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Growth and Yield of Sugarcane Seed Crop as Influenced by Fertilizer Rates and Timing in Anakapalle, Andhra Pradesh, India

P. Vinayalakshmi[1*], M. Martin Luther[2], M. Bharathalakshmi[3], Ch. Sujani Rao[4] and V. Srinivasa Rao[5]

[1]Department of Agronomy, Agricultural College, Bapatla, ANGRAU, Andhra Pradesh, India.
[2]Student Affairs, ANGRAU, Andhra Pradesh, India.
[3]Regional Agricultural Research Station, Anakapalle, ANGRAU, Andhra Pradesh, India.
[4]Department of Soil Science, RRU, RARS, ANGRAU, Lam, Guntur, Andhra Pradesh, India.
[5]Department of Statistics and Computer Applications, Agricultural College, Bapatla, ANGRAU, Andhra Pradesh, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted in sugarcane over 2019-20 and 2020-21 cropping seasons at the Regional Agricultural Research Station of Anakapalle (Andhra Pradesh) on sandy clay soils. The objective was to determine the effect of organic and mineral fertilizer rates and timing on growth and yield of a sugarcane seed crop. The experiment was laid out following split plot design with three main organic fertilizer treatments and six N-K fertilizer sub treatments, in three replications. Results showed a significant increase in stalk height, numbers of tillers ha^{-1} and cane yield due to organic fertilizer, namely biofertilizer and trash mulching, in combination with 125% STBNK applied at 30 days interval + additional dose of 25% recommended K fertilizer applied one month prior to harvest.

**Corresponding author: E-mail: vinaya.podapati126@gmail.com;*

Keywords: Organic fertilizer; N-K fertilizer; main effect; interaction effect; growth stage.

1. INTRODUCTION

Sugarcane plays prominent role as a commercial cash crop in the world economy and constitute huge economic influence particularly on rural India. India enjoys a pride place in sugarcane production but the average productivity is low as compared to other sugarcane growing countries. Nearly 10-12 % of cane grown is being utilized for seed purpose. In general, farmers use matured canes, cut into two or three budded setts, as seed material which results in reduced germination percentage and low crop stand establishment leads to less yields. In the establishment of satisfactory crop stand, attaining good germination or emergence is very important [1]. Well treated and nourished seed canes have been found to have good germination capacity and vigour of the subsequent crop. Therefore, quality seed production is the essential requisite of sugarcane farmer for elevating cane yield. Accordingly, seed cane plants should undergo special cultural treatments like fertilization, irrigation, crop protection measures *etc*. Apart from other farming practices, mineral nutrition has a prominent role in enhancing the cane yield. Insufficient or untimely application of nitrogen fertilizer to cane would result in poor growth, thin stems and short nodes [2]. The seed cane plants are fertilized in the same way as the commercial cane plants despite the difference in purpose of production. N and K are the major nutrients crucial for plant growth and development which contribute for increasing the sugarcane productivity. However, application of these nutrients in chemical forms are subjected to leaching and other losses which elicit low availability to plants. The addition of organic sources of nutrients can reduce nutrient losses and enhance fertilizer use efficiency. The Long-term experiments conducted on manures and fertilizers in sugarcane proved that neither chemical fertilizers alone nor the organic sources exclusively can achieve production sustainability of soil and crop productivity [3]. Thus, proper amalgamation of organic and biological sources of nutrients along with chemical fertilizers is a key to formulate sustainable production technology besides to apprehend maximum cane yield. Keeping this in view, a field experiment entitled this experiment was conducted to determine the effect of organic and mineral fertilizer rates and timing on growth and yield of a sugarcane seed crop.

2. MATERIALS AND METHODS

The experiment was carried out over 2019-20 and 2020-21 cropping seasons at the Regional Agricultural Research Station of Anakapalle in Andhra Pradesh, India. The soil conditions were sandy clay in texture, neutral in reaction and medium in organic carbon. The experiment was laid out following a split-plot design with three main organic fertilizer treatments and six N-K fertilizer sub treatments, in three replications. The organic fertilizer treatments consisted of a control and two – sources organic matter, namely a biofertilizer mixture (*Azospirillum*, Phospate Solubilizing Bacteria, Potassium Releasing Bacteria each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1}) and a trash mulching with bio decomposers. The N-K mineral fertilizer - involved different combinations of rates and timing of application at planting, and prior to harvest. These combinations were the following: 75% STBNK (Soil Test Based Nitrogen and Potassium) at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting (S_1), 75% STBNK at planting, 45, 90, 135 & 180 DAP(S_2), 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting (S_3), 100% STBNK at planting, 45, 90, 135 & 180 DAP (S_4), 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting (S_5), 125% STBNK at planting, 45, 90, 135 & 180 DAP (S_6). A high yielding commercial cane variety CoA 92081(87 A 298) was used. Growth and yield data of seed cane collected during crop cycle and at harvest, respectively, were subjected to standard statistical procedures.

3. RESULTS AND DISCUSSION

3.1 Germination %

Germination is found to be a critical phase in the life cycle of the plant as good germination denotes good start of the crop which bring about adequate plant stand at harvest. Data pertaining to germination % of cane setts as influenced by organic fertilizer sources as well as the timing and rates of N-K applications are presented in Table 1.

Results indicated that germination % was not significantly influenced either by organic fertilizer sources or dose and timing of N-K applications during each crop cycle as well as the aggregate data of both crop cycles.

Non-significant effect of various treatments on germination % of cane setts might be due to absence of absorbing and assimilatory organs of sett at germination stage. These results are in line of findings obtained by different investigators [4,5,6,7].

3.2 Plant Height (cm)

Plant height was significantly influenced by organic sources as well as time and dose of N and K application at all the growth stages *i.e*., 60, 120, 180 days after planting (DAP) and at harvest for each crop cycle as well as for aggregate data of both crop cycles (Table 2). Though, the plant height of different treatments was higher during the first year (2019-20) of study than that of second year (2020-21), the effect of various treatments was almost similar in both the years.

Plant height increased gradually with advancement in the age of the crop from 60 DAP to till harvest (Table 2).

At 60 DAP, significantly higher plant height (66.11, 58.16 and 62.13 cm during 2019-20, 2020-21 and in pooled data, respectively) was recorded with the application of biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1}) over control and was on a par with trash mulching with bio decomposers.

At 120 DAP, though the tallest plants were recorded with biofertilizer mixture application, it was statistically comparable with trash mulching with bio decomposers and both the treatments recorded significantly higher plant height over control. The differences in plant height of seed cane recorded at 180 DAP and at the time of harvest also followed the similar trend during both the years of the study and in pooled data as well.

At all the stages of crop growth, plant height increased with the addition of biofertilizers as well as trash mulching. It could be due to the fact that the application of biofertilizers and trash mulching improved the soil environment in respect of nutrients for crop growth at active growing stages as a result of elevated root proliferation, cell multiplication and elongation leading to increased plant height. The present findings are in line of the earlier findings obtained by several authors [8,9,10].

Among various sub plot treatments, the results pertaining to plant height, taller plants were recorded at different growth stages with application of 125% STBNK in five splits at planting, 30, 60, 90, 120 DAP + 25% additional dose of recommended K one month before harvesting (S_5) which was at par with 100% STBNK applied at planting, 30, 60, 90, 120 DAP + 25% additional dose of recommended K one month before harvesting (S_3) and both were found significantly superior to 75% STBNK applied at planting, 30, 60, 90, 120 DAP+ 25% additional dose of recommended K one month before harvesting (S_1). The lowest plant height was observed with 75% STBNK application at planting, 45, 90, 135 and 180 DAP during both the years of study and in pooled data too.

Increased dose of fertilizers might have provided adequate nutrition to plant leading to anatomical changes like increase in cell size, intercellular spaces, thinner cell walls and lower development of epidermal tissue resulting in increased number of nodes, more elongation of internodes or both which ultimately culminated in increased plant height. Similar findings were reported by different investigators [11,12,13].

3.3 Tiller Population at Different Growth Stages

Optimum plant population per unit area is crucial to get maximum yield. Tillering in seed cane found to be the most important parameter that contributes to number of plants per unit area.

Number of tillers per hectare recorded at 60, 120 DAP and shoot population at 180 DAP are presented in Table 3. indicated that the organic sources of nutrients significantly influenced the number of tillers ha^{-1} at 120 and shoot population at 180 DAP during both the years of study as well as in pooled data.

At 60 DAP, tiller number was not significantly affected by any of the main plot treatments. However, numerically maximum number of tillers was associated with the application of biofertilizers followed by trash mulching with bio decomposers.

At 120 DAP, higher number of tillers (132.25, 125.86 and 129.06 during 2019-20, 2020-21 and in pooled data, respectively) was recorded with the application of biofertilizer mixture *i.*e., *Azospirillum*, PSB, KRB each @ 500 ml acre^{-1} and VAM @ 12.5 kg ha^{-1} (M_2), which was at par with trash mulching with bio decomposers and both the treatments were found significantly superior over control.

Shoot population at 180 DAP during 2019-20, 2020-21 and in pooled data, were higher with biofertilizers + VAM application (108.93, 102.32 and 105.63 during 2019-20, 2020-21 and in pooled data, respectively) which was comparable with trash mulching and both were found significantly superior over control.

In general, application of biofertilizers showed noticeable increase in tiller number, probably due to plant regulating hormones secreted by *Azospirillum brasilense*. Ethylene is the foremost phytohormone regulating this physiological process in sugarcane [14]. Moreover, application of PSB has the ability to trigger the release of cytokinin's which will be essential for cell division in tiller buds. The present study results are in conformity with the findings of authors [10,15].

Data pertaining to number of tillers and shoot population were significantly affected by time and dose of nitrogen and potassium application at 120 and 180 DAP while such significant influence was not observed at 60 DAP. At all the stages of crop growth, number of tillers increased with increase in fertilizer dose from 75% to 125% STBNK.

At 60 DAP, tiller number did not differ significantly with any of the sub plot treatments. However, relatively higher number of tillers was noted with the application of 125% STBNK + additional dose of 25% recommended K (S_5) during both years of study and in pooled data.

At 120 DAP, application of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting recorded the highest number of tillers (135.46 ha^{-1}) during 2019-20 which may be due to early emergence and better photosynthetic efficiency with adequate nitrogen application. However, tiller population at 125 % STBNK at 30 days interval + 25% additional potassium was comparable with 125% STBNK applied at 45 days interval (S_6), 100% STBNK applied at 30 days interval + additional 25% RDK (S_3) and distinctly superior to 100% STBNK alone applied at 45 days interval (S_4), 75% STBNK applied at 30 days interval + additional 25% RDK (S_1) and 75% STBNK alone applied at 45 days interval (S_2) during the first year of study. The above indicated trend was invariably observed in shoot population `at 180 DAP during both the years of study and in pooled data as well.

In the second year of study and in pooled data, S_5 treatment exhibited maximum number of tillers (127.83 and 131.64) at 120 DAP which was significantly superior over rest of the treatments but maintained parity with S_6, S_3 and S_4. The lowest number of tillers was observed with S_2. More tiller number and shoot population were observed with increased rate of fertilizer due to continuous uptake of nutrients under higher level of fertilizers and implies increased rate of physiological process in plants owing to more tiller or shoot production in seed crop. The results are in agreement with the findings of different authors [7,12,16,17,18].

The interaction between organic sources and time and dose of nitrogen and potassium was found non-significant with respect to number of tillers or shoots in seed cane during all the growth stages.

3.4 Seed Cane Yield (t ha^{-1})

Seed cane yield was recorded at harvest *i.e*., at seven months age and the data are presented in Table 4. Different organic sources and time and dose of nitrogen and potassium application had a significant influence on seed cane yield. Further, the interaction between organic sources and time and levels of nitrogen and potassium application on seed cane yield was also found to be significant during both the years of study and in pooled data as well.

Application of organic and biofertilizers proved advantageous and increased the seed cane yield significantly. The higher cane yield of 81.50, 76.05 and 78.77 t ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively was recorded with the application of biofertilizer mixture *i.*e., *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} but maintained parity with trash mulching with bio decomposers. The lowest seed cane yield was noticed with control and found significantly inferior to rest of the treatments. Similar observations with regard to organic manures on cane yield were reported by [19,20,21,22,23].

Table 1. Germination % of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20	2020-21	Pooled data
Organic sources			
M_1- No Biofertilizers	65.16	55.04	60.10
M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}	66.55	57.31	61.93
M_3- Trash mulching with bio decomposer (A & B)	66.22	56.77	61.50
SEm±	1.37	1.30	1.64
CD (p = 0.05)	NS	NS	NS
CV (%)	8.82	9.77	11.38
Time and dose of N & K application			
S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	63.73	54.80	59.27
S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP	64.10	55.97	60.04
S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	67.35	56.11	61.73
S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP	65.91	56.38	61.15
S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	67.74	57.99	62.87
S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP	67.01	56.98	62.00
SEm±	1.85	1.41	1.46
CD (p = 0.05)	NS	NS	NS
CV (%)	8.40	7.48	7.17
Interaction	NS	NS	NS

NS- Non Significant

Table 2. Plant height (cm) at different growth stages of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20				2020-21				Pooled data			
	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest
Organic sources												
M_1	60.36	148.28	201.93	218.97	49.59	138.58	187.31	202.98	54.98	143.43	194.62	210.98
M_2	66.11	166.57	217.82	237.33	58.16	155.39	203.49	223.90	62.14	160.98	210.66	230.62
M_3	64.67	163.79	216.94	235.78	55.15	153.14	200.72	220.61	59.91	158.47	208.83	228.20
SEm±	1.13	3.66	3.38	3.81	1.47	3.46	3.28	4.23	1.28	3.57	3.33	4.05
CD (p = 0.05)	4.42	14.37	13.26	14.96	5.78	13.58	12.87	16.62	5.02	14.03	13.06	15.91
CV (%)	7.50	9.73	6.75	7.01	11.51	9.84	7.05	8.32	9.19	9.82	6.89	7.70
Time and dose of N & K application												
S_1	60.02	150.38	196.67	217.76	51.41	139.60	188.01	204.77	55.72	144.99	192.34	211.27
S_2	58.72	145.70	194.28	214.92	50.00	137.37	185.81	202.60	54.36	141.54	190.05	208.76
S_3	65.10	163.69	220.59	237.10	56.09	154.64	201.69	222.12	60.60	159.17	211.14	229.61
S_4	62.78	160.56	210.94	231.12	54.11	149.60	198.63	215.58	58.45	155.08	204.79	223.35
S_5	68.90	170.36	228.10	244.12	58.39	159.47	205.94	226.20	63.65	164.92	217.02	235.16
S_6	66.74	166.62	222.79	239.16	55.80	153.53	202.96	223.71	61.27	160.08	212.88	231.44
SEm±	1.46	4.43	4.73	5.37	1.58	4.14	4.10	4.63	1.49	4.46	3.87	4.87
CD (p = 0.05)	4.23	12.78	13.67	15.52	4.56	11.95	11.85	13.38	4.31	12.89	11.17	14.07
CV (%)	6.89	8.32	6.69	6.99	8.72	8.33	6.24	6.44	7.59	8.68	5.67	6.55
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: M_1- No Biofertilizers, M_2- Biofertilizer mixture (Azospirillum, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}, M_3- Trash mulching with bio decomposer (A & B), S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP, S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP, S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP

Table 3. Number of tillers ('000 ha^{-1}) at 60, 120 DAP and shoot population at 180 DAP in sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20			2020-21			Pooled data		
	60 DAP	120 DAP	180 DAP	60 DAP	120 DAP	180 DAP	60 DAP	120 DAP	180 DAP
Organic sources									
M_1	87.08	120.06	98.92	76.90	110.70	92.43	81.99	115.38	95.68
M_2	90.22	132.25	108.93	83.12	125.86	102.32	86.67	129.06	105.63
M_3	90.13	130.62	105.57	81.43	123.82	100.33	85.78	127.22	102.95
SEm±	2.05	2.48	1.56	1.80	3.11	1.90	1.80	2.78	1.77
CD (p = 0.05)	NS	9.73	6.13	NS	12.23	7.46	NS	10.90	6.94
CV (%)	9.76	8.24	6.34	9.47	11.00	8.20	9.02	9.51	7.39
Time and dose of N & K application									
S_1	86.78	121.46	101.66	79.08	113.44	93.67	82.93	117.45	97.67
S_2	87.38	120.18	99.79	79.04	110.36	91.50	83.21	115.27	95.64
S_3	89.81	131.10	107.87	81.28	124.14	101.64	85.55	127.62	104.75
S_4	89.32	125.39	103.01	80.32	120.59	96.88	84.82	122.99	99.94
S_5	91.01	135.46	108.67	81.61	127.83	104.22	86.31	131.65	106.44
S_6	90.56	132.29	105.85	81.55	124.41	102.26	86.06	128.35	104.06
SEm±	2.39	3.34	1.78	2.54	4.25	2.47	1.94	3.80	2.21
CD (p = 0.05)	NS	9.64	5.15	NS	12.27	7.13	NS	10.98	6.38
CV (%)	8.04	7.84	5.12	9.46	10.61	7.52	6.85	9.20	6.53
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: M_1- No Biofertilizers, M_2- Biofertilizer mixture (Azospirillum, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}, M_3- Trash mulching with bio decomposer (A & B), S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP, S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP, S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP

Table 4 Seed cane yield (t ha^{-1}) as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20	2020-21	Pooled data
Organic sources			
M_1- No Biofertilizers	73.07	69.03	71.05
M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}	81.49	76.02	78.76
M_3- Trash mulching with bio decomposer (A & B)	79.70	75.05	77.38
SEm±	1.364	1.065	0.954
CD (p = 0.05)	5.35	4.18	3.74
CV (%)	7.4	6.2	5.3
Time and dose of N & K application			
S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	72.99	67.51	70.25
S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP	69.93	65.11	67.52
S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	81.82	76.93	79.38
S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP	77.70	73.17	75.43
S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	83.98	79.40	81.69
S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP	82.10	78.08	80.09
SEm±	1.304	1.404	1.337
CD (p = 0.05)	3.77	4.05	3.86
CV (%)	5.0	5.7	5.33
Interaction	S	S	S

Table 4a. Interaction between organic sources, time and dose of nitrogen and potassium application on sugarcane seed crop yield (t ha^{-1}) as influenced by biological nutrient management during 2019-20

Biological nutrient management	Time and dose of N & K application						Mean
	S_1	S_2	S_3	S_4	S_5	S_6	
Control	63.63	60.10	80.23	72.23	81.83	80.37	73.07
Biofertilizer mixture	79.00	76.17	83.17	80.93	86.03	83.67	81.49
Trash mulching with bio decomposers	76.33	73.53	82.07	79.93	84.07	82.27	79.70
Mean	72.99	69.93	81.82	77.70	83.98	82.10	
	SEm±	**CD (p = 0.05)**	**CV (%)**				
Biological nutrient management (M)	1.364	5.35	7.4				
Time & dose of N&K application (S)	1.304	3.77	5.0				
Interaction							
M*S	2.259	6.52					
S*M	2.668	8.64					

Note: M_1- No Biofertilizers, M_2- Biofertilizer mixture (Azospirillum, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}, M_3- Trash mulching with bio decomposer (A & B), S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP, S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP, S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP

Table 4b. Interaction between organic sources, time and dose of nitrogen and potassium application on sugarcane seed crop yield (t ha^{-1}) as influenced by biological nutrient management during 2020-21

Biological nutrient management	Time and dose of N & K application						Mean
	S_1	S_2	S_3	S_4	S_5	S_6	
Control	58.30	55.13	75.50	70.33	78.30	76.63	69.03
Biofertilizer mixture	72.87	70.30	78.03	74.83	80.87	79.20	76.02
Trash mulching with bio decomposers	71.37	69.90	77.27	74.33	79.03	78.40	75.05
Mean	67.51	65.11	76.93	73.17	79.40	78.08	
	SEm±	**CD (p = 0.05)**	**CV (%)**				
Biological nutrient management (M)	1.065	4.18	6.2				
Time & dose of N&K application (S)	1.404	4.05	5.7				
Interaction							
M*S	2.432	7.02					
S*M	2.492	7.89					

Note: M_1- No Biofertilizers, M_2- Biofertilizer mixture (Azospirillum, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}, M_3- Trash mulching with bio decomposer (A & B), S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP, S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP, S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP.

Table 4c. Average cane yield data obtained in both cropping seasons on aggregate (plant cane)

Biological nutrient management	Time and dose of N & K application						Mean
	S_1	S_2	S_3	S_4	S_5	S_6	
Control	60.97	57.62	77.87	71.28	80.07	78.50	71.05
Biofertilizer mixture	75.93	73.23	80.60	77.88	83.45	81.43	78.76
Trash mulching with biodecomposers	73.85	71.72	79.67	77.13	81.55	80.33	77.38
Mean	70.25	67.52	79.38	75.43	81.69	80.09	
	SEm±	**CD (p = 0.05)**	**CV (%)**				
Biological nutrient management (M)	0.954	3.74	5.3				
Time & dose of N&K application (S)	1.337	3.86	5.3				
Interaction							
M*S	2.315	6.69					
S*M	2.322	7.32					

Note: M_1- No Biofertilizers, M_2- Biofertilizer mixture (Azospirillum, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}, M_3- Trash mulching with bio decomposer (A & B), S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP, S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP, S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP

Significant influence of biofertilizers and trash mulching was exhibited on growth and seed cane yield as biofertilizers are capable of synthesizing growth hormones and or regulators in addition to nitrogen fixation which in turn along with trash constitutes favourable effect on nutrient uptake and resulted in higher cane growth and yield [24].

The possible reasons for superior seed cane yield under biofertilizer applied treatment could be ascribed to the enhanced rooting and plant establishment; better uptake of low mobile ions such as P, improved nutrient cycling; improved plant tolerance to stress (biotic and abiotic) and amelioration of the quality of soil structure [25].

Application of nitrogen and potassium @ 125% STBNK in five splits at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting produced highest seed cane yield (83.96, 79.41 and 81.69 t ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) which was significantly superior to rest of the treatments except for the treatments 125% STBNK alone applied at 45 days interval and 100% STBNK applied at 30 days interval + additional dose of 25% recommended K one month before harvesting. The addition of 75% STBNK at planting, 45, 90, 135 and 180 DAP displayed distinctly lower yield and found comparable with 75% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting during both the years of study and in pooled data also. The decreased yield could be attributed to insufficient supply of required N and K to the plants. The present findings are in corroboration with various investigators [17,26,27,28].

The interaction between the organic sources and application of nitrogen and potassium at different doses and time was found significant during both the years of the study and in pooled data with reference to seed cane yield. The cane yield varied between 55.12 at 75% STBNK at planting, 45, 90, 135 and 180 DAP (M_1S_2) to 86.01 (M_2S_5) and significantly higher under application of biofertilizer mixture *i.*e., *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} along with the application of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting.

During first year of the study, application of 75% STBNK at planting, 45, 90, 135 and 180 DAP (S_2) was statistically comparable with S_1 under M_1, M_2 and M_3. The seed cane yield with S_5, S_6 and S_3 was statistically on par with each other irrespective of the organic sources. The application of biofertilizers along with chemical fertilizers enhanced the yield but appreciable increase was observed particularly at lower dose of inorganic fertilizers.

In S_1 and S_2 nutrient management treatments, M_2 and M_3 were statistically on par and both remained significantly superior over M_1. The M_1, M_2 and M_3 treatments were comparable with S_3, S_5 and S_6 treatments. Similar trend was observed during 2020-21 and in pooled data as well (Table 4a).

The application of 100% STBNK through chemical fertilizers and biofertilizers registered significantly higher seed cane yield possibly due to the contribution of biofertilizer, which increased the efficiency of applied fertilizer and soil microbial activity [29].

Treatments that included biofertilizer mixture and trash mulching as an option along with the application of higher dose of fertilizers (125 % STBNK) in different splits recorded higher cane yield. It is a well known fact that the addition of substantial quantities of fertilizers to soil are not amenable to plants and a considerable portion is lost through different mechanisms operating in the soil. Proper amalgamation of organic sources with chemical fertilizers at appropriate time increased the use efficiency of added inorganic nutrients through nutrient conservation, slow and steady release of nutrients and also improved nutrient availability, soil physico-chemical and biological properties which enacted better expression of yield attributes and in turn resulted in high seed cane yield. The results of present study are in accordance with various authors [15,22,30].

4. CONCLUSION

Based on the results of two years study, it is concluded that, combined application of biofertilizers or trash mulching with bio decomposers along with 125 % STBNK at 30 days interval in five splits + additional dose of 25% recommended potassium one month before harvesting can be recommended for realizing higher seed cane yield as it favoured good growth of the seed crop and resulted in higher cane yield from seed crop of sugarcane.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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