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Performance of Tropical sugar beet (*Beta vulgaris* L.) as influenced by sources of nitrogen and liquid manures in Deccan plateau of peninsular India

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ABSTRACT
Field trial was conducted during two consecutive kharif seasons of 2010 and 2011 to evaluate the influence of sources of nitrogen (SN_1, SN_2, SN_3, SN_4 and SN_5) and liquid manures (LM_1, LM_2, LM_3, LM_4 and LM_5) on growth, yield and quality of sugar beet (Beta vulgaris L.)at Agricultural Research Station (ARS), Madhurakhandi, University of Agricultural Sciences, Dharwad, Karnataka. The experiment was laid out in split plot design with three replications where in sources of nitrogen and liquid manures were assigned to main and subplot, respectively. Results of the study revealed that among the sources of nitrogen, application of 100 % RDN through inorganic fertilizer (IF) (SN_1) recorded significantly higher tuber (77.16 t/ ha) and sugar yield (8.50 t/ ha) than other sources of nitrogen. All the liquid manure treatments did not differ significantly, but differed significantly with that of control (no spray). Interaction results clearly revealed that application of 100 % RDN (120 kg/ ha) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN_1LM_4) was found optimum for getting higher sugar beet tuber yield (80.13 t/ ha), sugar yield (9.28 t/ ha), net returns (Rs. 64528/ ha) and B:C ratio (2.49). However, application of 75 % RDN through IF + 25 % RDN through vermicompost and poultry manure in equal proportions along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN_2LM_4) remained on par with SN_1LM_4.
***Keywords**: Growth, Liquid manure, Nitrogen, Poultry manure, Sugar beet, Quality, Vermicompost, Yield*

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INTRODUCTION

Sugarbeet (*Beta vulgaris* L.) belongs to the family Chenopodiaceae, is considered as the second important sugar crop all over the world after sugar cane *(Sacchurum officinarum* L.). It is grown in 57 countries. Top fifteen sugarbeet producing countries are Russian Federation, Ukraine, United States of America, Germany, France, Turkey, China, Poland, Egypt, United Kingdom, Iran (Islamic Republic of), Belarus, Netherlands, Italy and Belgium. Sugarbeet is mainly produced in Europe and, to a lesser extent, in Asia and North America [10]. It contributes about 21.8 % of world sugar [1]. It is a biennial halophytic as well as Na- salts scavenger C3 plant containing up to 20 % sugar on fresh weight basis. The storage organ of this plant is usually called the root, of which 90% is actually root derived and the remaining 10% (the crown) is derived from the hypocotyls [16].Composition wise, a freshly harvested sugarbeet root contains 75-76% water, 15-20 % sugars, 2.6% non-sugars and 4-6 % the pulp. Processing one ton of fresh sugarbeet roots yields 121 kg sugar, 38 kg molasses (containing 18.2 kg sugar, 12.1 kg impurities and 7.8 kg water) and 50 kg of pulp. Now, tropical sugar beet hybrids have also been developed by Syngenta India Ltd., Pune and are gaining momentum to grow in tropical and sub tropical regions including Karnataka, Tamil Nadu and Maharashtra as a promising alternative energy crop for the production of sugar as well as ethanol. The crop can be cultivated even in land which has gone wastes due to high salinity and the water requirement of sugar beet is one third of sugarcane crop. Further, as the harvesting period coincide with March to June; the human resources of sugar factory in the off season could be efficiently utilized for processing of sugar beet by the sugar mills, which facilitates in continuous functioning of the sugar mills. Sugar beet is a highly input intensive crop and heavy feeder of all the major plant nutrients particularly the nitrogen from the beginning of the crop growth. Nitrogen fertilizer has a pronounced effect on the growth, physiological and chemical characteristics of the crop. However, sucrose yield decreases by over-fertilizing sugar beet with higher N than needed for maximum sucrose production [8]. Further, fertilization with higher amount of inorganic sources of nitrogen may result in increased cost. So, integrated nitrogen management by using biodegraded wastes (vermicompost, poultry manure, liquid manures *etc.*) along with chemical nitrogen is need of the day in sustaining crop productivity besides improving sugar yield and to make use of farm wastes. The information on integrated nitrogen management through combination of organic and inorganic for sustainable sugar beet production is meagre. Keeping these points in to consideration field experiments was conducted to study the response of sugar beet to sources of nitrogen and liquid manures.

MATERIAL AND METHODS

A field experiment was conducted at Agricultural research station, Madhurakhandi (Northern dry zone of Karnataka) during the *kharif*-2010 and 2011. The experimental location is situated at 16^0 20'N latitude, 75^0 20'E longitude and at an altitude of 715 meters above mean sea level. The soil of the experimental plot was black clay loam having pH and electrical conductivity of 8.27 and 0.15 ds m^{-1}, respectively. The soil was low in available nitrogen (252 kg/ ha), medium in available phosphorus (36.8 kg/ ha) and high in available potassium (353 kg /ha).The distribution of rainfall was normal during the crop season (512.8 mm during 2010 and 301.9 mm during 2011). Other meteorological parameters such as temperature (minimum and maximum), relative humidity did not deviate much from the normal to influence the crop performance to a great extent in both the years. The experiment consisted of five sources of nitrogen as a main plot *i.e.* 100 % RDN through inorganic fertilizer (SN_1), 75 % RDN through inorganic fertilizer + 25% RDN through vermicompost and poultry manure in equal proportions (SN_2), 50 % RDN through inorganic fertilizer + 50 % RDN through vermicompost and poultry manure in equal proportions (SN_3), 25 % RDN through inorganic fertilizer + 75 % RDN through vermicompost and poultry manure in equal proportions (SN_4) and 100 % RDN through vermicompost (33%), poultry manure (33%) and green manuring (33%) (SN_5). The subplot treatments consisted of five liquid manures i.e. soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS (LM_1), foliar spray of vermiwash (20 %) at 30 and 60 DAS (LM_2), foliar spray of cow urine (10 %) at 30 and 60 DAS (LM_3), foliar spray of vermiwash (20 %) and cow urine (10 %) at 30 and 60 DAS (LM_4) and control (no spray) (LM_5). The treatments were laid out in split plot design with three replications.

The land was brought to fine tilth by initial ploughing once with tractor drawn plough and twice with cultivator. Later field was harrowed twice with bullock pairs, stubbles and weeds were removed from the field. At the time of sowing, the land was prepared in to ridges and furrows at 50 cm distance and the plots were laid out as per the plan of layout of the experiment. Healthy seeds of sugar beet genotype 'Calixta' obtained from JK Seeds Company were dibbled on the top of the ridges at 2 to 2.5 cm depth with one seed per hole adopting a spacing of 20 cm within the row. A seed rate of 3.6 Kg/ ha was adopted. Irrigation was given immediately after sowing of sugar beet and the subsequent irrigations were given by surface flow of water as and when the crop required till to the crop maturity period.

A common dose of FYM of 10 t/ ha and recommended dose of phosphorous (60 kg P_2O_5 /ha) through diammonium phosphate and potassium (90 kg K_2O/ ha) through muriate of potash were applied uniformly to all the plots. Recommended dose of nitrogen 120 kg/ ha was applied in the form of urea in split application (50 % N as basal, remaining 50 % N as top dress at 45 DAS). Organic manures *viz.,* vermicompost, poultry manure, green manuring and liquid manures (Jeevamrutha, vermiwash and cow urine) were applied as per the treatment schedule to the respective plots. The germination, emergence, growth and development of sugar beet were satisfactory which ensured better crop growth and yield. Need based plant protection measures were given against pests and diseases. Matured sugar beet tubers were harvested and topped manually. At the time of harvest, pre harvest irrigation was given for easy harvest.

All the biometric observations were recorded at different stages of crop growth. The soil samples were analyzed for available N, P_2O_5 and K_2O contents before and after the experimentation by using alkaline permanganate method, Olsen's method and flame photometer method, respectively. The quality parameters were determined as per the method of Meade and Chen. The data relating to each character were analysed as per the procedure of analysis of variance as suggested by Panse and Sukhatme. Means were compared by Duncan Multiple Range Test (DMRT). Economics of different treatments was worked out on the basis of input and output on the prevailing market prices and B:C ratio was calculated.

RESULTS AND DISCUSSION

Effect of sources of nitrogen on yield of sugar beet

Two years pooled data analysis revealed that sources of nitrogen significantly influenced the tuber yield of sugar beet (Table 2). Application of 100 % RDN through inorganic fertilizer (SN_1) recorded significantly higher tuber yield (77.16 t/ ha) compared to other sources of nitrogen. However, treatments which received 75 % RDN through IF + 25 % RDN through vermicompost (VC) and poultry manure (PM) in equal proportion (SN_2) and 50 % RDN through IF + 50 % RDN through VC and PM in equal proportion (SN_3) were on par with SN_1. Significantly lower tuber yield was recorded in SN_5 (application of 100 % RDN through VC (33%), PM (33%) and GM (33%) in equal proportion) (70.27 t /ha). The similar trend was noticed in green foliage yield.

The economic yield is a function of dry matter production, efficiency to translocate photosynthates from assimilatory area of the source (leaf) and accumulate in different plant parts and ultimately on yield attributing traits. Significantly higher tuber yield in SN_1 and SN_2 was mainly attributed to significantly superior yield attributes *viz*., tuber weight (1153.82 and 1096.66 g/ plant, respectively), tuber length (38.01 and 36.18 cm,respectively) and tuber girth (27.11 and 26.75 cm,respectively) (Table 2).Higher yield attributing characters in SN_1 and SN_2 were inturn due to higher total dry matter production (219.14 and 214.47 g/ plant, respectively) (Table 1).Further, higher total dry matter production in SN_1 and SN_2 was mainly due to higher growth parameters such as plant height (58.17 and 56.73 cm, respectively), leaf area index (7.87 and 7.43, respectively) and leaf area duration (285.55 and 265.54 days, respectively) (Table 1).

The higher tuber yield with SN_1 and SN_2 might be attributed to higher and readily available nitrogen for longer period since major quantity of nitrogen was in inorganic form which promoted growth of sugar beet and hence resulted in increased tuber yield. Wojcik [19] reported that tuber yield of 63.1 t/ha was recorded with application of 140 kg N/hausing urea as nitrogen source. Similarly, Balakrishnan and Selvakumar [2] reported that application of 100 % RDF + bio fertilizers along with FYM recorded significantly higher tuber length, tuber girth and tuber yield. Similar results were also reported by Shewate *et al*. [15] and Praveen Kumar [13].

Significantly higher sugar yield was observed in SN_1 (8.50 t/ ha) and SN_2 (7.94 t/ ha) when compared to other treatments. The lowest sugar yield was observed in SN_5 (6.50 t/ ha). Sugar yield is a function of tuber yield and quality characters. In other words, the improvement in sugar yield of SN_1 and SN_2 was due to higher tuber yield (77.16 and 75.58 t/ ha, respectively) and quality characters *viz*., brix (22.33 and 22.06 %, respectively), sucrose (17.11 and 16.56 %, respectively) and commercial beet sugar (CBS) (10.96 and 10.48 %, respectively) (Table 3). Findings are in line with observations of EL-Moursy*et al*. [6], Praveen Kumar [13] and Kale [9].

Effect of liquid manures on yield of sugar beet

Pooled analysis for two years revealed that the tuber yield of sugar beet was significantly influenced by liquid manures (LM) (Table 2). All the liquid manures (LM_1 to LM_4) recorded significantly higher tuber yield (74.15 to 75.68 t/ha) compared to control (LM_5) (68.45 t/ha). Similar trend was noticed with green foliage yield.

The higher tuber yield of sugar beet in these treatments (LM_1 to LM_4) was due to higher yield parameters namely tuber length (35.41 to 36.56 cm), tuber girth (26.56 to 26.96 cm) and single tuber weight (1047.57 to 1105.75 g) (Table 2). Higher yield attributing characters were in turn due to higher total dry matter production (210.87 to 215.20 g /plant) which in turn is the function of plant height (55.94 to 57.15 cm), leaf area index (7.01 to 7.30) and leaf area duration (246.85 to 260.06 days). Significantly lower yield and growth attributing characters were recorded under treatment LM_5 (Table 1 and 2). The higher tuber yield in these treatments (LM_1 to LM_4) was mainly due to beneficial effect of liquid manures which act as growth regulator and enhanced the availability of nutrients to crop. The beneficial effect of liquid organic manures was mainly attributed to the presence of large quantities of IAA and GA which are physiologically active in photosynthesis and other processes [18]. Similarly, Nekar *et al*. [12] observed that application of panchagavya and cow urine recorded significantly superior pod yield of ground nut compared to control.

All the liquid manure treatments (LM_1 to LM_4) recorded significantly higher sugar yield (7.58 to 7.99 t/ha) as compared to control (no spray) treatment (6.12 t/ha) (Table 3). The improvement in sugar yield of liquid manures (LM_1 to LM_4) was due to higher tuber yield (74.15 to 75.68 t/ha) and quality characters *viz*., brix (21.84 to 22.15 %), sucrose (16.21 to 16.64 %) and commercial beet sugar (CBS) (10.19 to 10.54

%) (Table 3). Beaulah [3] reported that, the quality parameters *viz.,* crude fibres, protein, ascorbic acid, carotene content and shelf life were higher under organic manure applied with panchagavya spray in rice.

Interaction

The tuber yield of sugar beet differed significantly due to interaction of sources of nitrogen and liquid manures (Table 2). Among the treatment combinations, application of 100 % RDN (120 kg ha^{-1}) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN_1LM_4) recorded significantly higher tuber yield (80.13 t/ ha). However, rest of the treatments were found on par with SN_1LM_4 except SN_3LM_5 and SN_4LM_5. Significantly lower tuber yield was recorded with application of 100 % RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN_5LM_5) (67.16 t/ha).

Tuber yield is the manifestation of yield attributing characters. The higher tuber yield in SN_1LM_4 was due to higher yield parameters namely tuber weight (1251.39 g /plant), tuber length (40.25 cm) and tuber girth (27.90 cm) (Table 2).The differences in various yield components in SN_1LM_4 which led to significant yield differences could be traced back to significant variations in dry matter production (226.46 g/ plant).The higher TDMP in SN_1LM_4 could also be related to higher photosynthatically active assimilatory surface area. Photosynthetic capacity of a plant depends upon plant height (60.44 cm), leaf area index (8.22)at peak stage of crop growth (120 DAS) and leaf area duration (302.56 days) between 120 DAS to harvest (Table 1).

Application of inorganic fertilizer along with organic manure and liquid manures might have resulted in better availability of nutrients mainly nitrogen. Higher quantity and readily available nitrogen throughout the crop growth since major quantity of nitrogen was in inorganic form which promoted growth and development of sugar beet. Further, beneficial effect of liquid manures (vermiwash and cow urine) which act as growth regulator and enhanced the availability of nutrients to crop. The beneficial effect of organic manures was mainly attributed to the presence of large quantities of IAA and GA which are physiologically active in photosynthesis and other processes which promoted growth of sugar beet and hence resulted in increased tuber yield. The results corroborate the findings of Sanwal *et al*. [14] and Yadahalli [20].

With respect to quality, application of 100 % RDN (120 kg/ha) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN_1LM_4) recorded significantly higher sugar yield(9.28 t/ha). Significantly lower sugar yield was recorded in SN_5LM_5 (5.85 t/ ha) (Table 3). Significantly higher sugar yield of SN_1LM_4 was due to higher tuber yield (80.13 t/ ha) and quality characters *viz*., brix (22.86 %), sucrose (17.87 %) and commercial beet sugar (CBS) (11.59 %) (Table 3). Similar results were reported by Borowczak [4]and Gasiorowska [7].

Economics

Pooled analysis of the gross returns, net returns and benefit cost (B: C) ratio were influenced by sources of nitrogen and liquid manures (Table 4). Among the sources of nitrogen, application of 100 % RDN through IF (SN_1) and application of 75 % RDN through IF + 25 % RDN through VC and PM in equal proportions (SN_2) recorded significantly higher gross (Rs. 103825 and 101707/ ha, respectively) and net (Rs. 60795 and 55007/ha, respectively) returns compared to other sources of nitrogen. SN_1 recorded significantly higher B:C (2.41) followed by SN_2 (2.17) compared to SN_5 (1.79). All the liquid manures (LM_1 to LM_4) recorded significantly higher gross returns (Rs. 99780 to 101831/ ha), net returns (Rs. 50703 to 52154/ ha) and B:C (2.05 to 2.07) compared to control (LM_5) (Rs.92115, 43112/ ha^{-1} and 1.89, respectively).

Among the interactions, application of 100 % RDN (120 kg ha^{-1}) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN_1LM_4) recorded significantly higher gross and net returns (Rs. 107831 and 64528 /ha, respectively). The B:C followed the trend observed in net returns. Significantly higher B:C was observed in all the treatment combinations involving SN_1 and SN_2 with different levels of liquid manures except SN_2LM_5. The variations in net returns and B:C could be attributed to the variations in gross returns and cost of cultivation. Singh *et al*. [17] recorded maximum net returns and B:C in onion with the application of nitrogen @ 120 kg/ ha along with 10 t/ ha of FYM. Similar results were also reported by Praveen Kumar [13] and Channagoudra [5].

The study revealed that, application of 100 % RDN (120 kg/ ha) through inorganic fertilizer (IF) along with foliar spray of vermiwash (VW) (20 %) and cow urine (CU) (10 %) at 30 and 60 DAS (SN_1LM_4) found optimum for getting higher sugar beet tuber yield, sugar yield and economic returns for northern dry zone of Karnataka. However, application of 75 RDN through IF + 25 RDN through vermicompost and poultry manure in equal proportions along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN_2LM_4) remained on par with SN_1LM_4.

Table 1: Effect of sources of nitrogen and liquid manures on growth parameters of sugar beet (Pooled data of two years- 2010 and 2011)

Treatment	Growth parameters			
	At 120 DAS		120DAS to harvest	At harvest
	Plant height (cm)	LAI	LAD (days)	TDMP (g /plant)
Sources of nitrogen (SN)				
SN_1	58.17a	7.87a	285.55a	219.14a
SN_2	56.73ab	7.43ab	265.54b	214.47ab
SN_3	55.45a-c	7.02bc	246.35c	209.98bc
SN_4	54.32bc	6.62cd	228.14d	204.90cd
SN_5	52.33c	6.26d	211.71e	199.80d
S.Em±	0.75	0.09	4.15	1.61
Liquid manures (LM)				
LM_1	56.68a	7.20a	255.53ab	213.61ab
LM_2	56.31a	7.11a	251.13ab	212.38ab
LM_3	55.94a	7.01a	246.85b	210.87b
LM_4	57.15a	7.30a	260.06a	215.20a
LM_5	50.92b	6.58b	223.73c	196.23c
S.Em±	0.79	0.07	3.24	1.02
Interactions (SN x LM)				
SN_1LM_1	59.73ab	8.08ab	296.76ab	224.80ab
SN_1LM_2	59.24a-c	7.98ab	291.69a-c	223.80a-c
SN_1LM_3	58.98a-d	7.87a-c	286.64a-d	222.22ad
SN_1LM_4	60.44a	8.22a	302.56a	226.46a
SN_1LM_5	52.46e-i	7.18d-i	250.08g-k	198.39m-p
SN_2LM_1	58.09a-e	7.63a-e	275.34b-f	219.48a-e
SN_2LM_2	57.74a-f	7.53a-g	270.59c-g	218.36a-f
SN_2LM_3	57.35a-g	7.43b-g	266.17d-h	217.09b-g
SN_2LM_4	58.51a-e	7.70a-d	279.22b-e	220.38a-e
SN_2LM_5	51.98f-i	6.88g-l	236.37i-h	197.05n-p
SN_3LM_1	56.62a-h	7.18d-i	254.45f-j	214.26d-i
SN_3LM_2	56.22a-h	7.09d-j	249.66g-k	213.00e-j
SN_3LM_3	55.89a-h	6.97e-k	244.67h-l	210.80f-k
SN_3LM_4	57.01a-h	7.28c-h	259.26e-i	215.68c-h
SN_3LM_5	51.49f-i	6.59i-m	223.69l-o	196.13op
SN_4LM_1	55.27a-h	6.74g-l	234.24j-n	208.12h-l
SN_4LM_2	54.92a-h	6.67h-l	230.60j-o	206.34i-m
SN_4LM_3	54.59a-h	6.59h-l	227.33k-o	205.20j-n
SN_4LM_4	55.70a-h	6.82f-l	238.23i-m	209.76g-k
SN_4LM_5	51.14hi	6.27lm	210.33op	195.06p
SN_5LM_1	53.68b-h	6.36k-m	216.85m-p	201.37l-p
SN_5LM_2	53.42c-h	6.28lm	213.09n-p	200.39l-p
SN_5LM_3	52.92d-i	6.21lm	209.42op	199.01m-p
SN_5LM_4	54.09b-h	6.47j-m	221.04l-p	203.72k-o
SN_5LM_5	47.55i	6.00m	198.18p	194.50p
S.Em±	1.77	0.16	7.25	2.28

Table 2: Effect of sources of nitrogen and liquid manures on yield parameters and yield of sugar beet (Pooled data of two years-2010 and 2011)

Treatment	Yield parameters at harvest			Green foliage yield (t/ ha)	Tuber yield (t/ha)
	Tuber weight (g/ plant)	Tuber length (cm)	Tuber girth (cm)		
Sources of nitrogen (SN)					
SN_1	1153.82a	38.01a	27.11a	8.10a	77.16a
SN_2	1096.66ab	36.18ab	26.75a	7.83ab	75.58ab
SN_3	1023.13bc	34.90bc	26.49a	7.61a-c	73.50a-c
SN_4	958.29cd	33.79bc	25.65ab	7.37bc	71.50bc
SN_5	899.51d	32.62c	24.60b	7.17c	70.27c
S.Em±	24.11	0.79	0.50	0.11	1.28
Liquid manures (LM)					
LM_1	1084.74ab	36.10a	26.84a	7.83a	75.12a
LM_2	1064.34ab	35.66a	26.72a	7.77a	74.60a
LM_3	1047.57b	35.41a	26.56a	7.67a	74.15a
LM_4	1105.75a	36.56a	26.96a	7.92a	75.68a
LM_5	829.01c	31.76b	23.53b	6.87b	68.45b
S.Em±	18.36	0.63	0.61	0.10	1.38
Interactions (SN x LM)					
SN_1LM_1	1232.20ab	39.46ab	27.64a	8.39a	79.21ab
SN_1LM_2	1206.95a-c	39.04a-c	27.51ab	8.33ab	78.38a-c
SN_1LM_3	1198.87a-c	38.34a-d	27.34ab	8.25a-c	78.16a-c
SN_1LM_4	1251.39a	40.25a	27.90a	8.46a	80.13a
SN_1LM_5	879.71m-p	32.98e-i	25.15ab	7.06i-m	69.91a-d
SN_2LM_1	1167.56a-e	37.36a-e	27.24ab	8.11a-e	77.25a-d
SN_2LM_2	1144.33a-f	37.03a-f	27.18ab	8.04a-f	77.20a-d
SN_2LM_3	1123.12a-g	36.46a-g	27.11ab	7.87a-h	76.87a-d
SN_2LM_4	1186.75a-d	37.82a-e	27.31ab	8.18a-d	77.59a-d
SN_2LM_5	861.53n-p	32.22f-i	24.92ab	6.94g-j	69.01b-d
SN_3LM_1	1079.69c-i	35.94a-h	26.93ab	7.80a-h	75.30a-d
SN_3LM_2	1062.52d-j	35.52a-i	26.84ab	7.74a-i	74.37a-d
SN_3LM_3	1043.33e-k	35.20b-i	26.69ab	7.65a-i	73.50a-d
SN_3LM_4	1108.98b-h	36.20a-g	27.02ab	7.98a-g	75.99a-d
SN_3LM_5	821.13op	31.62g-i	24.95ab	6.86h-j	68.34cd
SN_4LM_1	1007.98g-m	34.65b-i	26.43ab	7.54a-j	72.55a-d
SN_4LM_2	982.73h-n	34.27c-i	26.28ab	7.49a-i	72.20a-d
SN_4LM_3	973.64h-n	33.83d-i	26.15ab	7.44a-i	71.87a-d
SN_4LM_4	1021.11f-l	35.05b-i	26.53ab	7.58a-j	73.02a-d
SN_4LM_5	805.98op	31.17hi	22.87ab	6.79ij	67.85cd
SN_5LM_1	936.27j-o	33.11e-i	25.94ab	7.32c-i	71.31a-d
SN_5LM_2	925.16k-o	32.46f-i	25.81ab	7.27d-j	70.85a-d
SN_5LM_3	898.90l-p	33.20e-i	25.50ab	7.15d-i	70.36a-d
SN_5LM_4	960.51i-n	33.50e-i	26.01ab	7.39b-j	71.65a-d
SN_5LM_5	776.69p	30.82i	19.76c	6.71j	67.16d
S.Em±	41.06	1.42	1.35	0.22	3.08

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring , VW: vermiwash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN_1-100% RDN (120 kg ha^{-1}) through IF

SN_2-75 % RDN through IF +25 % RDN through VC and PM in equal proportion

SN_3-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion

SN_4-25 % RDN through IF +75 % RDN through VC and PM in equal proportion

SN_5-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM_1- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS

LM_2- Foliar spray of VW (20 %) at 30 and 60 DAS

LM_3- Foliar spray of CU (10 %) at 30 and 60 DAS
LM_4- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS
LM_5- Control (no spray)

Table 3: Effect of sources of nitrogen and liquid manures on quality parameters of sugar beet (Pooled data of two years-2010 and 2011)

Treatment	Brix (%)	Sucrose (%)	Commercial beet sugar content (%)	Sugar yield (t/ ha)
Sources of nitrogen (SN)				
SN_1	22.33a	17.11a	10.96a	8.50a
SN_2	22.06ab	16.56ab	10.48ab	7.94ab
SN_3	21.72a-c	16.02bc	10.04bc	7.39bc
SN_4	21.29bc	15.53cd	9.66cd	6.92cd
SN_5	20.84c	15.01d	9.26d	6.50d
S.Em±	0.28	0.23	0.15	0.20
Liquid manures (LM)				
LM_1	22.06a	16.50ab	10.43ab	7.85a
LM_2	21.96a	16.36ab	10.30ab	7.71a
LM_3	21.84a	16.21b	10.19b	7.58a
LM_4	22.15a	16.64a	10.54a	7.99a
LM_5	20.22b	14.52c	8.94c	6.12b
S.Em±	0.10	0.08	0.09	0.15
Interactions (SN x LM)				
SN_1LM_1	22.77ab	17.77ab	11.51a	9.13ab
SN_1LM_2	22.70ab	17.59a-c	11.35ab	8.90a-c
SN_1LM_3	22.61a-c	17.40a-d	11.18a-c	8.74a-c
SN_1LM_4	22.86a	17.87a	11.59a	9.28a
SN_1LM_5	20.73l-n	14.92m-o	9.19k-n	6.44j-l
SN_2LM_1	22.49a-d	17.04c-e	10.85a-d	8.37a-e
SN_2LM_2	22.38a-e	16.98c-e	10.82a-e	8.34a-e
SN_2LM_3	22.30a-f	16.83d-f	10.69b-f	8.21a-f
SN_2LM_4	22.52a-d	17.18a-e	10.98a-d	8.53a-d
SN_2LM_5	20.59mn	14.77m-p	9.08l-n	6.27j-l
SN_3LM_1	22.13a-g	16.51e-h	10.41c-h	7.84c-h
SN_3LM_2	22.07a-h	16.30f-i	10.21d-i	7.59d-i
SN_3LM_3	21.94c-i	16.12g-i	10.07e-j	7.40e-j
SN_3LM_4	22.21a-f	16.70e-g	10.58b-g	8.05b-g
SN_3LM_5	20.23no	14.50n-p	8.91mn	6.08kl
SN_4LM_1	21.70e-j	15.94h-j	9.95f-k	7.22f-j
SN_4LM_2	21.57f-k	15.78i-k	9.83g-l	7.09g-k
SN_4LM_3	21.44g-l	15.64i-l	9.72h-l	7.00g-k
SN_4LM_4	21.82d-j	16.02h-j	10.00g-j	7.31e-j
SN_4LM_5	19.90o	14.29op	8.79mn	5.97kl
SN_5LM_1	21.22i-m	15.27k-m	9.41j-n	6.71i-l
SN_5LM_2	21.10j-m	15.15k-n	9.32j-n	6.60i-l
SN_5LM_3	20.91k-n	15.09l-n	9.31j-n	6.55i-l
SN_5LM_4	21.36h-l	15.43j-m	9.54i-m	6.80h-l
SN_5LM_5	19.64o	14.14p	8.71n	5.85l
S.Em±	0.22	0.21	0.21	0.34

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring , VW: vermiwash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN_1-100% RDN (120 kg ha^{-1}) through IF
SN_2-75 % RDN through IF +25 % RDN through VC and PM in equal proportion
SN_3-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion
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LM_5- Control (no spray)

Table 4: Effect of sources of nitrogen and liquid manures on economics of sugar beet (Pooled data of two years -2010 and 2011)

Treatment	Gross returns (Rs./ ha)	Net returns (Rs./ ha)	B:C
Sources of nitrogen (SN)			
SN_1	103825a	60795a	2.41a
SN_2	101707ab	55007ab	2.17b
SN_3	98904a-c	48480bc	1.96c
SN_4	96213bc	42109c	1.78d
SN_5	94553c	41785d	1.79d
S.Em±	1719	1719	0.04
Liquid manures (LM)			
LM_1	101090a	51424a	2.05a
LM_2	100385a	50783a	2.04a
LM_3	99780a	50703a	2.05a
LM_4	101831a	52154a	2.07a
LM_5	92115b	43112b	1.89b
S.Em±	1849	1849	0.04
Interactions (SN x LM)			
SN_1LM_1	106583ab	63293ab	2.46a
SN_1LM_2	105475a-c	62247a-c	2.44a
SN_1LM_3	105170a-c	62467a-c	2.46a
SN_1LM_4	107831a	64528a	2.49a
SN_1LM_5	94067a-d	51439a-f	2.20ab
SN_2LM_1	103950a-d	56990a-e	2.21ab
SN_2LM_2	103881a-d	56983a-e	2.21ab
SN_2LM_3	103437a-d	57065a-e	2.23ab
SN_2LM_4	104405a-d	57432a-d	2.22ab
SN_2LM_5	92862a-c	46564d-f	2.00bc
SN_3LM_1	101330a-d	50647a-f	2.00bc
SN_3LM_2	100069a-d	49448b-f	1.97bc
SN_3LM_3	98902a-d	48806c-f	1.97bc
SN_3LM_4	102257a-d	51560a-f	2.01bc
SN_3LM_5	91961cd	41940f	1.84c
SN_4LM_1	97630 a-d	43266ef	1.79c
SN_4LM_2	97160a-d	42858f	1.79c
SN_4LM_3	96715a-d	42939f	1.80c
SN_4LM_4	98254a-d	43877d-f	1.80c
SN_4LM_5	91306cd	37605f	1.70c
SN_5LM_1	95954 a-d	42927f	1.81c
SN_5LM_2	95343a-d	42378f	1.80c
SN_5LM_3	94678a-d	42238f	1.80c
SN_5LM_4	96410a-d	43370f	1.81c
SN_5LM_5	90378d	38013f	1.72c
S.Em±	4135	4740	0.08

Means followed by common letter do not differ significantly by DMRT @ p=0.05
Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring , VW: vermiwash and CU: cowurine and DAS: Days after sowing

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