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Application of Recycled Gypsum on Alkali Soil for Improving Agricultural Productivity in China

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Gypsum has been known as a prominent material for improving alkali soil, and this material can be supplied easily in large scale by recycling waste gypsum plasterboard from construction and demolition sites in advanced countries. In April 2000, in the part of western Jilin Province in China, where alkali soil spread vastly, we conducted a cultivating experiment of corn and rice after treating with granule recycled waste gypsum at six alkali soil fields which total area were 14000 m^2.

We confirmed that pH of soil decreased in a short period and alkali soil changed soft a desirable condition for farm work, and furthermore, gypsum caused to accelerate the growth of a plant, both corn and rice.

Keywords: Alkali soil, Recycled waste gypsum, Improvement, Desertification

Introduction

A huge grassy plain spreading over the northern west area in China has been shrinking and turning to desert due to alkali soil year by year. This phenomenon is caused not only by dried weather, but also anthropogenic influences, such as irrigation with ground water containing alkaline salts and over grazing of livestock. Nowadays, the alkali soil in Jilin covers an area of more than about 1.6 million hm^2. As most of fields and paddy fields in western Jilin were made by reclaiming land of alkali soil, crops yields are seriously affected. Although Jilin Government has tackled to improve alkali soil problem for many years by means of several farming technologies, such as irrigation method, drainage method ,and removing salts by plantation method[1,2], on account of drastic desertification they still have been unable to check the spread of the alkalization.

Gypsum has been known as a prominent material for improving alkali soil, and to turn the alkali soil to farm land suited for cultivation as well as recover a grassy plain.

This material should be likely to be supplied easily in large scale by recycling waste gypsum plasterboard from construction and demolition sites in advanced countries.

Massive amounts of gypsum generated as wastes will be the savior not only for improving agricultural productivity, but for preventing desertication by recovering vegetation.

Experimental

The gypsum used in this experiment was collected from construction sites and manufacturing lines. Subsequently, gypsum boards are crushed and granulated into powder measuring 3mm or less by the machine equipped with specialized sorters separating papers. Average diameter of the particle is approximately 0.3mm. In **Table 1**, it's chemical components are shown. The contaminants of heavy metals in gypsum powder used and soils of test plots are also presented in **Table 2**. The contaminant contents were below the level according to the Chinese soil standard.

Figure1. The map of Jilin Province and the location of test plots.

Location of test plots

The location designated for test plots are totally 6 places (**Figure1**) and shown in **Table3**. These fields are affected with alkali soil and their properties are evaluated according to the three grades, such as serious, medium, and slight respectively.

We conducted a cultivating experiment of corn and rice

after treating with recycled waste gypsum powder which total area were 14,000 m^2, and the area of every test plots was about 2000m^2-3000m^2 on the average.

Table1. Chemical components of Granulated Gypsum Board (%)

S	P	Mg	Ca	K	Na	Al	Fe
16.5	0.011	0.055	22.5	0.043	0.066	0.079	0.14

Table2. Heavy metal contaminants contained in Granulated Gypsum Board and alkali soil used

Samples	Sites sampled	pH	Hg mg/Kg	Cd mg/Kg	Ni mg/Kg	Cu mg/Kg	Pb mg/Kg	Zn mg/Kg	As mg/Kg	Cr mg/Kg
Gypsum powder	YM Co. Japan	6.37	0.066	0.098	4.22	3.42	2.27	5.18	0.26	6.82
Soils of corn field	Sijinzhi-Zhen	9.6	0.030	0.117	7.60	7.50	12.80	3.40	4.10	28.72
Paddy soil	Xingrong shan-Z hen	8.3	0.051	0.095	15.28	11.05	14.57	4.86	7.66	25.34
Environmental Quality Standards for Soil Pollution in China (mg/Kg)		—	0.15	0.20	40	35	35	100	15	90

Table3. Locations of test plots and grade of alkali soil used

grade of alkali soil	Corn fields	Paddy fields
serious	1) Pot test at Institute of Soil and Fertilizer,Gongzhuling	------
moderate	2)Daguan Village, Sijinzhi-Zhen, Tongyu Prefecture in Baicheng City 3)Gaohanyingzhi Village, Fenhua-Zhen, Ninjiang Qu, Songyuan City	5) Xingrongshan-Zhen Tongyu Prefecture
slight	4)Sijinzhizhen Village, Tongyu Prefecture in Baicheng City	6)North Fenhua-Zhen 7)South Fenhua-Zhen

Spraying method of gypsum

As seedtime of corn and season of rice-planting in Jilin are late in April and early in May respectively, the time for spraying gypsum was scheduled for each reasonable terms. Before spraying gypsum , stumps and stems of corn left in the field after harvesting last year were removed with a farm tractor .

After cultivating fields, gypsum powder was sprayed by hand-powered (**Figure 2**) and stirred and mixed with soil 6-8cm in depth up to uniform by the farm tractor (**Figure 3**). The amount of gypsum sprayed per unit area was chosen 5 cases as 0kg/m2, 0.5 kg/m2, 1.0 kg/m^2, 1.5 kg/m^2, 2.0 kg/m2, 2.5 kg/m^2 respectively. This farm work was carried out about 10 days before seeding.

Investigating method of alkali soil

Soil samples were collected at 6 test plots twice in Spring and Autumn. To investigate depth profiles of alkalinity of soil, samples were taken from the surface to 60cm in depth in units of 10cm or 20cm.

Some itemized lists of physicochemical properties of the soil to be measured are presented in **Table 4**.

Table 4. Some itemized lists of physicochemical properties of alkali soil

Physicochemical properties
- pH
- ESP

Contents of Exchangeable cations and anions in the soils;
- Na, K, Ca, Mg
- Cl^-, HCO_3^-, CO_3^{2-}, SO_4^{2-}

Hardness of soils
Water content
Interstitial volume

Furthermore, a growth process of plants were observed for height of stem, number of leaf, the extent of reproduction by fission, and the yield of crops.

Table.5 Effect of gypsum application on pH and ESP in a medium alkali soil of corn field in autumn.

Characteristics	Treatment (Kg/m^2)					
	0.0	0.5	1.0	1.5	2.0	2.5
pH	8.79	8.02	7.83	7.84	7.65	7.57
ESP (%)	37.4	22.4	16.3	7.7	6.2	2.4

Table.6 Effect of gypsum application on the yield of rice and corn crops at 6 test plots

Test plots \ Gypsum applied (kg/m^2) / Yield (kg/hm^2)		0.0	0.5	1.0	1.5	2.0	2.5
Fenhua-Zhen(corn)	Yield (kg/hm^2)	4699	5460	5710	5856	6596	53.45
	Rate of increased productivity (%)		16.19	21.52	24.62	40.37	13.75
Sijinzhi-hen(corn)	Yield (kg/hm^2)	2640	3120	5640	2917	5388	4629
	Rate of increased productivity (%)		18.18	113.64	10.49	104.09	75.34
Sijinzhi-Zhen(corn)	Yield (kg/hm^2)	3414	3526	3318	3376	3532	4707
	Rate of increased productivity (%)		3.28	-2.81	-1.11	3.46	37.87
Xingrongshan-Zhen (rice)	Yield (kg/hm^2)	4223	4739	5735	5817	6898	5554
	Rate of increased productivity (%)		12.22	35.80	37.75	63.34	31.52
South Fenhua-hen(rice)	Yield (kg/hm^2)	7561	7435	9187	9138	10242	9587
	Rate of increased productivity (%)		-1.67	21.51	20.86	35.46	26.80
North Fenhua-hen (rice)	Yield (kg/hm^2)	9463	10525	10495	11374	10451	10276
	Rate of increased productivity (%)		11.22	10.91	20.19	10.44	8.59
Average yield (corn)	Yield (kg/hm^2)	3584	4035	4889	4050	5172	4894
	Increased productivity (kg/hm^2)		451	1305	466	1588	1310
	Rate of increased productivity (%)		12.58	36.41	13.00	44.31	36.55
Average yield (rice)	Yield (kg/hm^2)	7082	7566	8472	8776	9197	8472
	Increased productivity (kg/hm^2)		484	1390	1694	2115	1390
	Rate of increased productivity (%)		6.83	19.63	23.92	29.86	19.63

Results and Discussion

From the results of investigating physicochemical properties of soils, it was ascertained that these soils were affected with Sodium Carbonate as a common salt.

In **Table 5** , changes in pH and ESP of alkali soils affected by different gypsum treatment at the harvesting season were presented. For convenience' sake, the pH and ESP value were averaged for several points at every test plots. The pH of fields and paddy soils amended by gypsum decreased with increasing amount of gypsum application compared to the control. For example, pH of soil treated by gypsum of $2.5Kg/m^2$ reduced from 8.52 to 7.57.

Furthermore, ESP as a parameter of sodicity of soils reduced from about 40 % to nearly or under 15% which is the generally accepted limit above which the soils are classed as " alkali ".

Interestingly, the profile of sodium adsorption ratio (SAR) in depth indicated that the sodicity of soils reduced along with depth of soil layer. At least, soils up to 20 cm in depth have been improved within the period of this experiment. This indicates that Ca^{2+} ion eluted from gypsum penetrates to soil layer in depth and replaces with sodium ion on the surface of soil exchange complex. Due to the amendment of alkali soils by gypsum, physical properties of alkali soils not only changed floculated and reverted to a stable condition, but also permeability of soils to water and air was also improved.

It showed that gypsum treatment provided the greater harvest for corn and rice of 5 - 45% on average of 6 test plots(**Figure 4,5**), but at some corn field, it exceeded more than 100% of yield compared with the control(**Table 6**).

CONCLUSION

In the western part of Jilin Province, China, the experiments on the improvement of alkali soils was conducted by using gypsum powder recycled waste

gypsum plasterboard generated from construction sites and demolition sites in Japan.

From the results, it was verified that gypsum treatment is considerably effective not only to remediate the alkali soils due to Sodium Carbonate and to soften the hard soil in a short period, but also to increase cultivated field and the food production.

Application of recycled gypsum on alkali soil distributed widely in Jilin should bring about an immeasurable effect for recovering their lost plentiful vegetation.

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Figure 2. Spraying gypsum powder to corn field

Figure 3. Mixing gypsum powder with alkali soil by a farm tractor

Figure 4. Comparison of growing corn crops between experiment lot of 0.5 gypsum Kg/m^2 (left) and control (right).

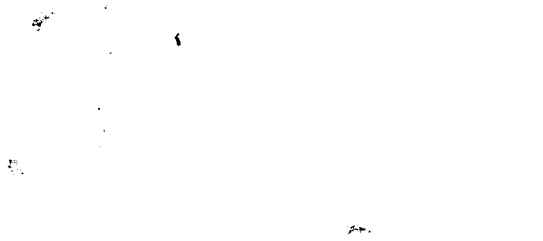

Figure 5. Comparison of growing corn samples harvested in autumn. The amount of gypsum applied is 0.0 Kg/m^2, 0.5 g/m^2, 1.0 Kg/m2, 1.5 Kg/m^2, 2.0 Kg/m^2, 2.5 Kg/m^2 respectively in order from left.