The Pharma Innovation Journal 2023; SP-12(8): 167-171

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(8): 167-171

www.thepharmajournal.com
Received: 19-05-2023
Accepted: 21-06-2023

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Biological nutrient management effects on drymatter production and economics of seedcane

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Abstract
A field experiment was carried out to assess the biological nutrient management in seedcane for two consecutive seasons during 2019-20 and 2020-21 on sandy clay soils of Regional Agricultural Research Station, Anakapalle. The experimental results showed that at all the growth stages higher dry matter production and economics were observed with application of biofertilizers + 125% STBNK applied at planting, 30, 60, 90 and 120 days after planting + additional 25% recommended potassium one month before harvesting which was comparable with trash mulching with bio decomposer + 125% STBNK applied at planting, 30, 60, 90 and 120 days after planting + additional 25% recommended potassium one month before harvesting.

Keywords: Biofertilizers, seedcane, soil test based nitrogen and potassium, trash mulching, drymatter production and economics

Introduction
Sugarcane is one of the world's oldest crop and grown commercially in tropics and subtropics. To boost cane productivity, sugarcane farmers must first produce quality seed. Despite their different intended uses for production, seedcane plants receive the same fertilisation as commercial cane plants. Due to a drop in factor productivity, it has been observed that sugarcane yield has plateaued in recent years. One of the main reasons for the fall in factor productivity is the loss of organic matter in the soil. It's crucial to add organic manures and inorganic fertilisers at the right time and in the right mix in order to replenish these nutrients. Sugarcane, being a C_4 plant, produces large quantity of biomass which can be effectively used to build up the organic matter status of the soil (Tayade *et al.*, 2016) [14]. The cane productivity of soils can be sustained by a balanced application of nutrients through an integrated use of organic and chemical fertilisers [Gopalasundaram *et al.*, 2012] [5]. Dry matter production at various growth stages is a primary factor influencing the yield and yield components of any crop. Therefore, it is necessary to suggest balanced dose and time of N & K application along with biofertilizers and trash mulching for improving the drymatter production which inturn increases yield and economics of seedcane crop. Thus, the present investigation was aimed out to assess the influence of integration of organic and inorganic fertilizers on drymatter production and economics of seedcane.

Materials and Methods
Experiment was carried out at the RARS, Anakapalle, Andhra Pradesh over 2019-20 and 2020-21 seasons and laid out in split-plot design having three replications with M_1, M_2 and M_3 as main treatments and S_1, S_2, S_3, S_4, S_5, S_6 as sub plot treatments. The recommended dose of NPK for seedcane is 112-100-120 kg ha^{-1}. At 60, 120, 180 DAP and at harvest samples of whole seedcane plants were obtained at random, cut into pieces and the fresh weight was taken then oven dried, powdered and dry weight was determined. The split plot design's standard analysis of variance approach was used to analyse the data given by Rangaswamy (2013) [11]. The most popular and high yielding variety CoA 92081 (87 A 298) was used as test variety for the study.

Results and Discussion
1. Dry matter Production
Data displayed in table 1 indicated that M_2 exhibited remarkable performance in increasing

drymatter production at 120 DAP and was comparable with M_3. At 180 DAP and at harvest unaltered trend of treatmental performance continued with regard to drymatter accumulation as noticed at 120 DAP during 2019-20 and 2021 and also in pooled data.

The per cent increase in drymatter at harvest with biofertilizer, trash mulching over control was 18.8, 17.6 during 1st year, 15.9, 13.3 during 2nd year and 17.4, 15.5 in pooled data, respectively.

The strategy that biofertilizers employ to promote growth and development in younger plants while maintaining as many pertinent morphological traits as possible, such as deeper roots and a greater availability of green leaves to absorb minerals from the significant soil depths and robustly perform photosynthesis, may be the cause of increased dry matter accumulation (Viana *et al*., 2019) [17]. The results are in line with Anil and Sreenivasa (2000) [1], Shankaraiah and Hunsigi (2000) [13] and Banerjee *et al*. (2018) [2].

At 60 DAP, S_5 registered appreciable increase in drymatter production and maintained parity with S_6, S_3. The S_3 was on par with S_4. Distinctly lower drymatter production was found with S_2 and S_1 during the 2019-20 and in pooled data.

During 2020-21 at 60 DAP, noticeable increase in drymatter accrual was recorded with S_5 treatment and was comparable with S_6, S_3 and S_4 treatments and significantly superior to rest of the treatments.

Analysis of data at 120 DAP, exhibited that the drymatter production was higher with S_5 level of fertilizers which was significantly superior to S_1 and S_2 treatments. However, the treatment S_5 showed statistical parity with S_6 and S_3 treatments. The treatment S_3 was closely followed by S_4 and was statistically on par with each other. The lower drymatter production recorded with the application of S_2 could be ascribed to the fact that nutrient supply at this level was not able to meet the requirement of the crop. Similar trend was also noticed at 180 DAP and at harvest during 2019-20, 2020-21 and in pooled data as well.

The per cent increase in drymatter at harvest with 125% STBNK + 25% additional K over 75% STBNK (S_1 & S_2) was 13.5, 19.4 during 1st year, 17.9, 22.8 during 2nd year and 15.6, 21.0 in pooled data, respectively.

Contemplating the data at various crop growth stages showed that higher drymatter production under higher nitrogen applied treatment could be ascribed to nitrogen, being an important constituent of enzymes, nucleotides and chlorophyll, its application resulted in taller plants with robust stalks. The results projected in the present study were in consonance with Pratap *et al*. (2006) [10] and Kumar and Kumar (2020) [7].

The interaction between organic sources and time and dose of N and K application on drymatter accumulation was found significant only at 180 DAP during 2019-20, 2020-21 and in pooled data (Table 1a).

The data indicated that lower drymatter accrual was with S_2 under M_1 and found significantly inferior to all other treatments during 2019-20 while, it shows parity with S_1 during 2020-21 and in pooled data. At M_2 and M_3 treatments, S_2 exhibited statistical parity with S_1. The treatments S_5, S_6 and S_3 were comparable under M_1 treatment and S_3 inturn was comparable with S_4. The S_5, S_6, S_3 and S_4 treatments were statistically comparable among themselves under M_2 and M_3 treatments during 2019-20, 2020-21 and also in pooled data.

During 2019-20, 2020-21 and in pooled data at S_1 and S_2, M_2 and M_3 treatments were comparable and both exhibit significant superiority over M_1. The M_1, M_2 and M_3 treatments were comparable at S_5 treatment. The M_2 treatment maintains parity with M_3 which inturn was comparable with M_1 at S_6, S_3 and S_4 treatments.

2. Economics

2.1 Gross Returns (Rs. ha^{-1})

Gross returns is a dependent variable related with market value of the produce. Data related to gross returns furnished under Table 2 proved that higher gross returns was observed with the application of biofertilizers which could be owing to higher yield. However, it was found to be at par with M_3 and both the treatments exhibited significant superiority over control (M1) during 2019-20, 2020-21 and in pooled data. These results are corroborating with the findings of Bhalerao *et al*. (2006) [3] and Tyagi *et al*. (2011) [16].

In the first year, second year and in pooled data, S_5 registered higher gross returns and was statistically comparable with S_6 and S_3. The next best treatment was S_4. Higher gross returns might be due to increased yield attributes and yield with the adequate supply of nitrogen and potassium at 125% STBNK. Lower gross returns was noticed with S_2 which was significantly lower than all other treatments except with S_1 one month before harvesting. Similar trend of effects has also been advocated by Gupta *et al*. (2006) [6], Virdia *et al*. (2009) [18], Dev *et al*. (2012) [4], Sarala *et al*. (2012) [12] and Meena and Kumar (2015) [8]. The interaction effect was not observed between organic sources and time and levels of N and K application in influencing gross returns.

2.2 Net Returns (Rs. ha^{-1})

Biofertilizer application recorded maximum net returns and it was followed by trash mulch and both exhibit superiority over control. The steady supply of nutrients through organics favoured higher growth, yield attributes and yield owing to higher net returns. The results confirm the findings of Bhalerao *et al*. (2006) [3], Tyagi *et al*. (2011) [16] and Patel and Chaudhari (2018) [9].

Among different sub plot treatments, appreciably higher net returns were obtained with S_5 treatment. However, it was comparable with S_6 and S_3. Lower net returns were accrued with S_2 and found significantly inferior to all other treatments except with S_1 during 2019-20, 2020-21 but not in pooled data. The more tiller population, more number of stalks and subsequently higher seedcane yield under adequate nutrient supply lead to high yield and inturn the higher net returns. These results are in consonance with the earlier findings of Gupta *et al*. (2006) [6], Meena and Kumar (2015) [8] and Kumar and Kumar (2020) [7].

At all the main plot levels, S_5 registered higher net returns. However, it was statistically comparable with S_3 and S_6 treatments at M_1 level and S_3, S_6 and S_4 treatments at M_3 level and M_2 level during 2019-20 and 2020-21 while, in pooled data S_5 was on par with S_3 and S_6 treatments at all the main plot levels. S_2 treatment recorded lower net returns but maintained parity with S_1 at all the main plot treatments (Table 2a).

At S_1, S_2 and S_4 levels, M_2 treatment exhibited higher net returns and comparable with M_3 treatment and the lower net returns were observed with M_1. Whereas at S_3, S_5 and S_6 levels, M_1, M_2 and M_3 were comparable among themselves.

2.3 Benefit Cost Ratio

The data on BC ratio of seedcane crop is furnished in Table 2 indicated that significant differences among main plot and sub plot treatments while, the interaction did not differ significantly.

The higher BC ratio was registered with biofertilizer applied treatment but it was on a par with M_3 treatment. The control treatment registered significantly lower BC ratio as compared to M_2 and M_3 treatments during 2019-20, 2020-21 and also in pooled data. The current results are in line with the earlier findings of Bhalerao *et al*. (2006) [3], Thakur *et al*. (2010) and Patel and Chaudhari (2018) [9].

The higher BC ratio was noticed with S_5 but it was on par with S_3 and S_6 treatments. BC ratio was lower with S_2 treatment which was comparable with S_1 treatment during 2019-20, 202-21 and also in pooled data. The higher gross returns owing to higher cane yield could generate high BC ratio with application of biofertilizers and supply of 125% STBNK + additional RDK. The results projected in the present study were in accordance with findings of Gupta *et al*. (2006) [6], Dev *et al*. (2012) [4], Sarala *et al*. (2012) [12], Meena and Kumar (2015) [8] and Kumar and Kumar (2020) [7].

Table 1: Drymatter production (kg ha^{-1}) 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	2087	7793	22550	25301	1554	6299	19956	24122	1820	7046	21253	24711
M_2	2169	9134	27042	30070	1608	7317	24218	27955	1889	8226	25630	29012
M_3	2155	9052	25639	29755	1588	7290	23465	27336	1871	8171	24552	28545
SEm±	42.9	242.7	391.2	913.5	36.4	220.0	396.4	494.7	34.5	248.5	394.6	625.7
CD (p = 0.05)	NS	953	1536	3587	NS	864	1556	1942	NS	976	1550	2457
CV (%)	8.5	11.9	6.6	13.7	9.8	13.4	7.5	7.9	7.9	13.5	7.0	9.7
Time and dose of N & K application												
S_1	1975	7843	22566	27052	1505	6580	19296	24330	1740	7211	20931	25691
S_2	1931	7582	20955	25717	1483	6372	17852	23361	1707	6977	19404	24539
S_3	2188	8996	26711	29495	1618	6993	24487	27803	1903	7994	25599	28649
S_4	2138	8421	25431	27652	1584	6820	23122	26526	1861	7621	24277	27089
S_5	2306	9836	27812	30694	1669	7794	25724	28691	1988	8815	26768	29693
S_6	2281	9281	26988	29642	1640	7252	24796	28114	1961	8267	25892	28878
SEm±	57.7	338.6	526.4	796.9	46.1	310.8	515.5	668.4	39.3	324.7	514.7	862.5
CD (p = 0.05)	167	978	1520	2302	133	898	1489	1930	114	938	1487	2491
CV (%)	8.1	11.7	6.3	8.4	8.7	13.4	6.9	7.6	6.3	12.5	6.5	9.4
Interaction	NS	NS	S	NS	NS	NS	S	NS	NS	NS	S	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 1a: Interaction between organic sources, time and dose of nitrogen and potassium application on drymatter production (kg ha^{-1}) at 180 DAP of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Time and dose of nitrogen and potassium application	Organic Sources (2019-20)			Mean	Organic Sources (2020-21)			Mean	Organic Sources (Pooled data)			Mean
	M_1	M_2	M_3		M_1	M_2	M_3		M_1	M_2	M_3	
S_1	18895	25795	23010	22566	15046	21616	21226	19296	16971	23705	22118	20931
S_2	15989	24240	22636	20955	13102	20868	19587	17852	14546	22554	21111	19404
S_3	25013	28220	26900	26711	22731	25713	25016	24487	23872	26967	25958	25599
S_4	23347	26808	26139	25431	21011	24458	23898	23122	22179	25633	25018	24277
S_5	26861	28653	27921	27812	24554	26683	25937	25724	25707	27668	26929	26768
S_6	25198	28536	27229	26988	23290	25973	25125	24796	24244	27254	26177	25892
Mean	22550	27042	25639		19956	24218	23465		21253	25630	24552	
	SEm±	CD (p = 0.05)	CV (%)		SEm±	CD (p = 0.05)	CV (%)		SEm±	CD (p = 0.05)	CV (%)	
(M)	391.2	1536	6.6		396.4	1556	7.5		394.6	1550	7.0	
(S)	526.4	1520	6.3		515.5	1489	6.9		514.7	1487	6.5	
Interaction												
M*S	911.8	2633			892.9	2579			891.5	2575		
S*M	927.6	2934			919.6	2915			917.2	2907		

Table 2: Cost of cultivation (Rs. ha^{-1}), gross returns (Rs. ha^{-1}), net returns (Rs. ha^{-1}) and BCR 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			
	Cost of cultivation	Gross returns	Net returns	BCR	Cost of cultivation	Gross returns	Net returns	BCR	Cost of cultivation	Gross returns	Net returns	BCR
Organic sources												
M_1	154179	219200	65021	1.42	156409	207100	50691	1.32	155294	213150	57856	1.38
M_2	157095	244483	87392	1.56	159321	228050	68729	1.43	158208	236267	78061	1.50
M_3	156541	239100	82721	1.53	158610	225150	66541	1.42	157576	232125	74631	1.48
SEm±	-	5018.6	2459.1	0.02	-	4223.0	2267.7	0.02	-	4632.7	1531.3	0.02
CD (p = 0.05)	-	19705	9656	0.09	-	16582	8904	0.08	-	18190	6013	0.08
CV (%)	-	9.1	13.3	6.39	-	8.1	15.5	6.4	-	8.7	9.3	6.2
Time and dose of N & K application												
S_1	153529	218967	65438	1.42	155759	202533	46774	1.30	154644	210750	56106	1.36
S_2	152959	209800	56841	1.37	155189	195333	40144	1.26	154074	202567	48493	1.32
S_3	156169	245467	89298	1.57	158399	230800	72401	1.46	157284	238133	80849	1.52
S_4	155599	233100	77501	1.50	157829	219500	61671	1.39	156714	226300	69586	1.45
S_5	158806	251933	93127	1.59	161036	238200	77164	1.48	159921	245067	85146	1.54
S_6	158236	246300	88064	1.56	160466	234233	73767	1.46	159351	240267	80916	1.51
SEm±	-	5677.3	2999.1	0.03	-	5361.6	3068.3	0.03	-	5309.1	2110.2	0.03
CD (p = 0.05)	-	16397	8662	0.08	-	15485	8862	0.08	-	15334	6095	0.08
CV (%)	-	7.3	11.5	5.87	-	7.3	14.8	6.3	-	7.0	9.0	5.7
Interaction	-	NS	S	NS	-	NS	S	NS	-	NS	S	NS

Table 2a: Interaction between organic sources, time and dose of nitrogen and potassium application on net returns (Rs. ha^{-1}) of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Time and dose of nitrogen and potassium application	Organic Sources (2019-20)			Mean	Organic Sources (2020-21)			Mean	Organic Sources (Pooled data)			Mean
	M_1	M_2	M_3		M_1	M_2	M_3		M_1	M_2	M_3	
S_1	39075	82263	74975	65438	20845	61633	57845	46774	29960	71948	66410	56106
S_2	29045	74333	67145	56841	11915	54503	54015	40144	20480	64418	60580	48493
S_3	86235	92123	89535	89298	69805	74493	72905	72401	78020	83308	81220	80849
S_4	62805	85993	83705	77501	54875	65463	64675	61671	58840	75728	74190	69586
S_5	88398	98086	92898	93127	75568	80356	75568	77164	81983	89221	84233	85146
S_6	84568	91556	88068	88064	71138	75926	74238	73767	77853	83741	81153	80916
Mean	65021	87392	82721		50691	68729	66541		57856	78061	74631	
	SEm±	CD (p = 0.05)	CV (%)		SEm±	CD (p = 0.05)	CV (%)		SEm±	CD (p = 0.05)	CV (%)	
(M)	2459.1	9656	13.3		2267.7	8904	15.5		1531.3	6013	9.3	
(S)	2999.1	8662	11.5		3068.3	8862	14.8		2110.2	6095	9.0	
Interaction												
M*S	5194.7	15003			5314.4	15349			3654.9	10556		
S*M	5484.9	17464			5395.7	17059			3687.2	11643		

Conclusion
From the above experiment, it can be suggested that, integrated use of organic sources along with 125% STBNK at planting, 30, 60, 90 and 120 days after planting + 25% recommended potassium as additional one month before harvesting can be recommended for realizing higher drymatter accrual and economics of seedcane.

Conflict of interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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