considerable amount of nutrients from soil (Mangalassery, *et al.*, 2020). The supplementation of nitrogen source through organic means will have a long term effect on improving the soil health. Such studies are very limited with respect to cashew. In view of these facts, there is a need to study the various combinations of available nitrogen sources and proper utilization pattern to find out optimum combination of different sources of nitrogen. The integrated, balanced and effective nitrogen management is need of the hour to take care of proper replenishment and compensation of nutrient losses from the soil and also to know the nitrogen management strategies for enhancing growth and yield of cashew nut.

MATERIAL AND METHODS

The present investigation was carried out at Regional Horticultural Research and Extension Centre, University of Horticultural Sciences Campus, GKVK, Bengaluru during the years 2016-17, 2017-18 and 2018-19 in the existing cashew (Ullal-1 variety) plantation of 6 years old trees by employing factorial randomized complete block design with thirteen treatments and three replications to know the integrated nitrogen management strategies for the growth and yield of cashew nut. The cashew cultivars were planted in 2010 and maintained at a plant density of 156 trees/ha with a spacing of 8.0 m x 8.0 m. Different sources of organic manures were used for nitrogen equivalent, application to cashew such as FYM, vermicompost and green leaf manures with different levels of N supplementations i.e., 25% organic and remaining 75% through inorganic, 50% organic and remaining 50% through inorganic, 75% organic and remaining 25% through inorganic, 100% organic and control as100% inorganic fertilizers were applied. Fertilizer was applied after thorough cleaning of plots and making basin around the individual tree with in 1.50 m radius. The fertilizer was applied to soil in a circular strip. All the treatment combinations were imposed during the onset of monsoon. The observations and the data were recorded for the growth parameters like plant height (m), tree girth (cm), canopy spread (m) @ N-S and E-W direction and the number of flowering laterals in all the directions. The canopy spread measured on N-S and E-W directions were averaged to arrive at mean canopy spread. Similarly, flowering laterals counted from four directions within one square meter area using bamboo frame under each direction were averaged to arrive at flowering laterals per square meter. The cashew nut yield was taken as kg per plant. The nuts, as and when picked from the ground below the plant canopy, were sun dried for 3 days, weighed and stored. The total yield per plant was worked out after the end of harvesting season.

RESULTS AND DISCUSSION

The sources of organic manures, different levels of N supplementations and combined applications of organic manures with different levels of N with inorganic fertilizers had no significant effect on the growth parameters like trunk girth and canopy spread. However, among sources vermicompost, among levels of N supplementations 50% organic and 50% inorganic and in interaction 100 % vermicompost were associated with increased growth parameters like trunk girth, plant height and canopy spread compared to other treatments. The lowest trunk girth, plant height and canopy spread were recorded in control treatment compared to other treatments (Table 1).

Table 1: Effect of different sources and combination of Nitrogen on Cashew trunk girth (cm), Plant height (m) and Canopy spread (m).

Treatment	Trunk Girth (cm)				Plant Height (m)				canopy spread (m)			
	2016-17	2017-18	2018-19	Pooled	2016-17	2017-18	2018-19	Pooled	2016-17	2017-18	2018-19	Pooled
Factor A: Sources of OM S1: FYM	53.25	57.75	61.75	57.58	3.50	3.80	4.85	4.05	5.72	6.02	6.53	6.09
S2 Vermicompost	54.42	59.17	60.58	58.06	3.73	4.03	5.09	4.28	5.68	5.95	6.91	6.18
S3: Green leaf Manure	53.50	58.17	60.50	57.39	3.57	3.88	5.03	4.16	5.25	5.53	7.05	5.94
SEm±	1.27	1.29	1.82	1.46	0.14	0.14	0.11	0.13	0.16	0.16	0.25	0.19
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Factor B: Level of N suppl. L1 : 25% organic and 75% Inorganic	80.33	87.50	91.00	86.28	5.32	5.73	7.60	6.22	8.42	8.82	10.33	9.19
L2: 50% organic and 50% inorganic	81.67	89.00	95.50	88.72	5.62	6.08	7.67	6.46	8.36	8.79	11.03	9.39
L3 75% organic and 25% inorganic	78.83	85.67	87.83	84.11	4.98	5.50	7.05	5.84	8.17	8.59	9.68	8.81
L4: 100% organic	81.50	88.00	91.33	86.94	5.68	6.10	7.63	6.47	8.36	8.78	9.97	9.04
SEm±	1.47	1.49	2.10	1.69	0.16	0.16	0.13	0.15	0.18	0.18	0.29	0.22
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction												
S1L1: 25% N FYM + 75% N urea	56.00	60.00	58.00	58.00	3.70	3.97	5.07	4.25	5.72	6.13	6.33	6.06
S1L2: 50% N FYM + 50 % N Urea	55.33	55.00	63.33	57.89	3.53	3.97	4.97	4.16	5.88	5.52	6.90	6.10
S1L3: 75% N FYM + 25% N Urea	52.33	54.33	64.67	57.11	3.07	4.13	4.57	3.92	5.68	5.96	6.70	6.11
S1L4 100% N FYM	56.33	57.33	60.33	58.00	3.87	3.77	5.07	4.24	6.05	5.43	6.90	6.13
S2L125 % vermicompost + 75% N through Urea	52.67	59.67	63.33	58.56	3.60	3.73	5.07	4.13	5.90	6.03	6.77	6.23
S2L2 50%N vermicompost + 50% N Urea	53.33	57.33	64.33	58.33	3.70	4.00	5.23	4.31	5.23	6.38	6.50	6.04
S2L3 75% N vermicompost + 25% N Urea	54.67	60.00	62.33	59.00	3.43	3.90	5.40	4.24	5.15	6.05	7.45	6.22
S2L4 100% vermicompost (50 kg)	55.00	61.00	65.33	60.44	4.23	3.78	5.13	4.38	5.70	6.12	7.30	6.37
S3L1 25%N leaf manure + 75% N Urea	50.00	60.67	55.00	55.22	3.33	4.20	5.07	4.20	5.30	6.08	6.83	6.07
S3L2 50% N Leaf manure + 50% N urea	54.67	59.00	57.67	57.11	3.90	3.80	4.77	4.16	5.80	6.23	6.18	6.07
S3L3 75% N Leaf manure+ 25% N Urea	55.00	58.67	59.33	57.67	3.47	4.53	4.77	4.26	5.95	5.97	6.67	6.20
S3L4 100% N leaf manure	54.33	56.67	64.33	58.44	3.27	3.60	5.07	3.98	4.98	5.50	7.92	6.13
Control	50.00	60.67	58.67	56.45	3.63	3.43	4.70	3.92	5.15	5.42	6.30	5.62
SEm±	2.55	2.58	3.64	2.92	0.27	0.27	0.22	0.25	0.32	0.32	0.50	0.38
CD5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

The results indicate that the organic supplementation of nutrients is most suitable for cashew cultivation (Kalaivanan and Rupa, 2016). However, integrated use of organic and inorganic sources of N is also found to be suitable. The different sources of nitrogen, the vermicompost recorded significantly higher number of flowering laterals (13.42) per square meter area over green leaf manure and on par with FYM. This could be due to the better availability of nutrients in vermicompost. In levels of combination there was no significant increase in number of lateral flowers per square meter area. However, the maximum flowering laterals per square meter area was recorded (13.23) in urea 50% organic and 50% inorganic. Among interaction 100% vermicompost (50 kg) followed by 75% N vermicompost + 25% N Urea, 50% N FYM + 50 % N Urea resulted in significantly higher flowering (14.87, 14.07 and 13.91, respectively) per square meter area over other treatments (Table 2). The integrated use of organic and inorganic sources of N was found to be suitable to obtain more number of flowers (O'Farrell *et al.*, 2010). Among the different sources of nitrogen, the application of vermicompost recorded significantly higher yield (7.92 kg/plant) over green leaf manure and was on par with FYM. This is due to higher number of flowering laterals produced on account of application of vermicompost as well as FYM. In levels of combinations 50% organic and 50% inorganic (urea) followed by 75% organic and 25% inorganic (urea) recorded higher yield (7.89 kg/plant and 7.77 kg/plant) over other combinations. Among interaction, 100% vermicompost (50 kg) followed by 75% N vermicompost + 25% N Urea (8.06 kg/plant), 50% N FYM + 50 % N Urea resulted in significantly higher yield (8.11 kg/plant and 8.00 kg/plant) over other treatments (Table 2). The yield of cashew nuts were highest with integrated practices as compared to sole treatments indicating the importance of combination of organic and inorganic sources of nutrients in tune with earlier work (O'Farrell *et al.,* 2010). Rupa and Bhat (2010) reported that fertigation saved about 50% fertilizers, while improving the yield and quality as compared with the common methods of fertilizer application. Cashew requires regular fertilizer application to ensure early and high yields in new plantations, and regular high yields from mature trees.

Table 2: Effect of different sources and combination of Nitrogen on flowering laterals/m^2 and Cashew nut yield (kg/plant).

Treatment	Number of flowering laterals/m^2				Cashew Nut Yield (kg/plant)			
	2016-17	2017-18	2018-19	Pooled	2016-17	2017-18	2018-19	Pooled
Factor A: Sources of OM								
S1: FYM	10.75	11.82	14.50	12.36	7.40	7.05	7.67	7.37
S2 Vermicompost	11.38	13.05	15.83	13.42	7.77	**8.05**	7.95	**7.92**
S3: Green leaf Manure	10.15	10.56	13.55	11.42	7.19	6.95	7.48	7.21
SEm±	0.18	0.78	0.95	0.64	0.24	0.26	0.28	0.26
CD @ 5%	0.52	NS	NS	1.65	0.68	0.73	0.77	0.73
Factor B: Level of N suppl.								
L1 : 25% organic and 75% Inorganic	10.31	11.22	13.73	11.75	7.22	7.52	7.50	7.41
L2: 50% organic and 50% inorganic	11.44	12.76	15.50	13.23	7.74	7.92	8.00	**7.89**
L3 75% organic and 25% inorganic	10.80	11.54	14.83	12.39	7.46	**8.16**	7.70	**7.77**
L4: 100% organic	10.47	11.73	14.43	12.21	7.40	**8.26**	7.59	7.75
SEm±	0.20	0.90	1.10	0.48	0.26	0.26	0.13	0.22
CD @ 5%	0.60	NS	NS	NS	0.75	0.75	0.38	0.63
Interaction								
S1L1: 25% N FYM + 75% N urea	10.00	10.67	13.50	11.39	6.98	6.95	7.30	7.08
S1L2: 50% N FYM + 50 % N Urea	11.67	13.67	16.40	13.91	7.95	7.95	8.10	**8.00**
S1L3: 75% N FYM + 25% N Urea	11.08	11.52	14.50	12.37	7.46	7.62	7.80	7.63
S1L4 100% N FYM	10.25	11.43	13.60	11.76	7.22	6.98	7.46	7.22
S2L125 % vermicompost + 75% N through Urea	10.50	11.50	14.00	12.00	7.45	7.22	7.60	7.42
S2L2 50% N vermicompost + 50% N Urea	11.08	12.18	14.90	12.72	7.62	7.46	7.80	7.63
S2L3 75% N vermicompost + 25% N Urea	11.75	13.77	16.70	14.07	7.98	**8.00**	8.20	**8.06**
S2L4 100% vermicompost (50 kg)	12.17	14.75	17.70	14.87	8.02	**8.10**	8.22	**8.11**
S3L1 25%N leaf manure + 75% N Urea	10.42	11.50	13.70	11.87	7.22	7.45	7.60	7.42
S3L2 50% N Leaf manure + 50% N urea	11.58	12.42	15.20	13.07	7.65	7.65	8.10	7.80
S3L3 75% N Leaf manure+ 25% N Urea	9.58	9.33	13.30	10.74	6.95	7.22	7.10	7.09
S3L4 100% N leaf manure	9.00	9.00	12.00	10.00	6.95	6.95	7.10	7.00
Control	8.83	8.00	10.50	9.11	6.02	6.02	7.10	6.38
SEm±	0.35	1.55	1.56	1.15	0.24	0.24	0.25	0.24
CD5%	1.03	3.95	4.68	2.96	0.70	0.70	0.72	0.71

Soil available NPK as influenced by sources and combination of Nitrogen to Cashew: The effect of different sources of nitrogen (organic and inorganic at different levels) was found to have significant influence on soil available NPK status after harvest of the crop (April). It is found that the organic sources were found to have positive effect on nitrogen build in soil; among the three sources, green manure was found to influence significantly as compared to FYM, while it was on par with Vermicompst. Among the desired effects of green manure are improving soil fertility and increasing the stability of N supply (Thorup-Kristensen *et al.,* 2003).

The different levels of N through fertilizer urea were also found to have significant effect on nitrogen availability in soil. Higher dose of fertilizer made the native soil nitrogen to remain and as a result higher availability has been noticed in soil even after harvest of the crop. Among the interactions, higher availability of soil nitrogen was found with 25% N through leaf manure +75% N through Urea followed by 25% N through vermicompost +75% N through Urea. Green manure is a promising, at least partial, substitution for chemical fertilizer (Yang *et al.*, 2018) agriculture, especially for nitrogen (N).

Over the years, there was build up of nitrogen availability in the soil due to different interactions. However, the available phosphorous was found to decline due to various sources and levels of nitrogen. The green leaf manure was superior among the three sources. The more availability of potash was found with vermicompost as compared to FYM and green manure. Even along with urea, the vermicompost was found to be better in making potash more available.

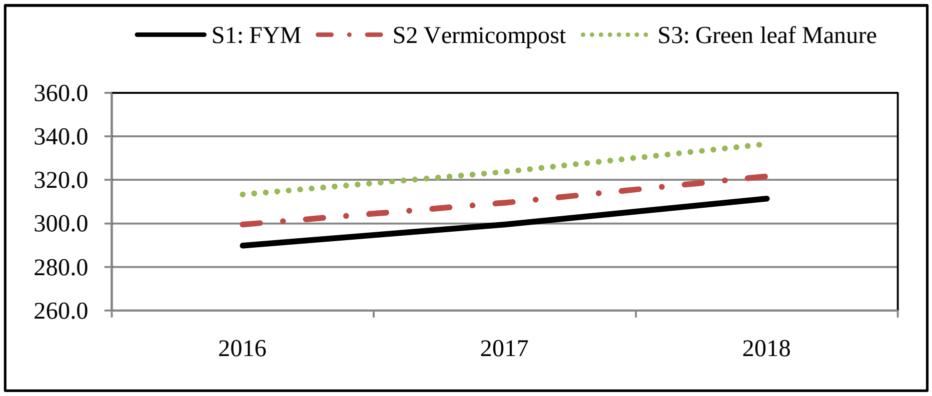

Fig. 1. Soil available nitrogen (kg/ha) as influenced by different organic manures.

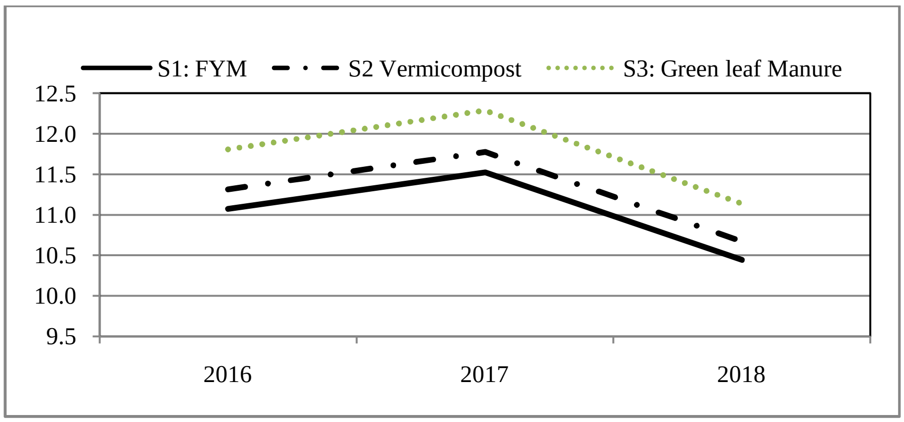

Fig. 2. Soil available phosphorous (kg/ha) as influenced by different organic manures.

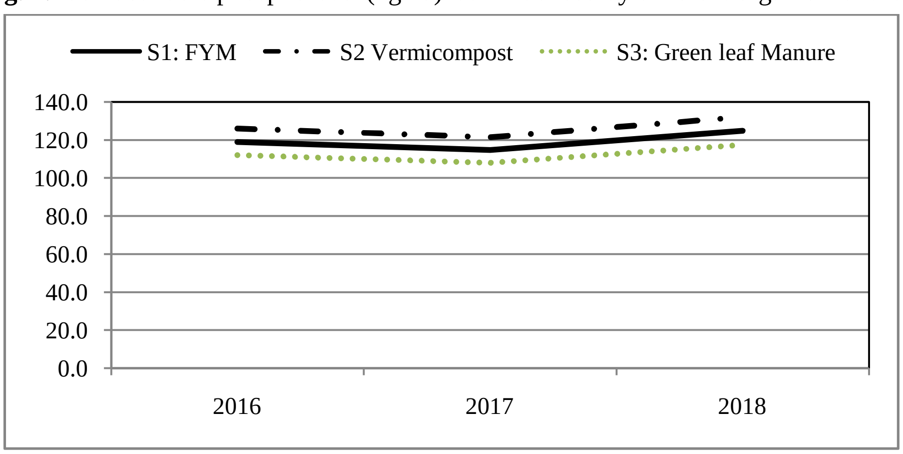

Fig. 3. Soil available potassium (kg/ha) as influenced by different organic manures.

The ill effects of neglect of fertilizer and manure application in cashew on soil organic carbon, nitrogen and potassium, which adversely affected the nutrient uptake by cashew as evident from the leaf nutrient status (Mangalassery *et al.*, 2021).

Sustainable yield and profit in cashew can be achieved by the application of different fertilizers and manures or their combinations to meet 100; N requirement of cashew (Yadukumar *et al.*, 2012).

Table 3: Soil available NPK as influenced by sources and combination of Nitrogen to Cashew.

Treatment	Soil available N (kg/ha)				Soil available P (kg/ha)				Soil available K (kg/ha)			
	2016-17	2017-18	2018-19	Pooled	2016-17	2017-18	2018-19	Pooled	2016-17	2017-18	2018-19	Pooled
Factor A: Sources of OM												
S1: FYM	289.8	299.5	311.3	300.2	11.1	11.5	10.4	11.0	119.0	114.8	124.8	119.5
S2 Vermicompost	299.5	309.4	321.7	310.2	11.3	11.8	10.7	11.3	126.0	121.5	132.1	126.5
S3: Green leaf Manure	313.3	323.7	336.5	324.5	11.8	12.3	11.1	11.7	112.0	108.0	117.4	112.5
SEm±	4.86	5.20	4.98	4.91	0.22	0.22	0.15	0.18	3.57	5.23	4.05	4.27
CD @ 5%	14.53	15.56	14.88	14.67	0.65	0.67	0.44	0.55	10.66	15.65	12.12	12.77
Factor B: Level of N suppl.												
L1 : 25% organic and 75% Inorganic	285.7	295.2	306.9	295.9	12.9	13.4	12.2	12.8	150.0	144.7	157.3	150.7
L2: 50% organic and 50% inorganic	301.1	311.2	323.5	311.9	12.3	12.8	11.6	12.2	140.0	135.0	146.8	140.6
L3 75% organic and 25% inorganic	303.6	313.7	326.2	314.5	12.1	12.6	11.4	12.0	133.0	128.3	139.5	133.6
L4: 100% organic	311.9	322.3	335.0	323.1	11.9	12.4	11.2	11.8	126.0	121.5	132.1	126.5
SEm±	3.51	4.54	3.68	4.21	0.12	0.11	0.12	0.11	4.12	4.50	5.74	4.87
CD @ 5%	10.50	13.58	11.00	12.60	0.35	0.33	0.36	0.34	12.33	13.46	17.15	14.56
Interaction												
S1L1: 25% N FYM + 75% N (Urea)	287.7	297.3	309.1	298.1	12.0	12.5	11.3	11.9	134.5	129.7	141.0	135.1
S1L2: 50% N FYM + 50 % N (Urea)	295.5	305.3	317.4	306.1	11.7	12.2	11.0	11.6	129.5	124.9	135.8	130.1
S1L3: 75% N FYM + 25% N (Urea)	296.7	306.6	318.7	307.3	11.6	12.1	10.9	11.5	126.0	121.5	132.1	126.5
S1L4 100% N FYM	300.8	310.9	323.2	311.6	11.5	11.9	10.8	11.4	122.5	118.1	128.5	123.0
S2L125 % vermicompost + 75% N (Urea)	326.2	313.7	303.6	314.5	13.3	13.8	12.5	13.2	147.0	141.8	154.1	147.6
S2L2 50%N vermicompost + 50% N (Urea)	305.4	293.8	284.3	294.5	12.7	13.2	11.9	12.6	154.0	148.5	161.5	154.7
S2L3 75% N vermicompost + 25% N (Urea)	311.3	299.5	289.8	300.2	12.2	12.7	11.5	12.1	137.2	132.3	143.9	137.8
S2L4 100% vermicompost (50 kg)	320.2	308.0	298.1	308.8	11.7	12.2	11.0	11.6	133.0	128.3	139.5	133.6
S3L1 25% N leaf manure + 75% N (Urea)	332.1	319.4	309.1	320.2	10.9	11.4	10.3	10.9	133.0	128.3	139.5	133.6
S3L2 50% N Leaf manure + 50% N (urea)	311.3	299.5	289.8	300.2	11.3	11.8	10.7	11.3	137.2	132.3	143.9	137.8
S3L3 75% N Leaf manure+ 25% N (Urea)	320.2	308.0	298.1	308.8	12.1	12.5	11.4	12.0	126.0	121.5	132.1	126.5
S3L4 100% N leaf manure	296.5	285.2	276.0	285.9	12.7	13.2	11.9	12.6	121.8	117.5	127.7	122.3
Control	296.5	262.4	253.9	270.9	11.7	12.2	11.0	11.6	119.0	114.8	124.8	119.5
SEm±	6.27	6.54	5.98	6.25	0.28	0.32	0.31	0.30	5.64	6.21	5.38	5.92
CD5%	18.76	19.56	17.88	18.68	0.85	0.97	0.94	0.89	16.85	18.56	16.10	17.70

Initial: Soil available N – 296.5 kg/ha , Soil available P- 12.3 kg/ha and Soil available K – 140.0 kg/ha

CONCLUSION

The research aimed at integrating various organic and inorganic sources of nutrients in cashew crop. In the present scenario, organic inputs and practices are becoming costly and challenging. Hence, the present study was conducted to integrate the two different sources. The growth and yield attributes were maximum when 100 % N equivalent was supplied through vermicompost followed by 75% N through vermicompost + 25% N through Urea. Since the cashew is perennial in nature, the application of organic manures helps to improve the physical, chemical and biological properties of the soil thereby better utilization of nutrients supplied through vermicompost would result in getting better yield. Nitrogen availability in the soil due to different interactions increased over a period of study. However, the available phosphorous was found to decline due to various sources and levels of nitrogen. The green leaf manure was superior among the three sources studied. The more availability of potash was found with vermicompost as compared to FYM and green manure. Even along with urea, the vermicompost was found to be better in making potash more available. Further, Pest and disease response and also postharvest quality parameters of the fruits in response to the integrated nutrient management efforts has to be correlated and studied in future.

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Conflict of Interest. Nil.

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