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Impact of gypsum, organic manure and nitrogen levels to produce BT. cotton crop from partially reclaimed coastal salt affected soils

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Abstract
A field experiment was conducted at Coastal Soil Salinity Research Station, NAU, Danti-Umbharat, Gujarat during *kharif* season (2019-20 to 2021-22) to study the effect of gypsum, organic manure and nitrogen levels to produce *Bt.* cotton crop under partially reclaimed coastal salt affected soils. Experiment consisted of total twelve treatments combinations that were repeated three times using a factorial randomized block design. These combinations included two gypsum levels (G_1: 25% GR and G_2: 50% GR), two organic manure levels (O_1: FYM 10 t/ha and O_2: Biocompost 10 t/ha) and three levels of nitrogen (N_1: 50% RDN, N_2: 75% RDN and N_3: 100% RDN, 240 kg N/ha). The results revealed that the application of gypsum @ 50% GR (G_2) recorded significantly highest growth, yield parameters and seed cotton yield *viz.*, number of sympodia per plant (21.2), boll weight (3.37 g), number of bolls per plant (28.6) and seed cotton yield (1639 kg/ha) in pooled results. Among organic sources, application of biocompost @ 10 t/ha (O_2) resulted in significantly highest boll weight (3.33 g), number of bolls per plant (28.7) and seed cotton yield (1636 kg/ha) in pooled results. In case of nitrogen levels, application of 100% RDN (240 kg N/ha) (N_3) yielded significantly higher boll weight (3.35 g), number of bolls per plant (29.6) and seed cotton yield (1699 kg/ha) over treatments N_1 and N_2 but in boll weight treatments N_2 was at par with treatment N_3 in pooled results. Interaction effect of gypsum @ 50% GR along with biocompost @ 10 t/ha (G_2O_2) recorded highest seed cotton yield (1750 kg/ha) as compared to rest of the treatments combinations. Further, gross income and net income realized was higher in G_2O_2 (Rs.122500/ha and Rs.51363/ha) and N_3 (Rs.118930/ha and Rs.48983/ha) as compared to other treatments. From the results it could be concluded that application of gypsum @ 50% GR along with biocompost @ 10 t/ha and 100% RDN (240 kg N/ha) enhance yield of *Bt.* Cotton with improvement in partially reclaimed coastal salt affected soils.

Keywords: Bt. Cotton, gypsum, organics, nitrogen, coastal salt affected soils)

Introduction
Soil deterioration because of salinity/sodicity is a major environmental threat to sustainable agriculture, which have damaging effects on soil properties and crop growth. Coastal salt affected soils generally render hostile conditions for plant growth due to insufficient organic matter and excess of toxic soluble salts. Because of the high concentration of soluble Na^+, the physical and chemical characteristics of these soils are generally degraded. The properties of these soils could be improved by using various soil amendments. Use of soil amendments like gypsum as well as organic sources (FYM and biocompost) improve soil properties and enhance crop growth.

Gypsum is frequently use as chemical amendment for sodic soil restoration because of its low cost, ease of handling and quick reaction. Gypsum enhances the physical characteristics of soils by eliminates Na^+ from the root zone and decreasing the pH of salt-affected soils (Rizwan *et al.*, 2019). Currently, organic resources like biocompost and farmyard manure are used to ameliorate the salt affected soil. By adding organic sources to salt affected soils can improve surface soil fertility, soil structure and permeability thus, enhancing salt leaching, reducing surface evaporation, inhibiting salt accumulation in surface soils. In addition, use of organic sources as amendments plays a dual role, in not only increasing the solubility (Singh *et al.*, 2015) [28] of

gypsum through the organic acids released during decomposition but also helps to improve the soil properties (Wahid *et al.*, 1998; Sardina *et al.*, 2003; Tajada *et al.*, 2006) [31, 24, 30]. Moreover, nitrogen is the most crucial nutrient for cotton crop growth and output, and it is needed mostly throughout the growth period.

Cotton is important cash crop and it grown in about 27 lakh ha in the Gujarat. *Bt.* cotton hybrids occupy more than 90% of total cotton cultivation area. Earlier studies at Danti-Umbharat indicated that *Bt.* cotton can be grown well on coastal salt affected soils. Hence, present study was under taken to examining the effect of gypsum, organic manure and nitrogen levels on *Bt.* cotton crop under partially reclaimed coastal salt affected soils.

Materials and Methods

Field experiment was conducted at the Coastal Soil Salinity Research Station, Navsari Agricultural University, Danti-Umbharat in the South Gujarat near the Arabian Sea to produce *Bt.* cotton crop using gypsum, organic manure and nitrogen levels under partially reclaimed coastal salt affected soil condition during 2019-20 to 2021-22. Geographically, Danti-Umbharat is situated at 72^0 50' E longitudes and 20^0 83' N latitude and with an elevation of 2.5 meter above mean sea level on the western coastal belt of India. The area receives an annual rainfall of 1100 mm, most of which occurs from the second week of June to last week of September. The initial soil was clayey in texture, partially saline-sodic in reaction and salinity, low in available nitrogen, high in available P_2O_5 and K_2O. Total twelve treatment combinations were tested using a factorial randomized block design with three replications. These combinations included two gypsum levels (G_1: 25% GR and G_2: 50% GR), two organic manure levels (O_1: FYM 10 t/ha and O_2: Biocompost 10 t/ha) and three levels of nitrogen (N_1: 50% RDN, N_2: 75% RDN and N_3: 100% RDN, 240 kg N/ha). Each plot measured 4.8 m × 3.6 m with distance between row to row and plant to plant was 120 × 45 cm. *Bt.* cotton (cv G. Cot. Hy.12, BG-II) as the test crop.

The amount of gypsum requirement (GR) were estimated by versenate titration. During land preparation, amendments (gypsum, FYM, and bio-compost) were applied according to treatments; nitrogen (240 kg/ha) was applied in 5 equal splits at 30, 60, 75, 90, and 105 days after sowing through urea, along with 40 kg of phosphorus as basal through single super phosphate (SSP). Nutrient composition of organic inputs used in the experiments was presented in Table 1. The observations were recorded viz., plant height, number of sympodia per plant, boll weight, number of bolls per plant, seed cotton yield and analysed statistically (Panse and Sukhatme, 1967) [18]. Initial and treatment wise from all replications soil samples (0-15 cm and 15-30 cm soil depths) after three years were taken for analyzing chemical properties of soil. Soil reaction, salinity and organic carbon content were determined the method described by Jackson (1973) [13]. Exchangeable sodium percentage (ESP) computed by method given by Richards (1954) [20]. Available nitrogen in soil was determined by alkaline potassium permanganate method of Subbiah and Asija (1956) [29]. Available P_2O_5 content was extracted using Olsen's method given by Jackson (1973) [13]. Available K_2O was measured using normal neutral ammonium acetate method as described by Jackson (1973) [13].

Results and Discussion

Growth, yield parameters and Seed cotton yield

The results of growth, yield parameters and yield of *Bt.* cotton affected by gypsum, organic manure and nitrogen levels are presented in Table 2. Application of gypsum @ 50% GR (G_2) recorded significantly highest values of number of sympodia per plant (21.2), boll weight (3.37 g), number of bolls per plant (28.6) and seed cotton yield (1639 kg/ha) as compared to application of gypsum @ 25% GR (G_1) in pooled results. The increase in growth, yield parameter and seed cotton yield might be due to increased gypsum rate in soil which improve the physicochemical conditions in the root zone by reducing the pH and ESP. The supply of nutrients through gypsum provides conducive physical environments leading to better aeration, root activity and nutrient absorption and the consequent complementary effect would have resulted in higher growth, yield parameter and seed cotton yield. Similar results of gypsum were recorded by Gupta and Arora (2016) [12], Ravinder *et al.* (2017) [19], Chandrakar *et al.* (2018) [7].

In case of organic manures, application of biocompost @ 10 t/ha (O_2) achieved significantly highest boll weight (3.33 g), number of bolls per plant (28.7) and seed cotton yield (1636 kg/ha) as compared to application of FYM @ 10 t/ha (O_2) in pooled results. This might be due organics had a significant impact on the structure, basic infiltration rate, quality and improvement of nutrients in the soil, all of which lead to an increase in yield parameters and seed yield of cotton. The outcomes correspond with the findings of Khan *et al.* (2014) [14], Saied *et al.* (2017) [22] and Sarwar *et al.* (2020) [25].

Among nitrogen levels, application of 100% RDN (240 kg N/ha) (N_3) recorded significantly higher boll weight (3.35 g), number of bolls per plant (29.6) and seed cotton yield (1699 kg/ha) as compared to application of 50% RDN (N_1) and 75% RDN (N_2) but in boll weight N_2 was comparable to treatment N_3 in pooled results. Increases in mineral uptake, photosynthetic assimilation, and their accumulation in sinks may be the reason behind an increase in boll weight (Saleem *et al.*, 2010 and Dong *et al.*, 2012) [23, 9]. According to a number of studies, an increase in N rates resulted in an increase in the number of bolls per plant (Seadh *et al.*, 2012; Zhao *et al.*, 2012; Emara and Abdel-Aal, 2017) [26, 33, 10]. Several investigations found that seed cotton yield was increase with N application. According to Gadhiya *et al.* (2009) [11], seed cotton yield was considerably higher with higher level of N @ 240 kg/ha.

The interaction effect of gypsum and organics (Table 3) was found to significantly affect the seed cotton yield in pooled results. Hence, application of gypsum @ 50% GR along with biocompost @ 10 t/ha (G_2O_2) recorded significant highest seed cotton yield (1750 kg/ha) in pooled result as compared to rest of the treatments combinations. Increased seed cotton yield might be due to the application of gypsum along with biocompost resulted in better soil properties, a sustained supply of nutrients and improved micro-environmental conditions, which in turn may have improved nutrient utilization through the actions of soil microorganisms involved in nutrient transformation and fixation. Ameen *et al.* (2017) [3], Zaka *et al.* (2018) [32], Ahmed *et al.* (2020) [2], Kitila *et al.* (2020) [15], Bekele (2022) [5], Amer *et al.* (2023) [4] also opined the results of gypsum along with organics in their experiments. Further, interaction effect of Y x O x N was also found to produce significant difference on seed cotton yield in pooled result.

Soil properties

The effect of gypsum on soil $pH_{2.5}$ was found to be significantly affected after three years at both the soil depths (Table 4). Significantly maximum improvement in soil $pH_{2.5}$ was recorded due to application of gypsum @ 50% GR (G_2) at both the soil depths as compared to gypsum @ 25% GR (G_1). The soil $pH_{2.5}$ values recorded with G_2 were 8.60 and 8.72 at 0-15 cm and 15-30 cm soil depths, respectively and the corresponding values at these depths for G_1 were 8.78 and 8.82. Among organic sources and nitrogen levels, the soil $pH_{2.5}$ not much varied across the treatments at both soil depths after three years. The improvement in soil $pH_{2.5}$ with gypsum applied treatments might be attributed to the replacement of exchangeable Na^+ during Na^+-Ca^{2+} exchange and subsequent leaching. Similar finding was also reported by Murthy *et al.* (2013) [16], Singh and Singh, (2014) [14], Gupta and Arora (2016) [12] and Adane *et al*. (2019) [1]. The soil salinity (soil $EC_{2.5}$) levels analysed after three year of crop indicated no significant difference among gypsum, organic sources and nitrogen levels (Table 4). Soil exchangeable sodium percentage **(**ESP) was significantly affected due to application of different levels of gypsum (Table 4). Application of gypsum @ 50% GR (G_2) recorded significantly lower ESP as compared to gypsum @ 25% GR (G_1) after three year of experiment at both the soil depths. In case of organic sources and nitrogen levels, not much difference was recorded in soil ESP at both soil depths after three years. Further there was reduction in ESP at both the soil depths as compared to initial values. The possible reason of reduction in ESP under application of gypsum treatment might be due to enhanced chemical reaction Na^+ was exchanged with Ca^{2+} from the soil exchange complex. Then, Na^+ in soluble form moves down due to improved soil physical and chemical conditions. Similar results were also observed by Chaum *et al*., (2011) [8], Murthy *et al.* (2013) [16], Gupta and Arora (2016) [12], Kim *et al.* (2018) [14], Adane *et al*. (2019) [1], Kitila *et al.* (2020) [15] and Bekele *et al.* (2020) [6]. No significant difference in soil organic carbon (SOC) status was observed in any of the gypsum levels, organic sources and nitrogen levels at both the soil depths (Table 4). However, all treatments significantly increased the SOC values at both soil depths from initial values. The different gypsum levels, organic sources and nitrogen levels did not significantly affect the available N, P_2O_5 and K_2O contents of the soil at both the depths after three year of experimentation (Table 5). However, the values of these properties at both the depths were improved considerably in all the treatments from their initial value.

Economics

The cost economics of different treatments are given in table 6. Since the interaction effect of gypsum (G) and organic (O) application was found significant, the economics was calculated together and separately for nitrogen levels. The cost of cultivation varied as per input cost. Among GxO interaction, higher cost of cultivation (Rs.71137/ha) was worked out for G_2O_2 *i.e.*, gypsum @ 50% GR with 10 t biocompost per hectare. In case of nitrogen levels, obviously the higher cost of cultivation was worked in N_3 -100% RDN (Rs.69947/ha) as compared to rest of the lower N levels. Gross income realized was higher in G_2O_2 (Rs.122500/ha) and N_3 (Rs.118930/ha) as compared to N_1 and N_2 other treatments. Similar trend was observed for net income also with higher net income realized for G_2O_2 and N_3 were Rs.51363/ha and Rs.48983/ha.

Table 1: Nutrient composition of organic inputs

Parameters	FYM	Bio compost
Organic carbon (%)	11.46 -11.85	12.09 - 13.86
N (%)	0.83 - 0.98	1.86 - 2.75
P (%)	0.67 - 0.79	1.12 - 1.36
K (%)	0.43 - 0.51	1.26 - 1.48
Fe (ppm)	8341- 9545	9510- 9716
Mn (ppm)	296.4 - 363.1	423.7 - 499.0
Zn (ppm)	126.7 - 134.8	128.0 - 136.2
Cu (ppm)	55.0 - 63.4	84.7 - 91.6

Table 2: Growth, yield parameters and seed cotton yield as influenced by different treatments (pooled over three years)

Treatments	Plant height (cm)	No. of sympodia/ plant	Boll weight (g)	No. of bolls/ Plant	Seed cotton yield (kg/ha)
Gypsum req.					
G_1- 25% GR	117.6	20.2	3.21	27.2	1484
G_2- 50% GR	120.8	21.2	3.37	28.6	1639
SEm±	1.14	0.24	0.021	0.46	22.40
CD at 5%	NS	0.70	0.06	1.31	63
Organic source					
O_1 - FYM @ 10 t/ha	119.1	20.7	3.25	27.1	1487
O_2 - BC @ 10 t/ha	119.4	20.7	3.33	28.7	1636
SEm±	1.14	0.24	0.021	0.46	22.40
CD at 5%	NS	NS	0.06	1.31	63
Nitrogen levels					
N_1- 50% RDN	118.6	20.3	3.25	26.3	1439
N_2- 75% RDN	119.7	20.8	3.28	27.8	1547
N_3- 100% RDN	119.5	21.1	3.35	29.6	1699
SEm±	1.39	0.29	0.026	0.57	27.44
CD at 5%	NS	NS	0.07	1.61	77
Mean	119.2	20.7	3.29	28.0	1561
	Y	Y	Y	Y	Y
SEm±	1.39	0.29	0.026	0.57	27.44

CD at 5%	3.92	0.83	0.07	1.61	77
CV (%)	7.00	8.49	4.69	12.19	10.54
Interactions	--	--	--	--	GxO, YxOxN

Table 3: Interaction effect of GxO on seed cotton yield (kg/ha) in pooled results

Gypsum levels	Organic source	
	Pooled	
	O_1	O_2
G_1	1446	1522
G_2	1528	1750
SEm±	31.68	
CD 0.05	89	

Table 4: Soil reaction ($pH_{2.5}$), salinity ($EC_{2.5}$), exchangeable sodium percentage (ESP) and organic carbon under different treatments (Initial and after three year)

Treatments	Soil $pH_{2.5}$		Soil $EC_{2.5}$ (dS/m)		Soil ESP		Soil organic carbon (%)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Initial	8.84	9.03	0.79	0.90	11.03	12.80	0.49	0.43
Gypsum req.								
G_1- 25% GR	8.78	8.82	0.93	1.00	8.72	9.47	0.57	0.48
G_2- 50% GR	8.60	8.72	1.02	1.10	7.13	8.11	0.60	0.50
SEm±	0.024	0.025	0.031	0.037	0.315	0.412	0.015	0.018
CD at 5%	0.07	0.07	NS	NS	0.92	1.21	NS	NS
Organic source								
O_1 - FYM @ 10 t/ha	8.71	8.75	0.96	1.07	8.31	8.90	0.58	0.49
O_2 - BC @ 10 t/ha	8.66	8.79	0.99	1.02	7.53	8.68	0.59	0.49
SEm±	0.024	0.025	0.031	0.037	0.315	0.412	0.015	0.018
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen levels								
N_1- 50% RDN	8.72	8.79	0.97	1.09	8.40	9.05	0.59	0.48
N_2- 75% RDN	8.65	8.78	0.99	1.07	7.67	8.73	0.57	0.48
N_3- 100% RDN	8.69	8.74	0.97	0.98	7.69	8.59	0.60	0.51
SEm±	0.030	0.031	0.039	0.045	0.385	0.505	0.019	0.022
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Mean	8.69	9.03	0.98	1.05	7.92	8.79	0.59	0.49
CV (%)	1.19	1.23	13.64	14.96	16.85	19.88	10.90	15.59
Interactions	--	--	--	--	--	--	--	--

Table 5: Soil available nitrogen (N), available P_2O_5 and available K_2O under different treatments (Initial and after three year)

Treatments	Available N (kg/ha)		Available P_2O_5 (kg/ha)		Available K_2O (kg/ha)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Initial	218.6	181.1	141.1	99.5	1691	1914
Gypsum req.						
G_1- 25% GR	227.5	187.8	148.7	98.6	1790	2107
G_2- 50% GR	230.0	197.3	152.1	103.2	1751	1969
SEm±	5.27	3.96	5.42	3.81	50.0	57.7
CD at 5%	NS	NS	NS	NS	NS	NS
Organic source						
O_1 - FYM @ 10 t/ha	229.5	189.7	143.3	100.5	1742	1988
O_2 - BC @ 10 t/ha	228.0	195.4	157.5	101.2	1799	2088
SEm±	5.27	3.96	5.42	3.81	50.0	57.7
CD at 5%	NS	NS	NS	NS	NS	NS
Nitrogen levels						
N_1- 50% RDN	219.4	187.3	152.0	100.5	1791	2007
N_2- 75% RDN	228.3	189.3	142.6	97.7	1746	2091
N_3- 100% RDN	238.4	201.1	156.5	104.5	1774	2016
SEm±	6.456	4.856	6.641	4.670	61.2	70.7
CD at 5%	NS	NS	NS	NS	NS	NS
Mean	228.7	192.5	150.4	100.9	1770	2038
CV (%)	9.78	8.74	15.30	16.04	11.98	12.02
Interactions	--	--	--	--	--	--

Table 6: Economics of different treatments (Pooled over three years)

Treatment	Seed cotton yield (kg/ha)	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)
Gypsum x Org. Source				
G_1O_1	1446	65848	101220	35372
G_1O_2	1522	64380	106540	42160
G_2O_1	1528	71583	106960	35377
G_2O_2	1750	71137	122500	51363
Nitrogen levels				
N_1 - 50% RDN	1439	66632	100730	34098
N_2 - 75% RDN	1547	68135	108290	40155
N_3 - 100% RDN	1699	69947	118930	48983

Selling price of seed cotton @ Rs.70/kg

Conclusion

From the results of the study, it can be concluded that *Bt.* Cotton can be grown with application gypsum @ 50% GR along with 10 t biocompost/ha during land preparation in partially reclaimed coastal salt affected soils. Further, they are advised to apply nitrogen (240 kg/ha) in 5 equal splits at 30, 60, 75, 90, 105 days after sowing along with phosphorus (40 kg/ha) as basal for getting higher seed cotton yield and higher return. Application of gypsum was also found to reduce soil sodicity.

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