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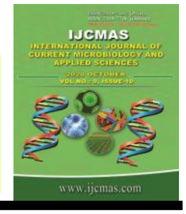

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Performance of Paddy and Characteristics of a Black Alkali Soils as Affected by Gypsum and Spent Wash with Organic Materials

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Rice (*Oryza sativa* L.) is the most suitable crop for alkali soils thus, a pot experiment was conducted with seven treatments *viz.*, control, Phosphogypsum75% of GR**,** Spent wash @ 5 lakh L/ha, Lagoon sludge 10 t/ha, Spent wash @ 2.5 lakh L/ha + Lagoon sludge 5 t/ha, Spent wash 2.5 lakh L/ha + Vermicompost 5 t/ha and Lagoon sludge 5 t/ha + Vermicompost 5 t/ha on paddy (*Oryza sativa* L.). The soil is classified as *fine smectitic hyperthermic family Typic Helplusterts*-Sodic phase. The Spent wash @ 2.5 lakh L/ha + Lagoon sludge 5 t/ha was found to best for the growth and yield components, yield, N, P, K, Ca and Mg content in and uptake and microbial population and minimum ESP and exchangeable Na.

Introduction

Rice (*Oryza sativa* L.) is grown on alkali soils as it is moderately sensitive to sodicity. Globally it is grown an area of 155.62 million ha with the production of 461 million t and productivity of 4.09 t/ha. In India it is grown on an area of 44.50 million ha with production of 102.75 million t and productivity of 2.20 t/ha which was low (Thakur *et al.*, 2017). Salt affected area of 800 million ha of land which is 20% of the total arable area and is increasing 1-2% each year (Rehman *et al.*, 2016). In India 6.73 million ha land is salt affected, out of which 2.42 lakh ha area is found in Madhya Pradesh (Mandal *et al.*, 2010).

Soil salinity and sodicity are the serious threats to irrigated agriculture in the world (Farooq *et al.*, 2015). Sodic soils are poor in organic matter N, P, Ca, Zn and Mn resulting low yields of crops. The high amount of soluble salts and exchangeable Na+ present in soil are main causes that inhibit production of crops. Gypsum is low cost materials which are reduced pH, ECe and ESP of soil hence used for reclamation of sodic soils (Yadav and Chhipa 2007, Maurya *et al.,* 2009). But its availability is scared and hence, there is a need to explore alternate source.

Organic materials such as FYM, vermicompost and press mud improve the physical properties, there by facilitating leaching of salts, helping mobilize Ca in calcareous alkali soils through decomposition of products, serving as source of plant nutrients and invigorating microbial activities that are poor in alkali soils.

In India, about 285 distilleries, which produce about 2.75 billion liters of alcohol and 30- 45 billion liters of spent wash (as a by-product) per year (Anonymous 2007). Spent wash and lagoon sludge are the by-products of sugar and distillery industries. Spent wash is an organic material, highly acidic in nature and having Ca, Mg, K, and S in sufficient amounts due to the acidic nature of spent wash. This may be better preposition for reclamation of sodic soils. The use of lagoon sludge along with spent wash is also beneficial for reclamation of sodic verticals' (Anonymous 2014-15). In view of above fact there is need of efficient, inexpensive and environmentally acceptable amendment for reclamation of alkali soils.

Materials and Methods

Details of experimental site

The study was conducted at of Salt Affected Soils Project, College of Agriculture, Indore (M.P.) during *Kharif* season of 2017- 2018. Indore is situated in *Malwa* Plateau with latitude 22.43^0N and longitude of 75.66^0E an altitude of 555.5 m above mean sea level. It has subtropical climate with annual average rainfall is 964 mm and temperature ranged of 21^0C to 45^0C and 06^0C to 31^0C in summer and winter seasons, respectively (Table 1).

Experimental details

The bulk surface soil (0-15 cm) for the pot experiment was collected from Salinity Research Farm, Barwaha, Khargone district of Madhya Pradesh. The samples were air dried then crushed with wooden roller. The lot was passed through a 2 mm sieve and thoroughly mixed before use in the experiment. Spent wash (a distillery effluent) and lagoon sludge used in the investigation were procured from Associated Alcohol and Breweries, Village Khodi (Barwaha), Tehsil Sanawad District Khargone, Madhya Pradesh. The vermicompost was collected from farm, College of Agriculture, Indore (M.P.) (Table 2).

The pots were filled with 17 kg of processed soil. The phosphogypsum, lagoon sludge and vermicompost were added in upper 15 cm soil and moist the soil for chemical reaction. Twenty five days old seedlings were carefully uprooted from the nursery bed and were transplanted in each Pots. The paddy crop was fertilized with 150, 75 and 40 kg/ha N, P_2O_5 and K_2O, respectively.

Chemical analysis of plant samples

The air dried samples were ground in Wiley mill and digested in di-acid mixture for analysis. Nitrogen was determined by micro Kjeldahl method as out lined by Tandon (2001). Phosphorus was determined by vanadomolybdo phosphoric acid yellow colour method and the colour intensity of yellow colour was recorded on spectro photometer at 470 nm wave length (Chapman and Prett, 1961). K and Na were determined by flame photometer as per the method described by Jackson (1973). Ca and Mg were determined by using standard versanate method after precipitating heavy metals with zirchonium oxychloride (Black, 1965). Nutrient uptake (g/pot) was calculated by nutrient content (%) multiplying by dry matter yield (g/pot)/100

Chemical analysis of soil samples

The samples were dried in shade, crushed and sieved through 2 mm sieve. The soil pHs and ECe were determined in the saturation paste and saturation extracts, respectively as per the method outlined by Richards (1954). Organic carbon was estimated by the Walkley and Black (1934) method. Soil available nitrogen was estimated by alkaline permanganate method as suggested by Subbiah and Asija (1956). The determination of available phosphorus was done as per method outlined by Olsen *et al.*, (1954). Available potassium was determined by using 1N, neutral ammonium acetate solution as described by the Black (1965). The exchangeable Na was estimated using 1N ammonium acetate solution of pH 7.0 as per the method described by Richards (1954). The exchangeable Ca and Mg were estimated using 1N sodium acetate solution of pH 8.2 as per the method described by Richard (1954). The data obtained from a set of observations for each character was subjected to ANOVA) as advocated by (Panse and Sukhatme, 1957).

Results and Discussion

Growth and yield parameters

Data showed (Table 3) that the application of Spent wash @ 2.5lakh L/ha+ Lagoon sludge 5 t/ha resulted maximum plant height, number of effective tillers plants^{-1}, length of panicle, number of grains penicle^{-1} and test weight in paddy under black alkali soil which was statistically at par with Spent wash @ 5 lakh L/ha. Addition of Spent wash @ 2.5lakh L/ha+ Lagoon sludge 5 t/ha increase the plant height, number of effective tillers plant^{-1}, length of panicle, number of grains penicle^{-1} and test weight of paddy by 16.4, 189.0, 78.1, 39.5, 57.1 per cent, respectively, over control. This could be attributed to the reason that increased in plant growth characters viz. grain weight in parameters plant height, number of effective tillers plants^{-1}, length of panicle, number of grains penicle^{-1} and test weight due to better availability of nutrient with reclamation of soil might improve the yield attributes of Bhukaya (2007), Chidankumar *et al.*, (2009), Gahlot *et al.*, (2011), Khandkar *et al.*, (2017).

Yield

Significant increase in grain and straw yield were observed due the application of different treatments in black alkali soil. The grain and straw yield of paddy due to the application Spent wash @ 2.5lakh L/ha + Lagoon sludge 5 t/ha was 111.6 and 81.6 per cent over control. The improvement grain and straw yield due to combined application of Spent wash @ 2.5lakh L/ha+ Lagoon sludge 5 t/ha could be ascribed chiefly to higher growth and nutrient availability. Which ultimately increased yield the yield were also reported by addition of Spent wash @ 2.5 lakh L/ha + lagoon sludge @ 5t/ha. The significant increase in due to the addition of spent wash was also reported by Ramana *et al.*, (2002), Geetha *et al.*, (2007), Khandkar *et al.*, (2017).

Nutrient content and uptake by paddy

It is evident from the results that the content of nutrients (N, P, K, Ca, Mg and Na) in grain and straw of rice were significantly affected by the addition of Spent wash @ 2.5 lakh L/ha + lagoon sludge @ 5t/ha than the control. Data showed the nitrogen, phosphorus potassium content increase in grain and straw by 15.0 and 40.4%; 50.0 and

52.3%; 52.3 and 33.9% over control. But it was statistically at par with Spent wash @ 5 lakh L/ha. Increased could be due to amelioration of black alkali soil as ascribed by the lover ESP.

Addition of Spent wash @ 2.5 lakh L/ha + lagoon sludge @ 5 t/ha decrease the Na content of grain and straw by 57.5 and 41.4 of paddy whereas increased the Ca and Mg content in grain and straw as compared to control. This improvement might be due to higher content of these nutrients in spent wash/lagoon sludge as well as the ameliorating effect of spent wash and lagoon sludge. While reduction in Na content might be due to due to decrease in ESP of soil The results corroborates with the findings of Das *et al.,* (2010), Khandkar *et al.,* (2017). Spent wash @ 2.5 lakh L/ha + lagoon sludge @ 5 significantly affected the uptake of N, P, K, Ca and Mg Na by grain and straw. The increase could be associated with improvement in soil physical and chemical properties and revival of exchangeable Na from soil complex which resulted in improvement in yield and nutrient content of plants and ultimately increased nutrient uptake. The reduced the Na uptake by 31.2 per cent over control might be due to the reclaiming effect of spent wash and lagoon sludge on black alkali soil. The results of the experiment are in conformity with those of Patil and Choudhary (2002), Ramana *et al.*, (2002), Das *et al.*, (2010) and Khandkar *et al.*, (2017) (Table 4 and 5).

Table.1 Characteristics of materials used for study

Characteristics	**Spent Wash**	**Characteristics**	**Lagoon sludge**	**Vermicompost**
pH	5.01	pH	6.42	8.12
EC (mS/m)	920	EC (mS/m)	791	345
BOD (mg/L)	3940	OC (%)	30.4	13
COD (mg/L)	10910	Total - N (%)	1.26	1.3
Nitrogen (mg/L)	1180	Total - P (%)	0.26	0.71
Phosphorus (mg/L)	488	Total – K (%)	1.22	1.2
Potassium (mg/L)	7890	Total - Ca (%)	1.78	0.72
Calciun (mg/L)	1350	Total – Mg (%)	0.52	0.34
Magnesium (mg/L)	770			
Sodium (mg/L)	310			

Table.2 Treatment details and quantity of amendments required for 17 kg soil

Symbol	**Treatment details**	**Quantity pot^{-1}**
T1	Control	0
T2	Phosphogypsum75% of GR	198.73 g
T3	Spent wash 5 lakh L/ha	3.5 litres
T4	Lagoon sludge 10 t/ha	85 gm
T5	Spent wash2.5 lakh L/ha + Lagoon sludge 5 t/ha	1.7 litres + 42.5 g
T6	Spent wash 2.5 lakh L/ha + Vermicompost 5 t/ha	1.7 litres + 42.5 g
T7	Lagoon sludge 5 t/ha + Vermicompost5 t/ha	42.5 g + 42.5 g

Table.3 Effect of gypsum and organics on growth and yield components and yield of paddy

Treatment	plant height (cm)	Number of tillers plant^{-1}	Length of panicle (cm)	Number of grains penicle^{-1}	Test weight (g)	Grain yield (g/pot)	Straw yield (g/pot)
T1	64.25	3.2	5.85	58.02	13.12	19.35	26.57
T2	70.9	6.52	8.21	72.77	17.31	27.05	31.76
T3	73.08	8.63	10.06	79.34	19.35	39.12	43.17
T4	72.12	7.48	9.87	78.5	18.16	37.87	42.55
T5	74.79	9.25	10.42	80.99	20.62	40.95	48.26
T6	67.38	5.52	7.78	67.98	16.24	24.33	29.93
T7	65.5	4.84	6.71	63.01	14.93	21.48	26.52
SEM	**1.21**	**0.28**	**0.3**	**1.41**	**0.45**	**0.8**	**1.89**
***LSD* (*P* < 0.05)**	**3.57**	**0.83**	**0.88**	**4.16**	**1.32**	**2.36**	**5.56**

Table.4 Effect of gypsum and organics on nutrient content in grain and straw of paddy

Treatment	Grain (%)						Straw (%)					
	N	**P**	**K**	**Na**	**Ca**	**Mg**	**N**	**P**	**K**	**Na**	**Ca**	**Mg**
T1	1.2	0.20	0.42	0.33	0.19	0.15	0.42	0.021	1.12	0.82	0.13	0.11
T2	1.32	0.26	0.57	0.22	0.43	0.34	0.52	0.028	1.39	0.67	0.39	0.24
T3	1.35	0.29	0.62	0.16	0.58	0.45	0.57	0.031	1.44	0.51	0.49	0.3
T4	1.34	0.28	0.59	0.2	0.46	0.36	0.54	0.029	1.41	0.6	0.42	0.28
T5	1.38	0.31	0.64	0.14	0.62	0.51	0.59	0.032	1.5	0.48	0.55	0.33
T6	1.3	0.25	0.54	0.18	0.34	0.29	0.5	0.027	1.36	0.58	0.35	0.21
T7	1.28	0.23	0.51	0.21	0.3	0.26	0.48	0.025	1.2	0.58	0.28	0.18
SEM	***0.02***	***0.008***	***0.008***	***0.01***	***0.02***	***0.03***	***0.011***	***0.0007***	***0.006***	***0.02***	***0.01***	***0.01***
***LSD* (*P* < 0.05)**	***0.06***	***0.024***	***0.026***	***0.05***	***0.06***	***0.09***	***0.032***	***0.0023***	***0.02***	***0.08***	***0.05***	***0.05***

Table.5 Effect of gypsum and organics on nutrient uptake by paddy

Treatment	Grain (g/pot)						Straw (g/pot)					
	N	**P**	**K**	**Na**	**Ca**	**Mg**	**N**	**P**	**K**	**Na**	**Ca**	**Mg**
T1	0.233	0.039	0.081	0.064	0.022	0.022	0.111	0.005	0.298	0.218	0.051	0.039
T2	0.357	0.07	0.154	0.06	0.042	0.041	0.167	0.009	0.441	0.213	0.076	0.056
T3	0.529	0.114	0.243	0.062	0.064	0.066	0.247	0.013	0.624	0.222	0.126	0.088
T4	0.508	0.106	0.223	0.076	0.059	0.059	0.231	0.012	0.6	0.255	0.102	0.075
T5	0.565	0.127	0.262	0.058	0.076	0.074	0.286	0.015	0.724	0.232	0.15	0.102
T6	0.316	0.061	0.132	0.044	0.037	0.035	0.149	0.008	0.409	0.173	0.065	0.051
T7	0.275	0.05	0.11	0.045	0.03	0.027	0.127	0.007	0.318	0.155	0.056	0.042
SEM	**0.011**	**0.003**	**0.006**	**0.005**	**0.004**	**0.003**	**0.01**	**0.000**	**0.025**	**0.017**	**0.006**	**0.006**
***LSD* (*P* < 0.05)**	**0.034**	**0.011**	**0.018**	**0.016**	**0.012**	**0.009**	**0.031**	**0.002**	**0.074**	**0.05**	**0.02**	**0.019**

Table.6 Effect of gypsum and organics on soil characteristics after harvest of paddy

Treatment	Physico-chemical properties			Availed nutrients(kg/ha)			Exchangeable cations ($mmol_+$/kg)			
	pHs	ECe (mS/m)	OC (%)	N	P_{Olsen}	K	Na+	K+	Ca++	Mg++
T1	8.51	149	0.28	191.57	11.2	382.03	15.12	0.54	11.79	8.63
T2	8.48	136	0.39	197.29	14.43	429.14	11.27	0.72	13.78	10.36
T3	8.44	134	0.44	225.98	15.73	480.1	9.57	0.8	14.7	11
T4	8.45	133	0.42	224.77	13.52	470.72	10.12	0.79	13.82	10.84
T5	8.41	136	0.46	227.91	17.12	483.98	9.44	0.89	14.87	11.2
T6	8.5	139	0.36	192.82	15.28	409.59	12.6	0.7	12.78	9.74
T7	8.53	142	0.32	193.86	12.55	407.58	13.82	0.62	12.23	9.34
SEM	**0.028**	**4.5**	**0.021**	**6.27**	**0.47**	**5.98**	**0.72**	**0.01**	**0.2**	**0.12**
LSD **(*P* < 0.05)**	**NS**	**NS**	**0.063**	**18.46**	**1.39**	**17.59**	**2.13**	**0.04**	**0.59**	**0.34**
Initial	**8.6**	**150**	**0.28**	**178**	**11.4**	**386**	***15.82***	***0.42***	***13.8***	***6.32***

Table.7 Effect of gypsum and organics on microbial populations after harvest of paddy

Treatment	Microbial populations		
	Bacteria (cfu $\times 10^7 g^{-1}$ soil)	Fungal (cfu$\times 10^3 g^{-1}$ soil)	Actinomycetes (cfu $\times 10^4 g^{-1}$ soil)
T1	2	8.25	9.25
T2	5.02	16.3	21
T3	6.5	20.27	29.25
T4	5.8	17.82	25.42
T5	7.25	20.8	29.5
T6	4.75	15	17
T7	3.77	10.5	13.75
SEM	**0.72**	**1.02**	**1.5**
LSD **(*P* < 0.05)**	**2.12**	**3.01**	**4.41**
Initial	***1.75***	***6.25***	***7.64***

Soil health improvement

Physiochemical status

The lowest pHs 8.41 was noticed with the application of Spent wash @ 2.5 lakh L/ha +Lagoon sludge @ 5 t/ha followed by Spent wash @ 5 lakh L/ha (8.44). There was numerical decrease in pHs and ECe of soil after harvest of crop. The reduction in pHs of soil would be due to acidic nature of spent wash and release of organic acids on decomposition. Similar findings were also reported by Rath *et al.,* (2010), Deshpande *et al.,* (2012) and Naorem *et al.,* (2017). The improvement in organic carbon status of soil by 64.2 per cent over control could be ascribed due to decomposition of organic matter in soil on supplied through distillery spent wash and lagoon sludge. Similar results were also reported by many workers (Selvalakshmi *et al.,* 2001, Deshpande *et al.,* 2012).

The highest available N, P and K (227.9, 17.1 and 483.98 kg/ha) which were improved by 19.0, 52.8 and 26.6 per cent over control were noticed with the application of Spent wash @ 2.5 lakh L/ha + Lagoon sludge @ 5 t/ha followed by Spent wash @ 5 lakh L/ha. The treatment brought about improvement in soil health which in turn increase the mineralization of native and applied nitrogen brought about a considerable improvement in nitrogen content of soil (Table-6). The results are in conformity with those reported by Ramana *et al., (*2002), Bhaskar *et al.*, (2003), Selvamurugan *et al., (*2013) Khandkar *et al., (*2017).

Exchangeable cations in soil

Increase in exchangeable K, Ca and Mg content with the application of Spent wash @ 2.5 lakh L/ha + lagoon sludge @ 5 t/ha was 64.8, 26.1 and 29.7 per cent respectively over control followed by spent wash @ 5 lakh L/ha. This could be due to the higher content theses nutrient in spent wash and lagoon sludge. Similar results were also reported by Bhaskar *et al., (*2003) and Das *et al., (*2010). The exchangeable Na was decreased significantly by 37.5 per cent over control with the addition of Spent wash @ 2.5 lakh L/ha+ lagoon sludge @ 5 t/ha. the reduction might be due to the replacement of exchangeable Na by Ca/Mg present in spent wash applied.

The decrease in ESP of post harvest soil due to the replacement of Na^+ by Ca^{2+} during decomposition of spent wash must have led to the reduction in soil ESP. The findings are in close agreement of those reported by Kumar *et al.,* (2017). Those it can be concluded that the increasing the growth and yield of paddy as well as in the amelioration of black alkali soil more uptake of N, P, K, Ca and Mg and decrease in Na uptake conforms the amelioration of soil.

Microbial status

The highest population Bacteria (7.25 cfu $\times 10^7 g^{-1}$ soil), fungi (20.80cfu $\times 10^3$ g^{-1} soil) and actinomycetes (29.50 cfu $\times 10^4$ g^{-1} soil) was observed when spent wash @ 2.5 lakh L/ha + lagoon sludge @ 5 t/ha was applied. The per cent increased in microbial population of Bacteria, fungi and actinomycetes there 262.5, 152.1 and 218.9 respectively, over control by the application of spent wash along with lagoon sludge.

The increase possibly due to the presence of high organic matter present in spent wash and lagoon sludge. Similar effects of spent wash application on microbial population of soil were also reported by Deshpande *et al.*, (2012), Goli and Sahu (2014) and Kumar *et al.*, (2017).

In conclusion the findings revealed that Spent wash @ 2.5 lakh L ha^{-1} + Lagoon sludge 5 t ha^{-1} was found to increase significantly the growth and yield components, yield, N, P, K, Ca and Mg content in and uptake by paddy whereas, decreased the Na content and uptake and soil health improvement in terms in the organic carbon, availability N, P, and K, exchangeable Ca exchangeable Mg and microbial population over control whereas, decreased the pHs ECe, sodium and ESP value (Table 7).

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