Utilization of Pressmud as Organic Amendment to Improve Physico-Chemical Characteristics of Calcareous Soil under Two Legume Crops

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Summary: The soils of Dera Ismail Khan are calcareous in nature and are particularly low in organic matter, N, P and micronutrients; especially Zn. Use of only NPK fertilizers has also disturbed the C: N ratio. Consequently, the soil resource base has been degraded and factor productivity has declined. Application of organic fertilizers improves crop yield, soil physico-chemical characteristics and recycles wastes in environment friendly manner. To achieve these objectives pressmud was applied to mung bean and lentil crops in pots having 20 kg soil @ 2, 4, 6, 10, 15 and 20 tonnes ha^{-1}. Treatments having recommended dose of N: P_2O_5: K_2O (30:60:45 kg ha^{-1}) were also included in the experiments. Maximum increase for most of the yield parameters of lentil was recorded in NPK treatment, followed by P_6 receiving 20 tonnes ha^{-1} press mud. The post harvest analysis of soils treated with pressmud showed progressive increase in EC, organic matter content, Na^+, HCO^-_3, Cl^{1-} and SO_4^{2-} with increasing levels of pressmud. The concentration of NPK, Zn, Cu, Fe and Mn in the treated soil samples also increased and was maximum where pressmud was applied @ 15 and 20 tonnes ha^{-1}.

Introduction

The utilization of industrial wastes, like pressmud, on agricultural fields is gaining popularity due to the fact that the nutrient supplying capacity of the soil is becoming a limiting factor. Traditional use of mineral fertilizer in agriculture cannot be over emphasized, but with fertilizer costs going up, these need to be supplemented or substituted with available organic wastes or manures. This phenomenon, gaining popularity recently is called sustainable agriculture. Pressmud is a good source of organic matter, NPK and important micronutrients and has established its importance in improving fertility, productivity and other physical properties of agricultural soils [1, 2]. Therefore, land application of this industrial waste for crop production provides a feasible and cost effective disposal alternative [3]. The practice could also be considered helpful for disposal/management of industrial wastes with minimum risk of environmental pollution.

Legumes are the major caloric and protein source in our country especially for vegetarian population. It is becoming an important crop, as it is one of the best alternatives to meet the food needs of the large population of developing countries on account of its quick maturation, nutritional superiority & nitrogen fixing. It can play a pivotal role in soil nutrients build-up process because of the most effective system of biological nitrogen fixation through its symbiotic relationship with Rhizobium & Bradyrhizobium.

Lentil (*Lens culinaris*) and mung bean (*Vigna radiata* L. Wilczek) are the important legume crops used as pulses. Lentil locally called masoor belongs to family Papilionaceae and has been widely grown since early times. It is still cultivated worldwide. In Pakistan, it covered an area of 54900 hectares, which produced 35500 tonnes of grain legumes in 1999-2000 [4]. Mung bean was also cultivated on 2,20,700 ha area in Pakistan and gave 94800 tonnes production in 1999-2000.

Press mud is produced as a waste product in vacuum filters and press filters of the sugar industry (during sugar manufacture) in the range of 3-8 % of the crushed cane, depending on the nature of sugar manufacturing process. Regular additions of organic materials such as sugar industry wastes, municipal biosolids, animal manures and crop residues are of utmost importance in maintaining the tilth, fertility and productivity of agricultural soils [5]. They also protect the soils from wind and water erosion, thus preventing nutrient losses through runoff and leaching. Press mud or filter cake is one of the important organic wastes capable of supplying sufficient amount of plant nutrients to soil. Due to its favorable effects on physical condition of soil, the

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water holding capacity and aeration of the soil is improved. The high amount of NPK contents has made it a valuable nutrient resource [6]. Along with luxurious amount of organic matter, important micronutrients like Zn, Cu, Fe and Mn are also abundant in press mud, being deficient in calcareous soils. Therefore, press mud is more likely to improve the micronutrient distribution and enhance microbial activities. Thousands of tonnes of pressmud produced annually cause great disposal problems for the sugar industry and environmentalists. Recently its use as fertilizer in agriculture has been started [7]. Limited research on the use of press mud has shown positive effects on improving crop yield [8-11]. Press mud also improves input use efficiency when used in combination with organic fertilizer [12].

The overall objective of the study was to develop a comprehensive strategy to utilize our organic wastes in environmentally safe manner. The present study was therefore, planned to investigate the quality of pressmud and its impact on soil health and yield of crops (lentil and mung bean). Recommendations of proper doses for its safe use on agricultural lands were also an objective of the study.

Results and Discussion

The results concerning the effect of pressmud on soil properties, yield and yield components of mung bean and lentil have been presented and discussed in the following pages.

Effect of Pressmud on Growth Parameters of Mung Bean

The data given in Table-2 shows that different growth and yield parameters of mung bean recorded significantly differences in response to various pressmud treatments. Maximum germination was recorded in fertilizer (NPK) treatment followed by the treatment having pressmud @ 20 t ha^{-1}(P_6). The lowest germination % age was recorded in P_1, P_2, P_3 followed by P_4 and control treatments. These differences in germination % age may be attributed to the levels of pressmud application which resulted in an environment conducive to the seed germination.

The root length data also revealed significantly difference response towards various treatments. Maximum root length (13.83 cm) was recorded in Fertilizer (NPK) treatment that was statistically at par with all other treatments except control. The decrease in root length in control may be due to low nutrient content as compared to other treatments.

Plant height was increased significantly by the fertilizers (NPK) and different doses of pressmud application. It revealed that maximum plant height (29.08 cm) was recorded in treatment getting fertilizer that was significantly different from all

Table-1: Physico-chemical characteristics of soil and pressmud.

Characteristics	Units	Soil Value	Pressmud Value
Textural class		Sandy Clay Loam	------
Dry bulk density	g cm^{-3}	1.34	------
Total Porosity	%	51.00	------
pH		8.2	7.8
EC_e	dSm^{-1}	0.38	2.2
CaO_3	mg kg^{-1}	63000	------
HCO_3^-	mg kg^{-1}	100	9150
CO_3^{--}	mg kg^{-1}	26	------
Cl^-	mg kg^{-1}	93	4822
SO_4^{--}	mg kg^{-1}	27	1992
Soluble Na	mg kg^{-1}	69	750
Ca^{++}+ Mg^{++}	mg kg^{-1}	94	5442
O.M	mg kg^{-1}	8200	210000
Total N	mg kg^{-1}	300	20000
Available P	mg kg^{-1}	7.5	13000
Available K	mg kg^{-1}	172	19500
Cu	mg kg^{-1}	6.5	64
Fe	mg kg^{-1}	5.4	322
Mn	mg kg^{-1}	11.0	298
Zn	mg kg^{-1}	6.2	125

Table-2: Effect of pressmud on growth and yield parameters of mung bean.

Treatments	Germination %	Root Length (cm) *	Plant Height (cm) *	No. of Branches $Plant^{-1}$ NS	No. of Pods $Plant^{-1}$ *	No. of Grains Pod^{-1} NS	1000 Grain wt (g) *	Dry Matter Yield $Plant^{-1}$ (gm) *	Grain Yield $Plant^{-1}$ (gm) *
Control	77.75 cd	7.16 b	19.75 e	8.58	3.74 c	5.35	43 c	7.92 b	4.77 c
Fertilizer	80.5 a	13.83 a	29.08 a	8.08	8.5 a	8.0	54.5 a	20.85 a	11.5 a
P_1	75 d	8.58 ab	20.55 e	6.58	4.28 bc	5.73	43.75 c	8.67 b	4.80 c
P_2	75 d	8.74 ab	21.69 de	6.74	5.20 abc	5.98	44 c	10.27 ab	5.14 c
P_3	75 d	8.75 ab	23.34 cd	6.91	5.22 abc	7.4	45.25 bc	10.45 ab	5.15 c
P_4	76 cd	9.15 ab	24.62 bc	9.08	5.58 abc	7.5	45.75 bc	14.1 ab	6.45 c
P_5	78 bc	12.28 a	25.87 b	8.24	7.58 abc	7.6	46.75 bc	15 ab	8.01 bc
P_6	78.75 ab	13.49 a	26.51 b	7.58	8.16 ab	7.73	48.75 b	16 ab	9.8 ab
LSD (0.05)	1.84	3.56	1.98	2.06	2.64	2.17	3.19	7.37	2.24

* = Mean values followed by the same letters are not significantly different at α =0.05

other treatments. This increase in plant height could be attributed to the abundance of N, P and other nutrients and improvement in soil texture and structure by the presence of high amount of organic matter in the organic applications. Organic manures including pressmud application to crops have positively affected the plant growth parameters [13, 14].

Effect of Pressmud on the Yield and Yield Parameters of Mung Bean

Statistical analysis of data pertaining to number of branches plant^{-1} and number of grains pod^{-1} as given in Table-2 revealed that there were no significant differences among all the treatments including control.

The effect of pressmud and mineral fertilizer helped to increase the number of pods plant^{-1} because of its positive effect on soil, nutrients' availability and organic matter contents along with pH, exchangeable Ca and Mg in the soil as shown in Table-4. Researchers during their experiments have proved that press mud increased the mung bean yield and exchangeable Ca and Mg and P contents in the soil [15].

The 1000-grain weight data revealed significant increase due to various doses of pressmud and mineral fertilizer in comparison to control. Maximum (54.5 g) 1000-grain weight was found in the fertilizer (NPK) treatment that was significant in regard to all other treatments. This increase in 1000 grain weight is attributed to the nutrients availability after treatment of soil with organic and inorganic amendments. These results are also in agreement with the work of other researchers who found that organic manures including pressmud significantly increased the grain and straw yield of mung bean [16].

The grain yield was also significantly affected by different treatments. Maximum (11.5 g) grain yield plant^{-1} was found in the treatment receiving NPK fertilizer, followed by 9.8 g in pressmud treatment P_6, both of which were statistically at par with each other. As pressmud has been proved as a good source of organic matter, N, P, K, Cu and Zn etc. Therefore, it is evident from the study that different doses of pressmud favorably affected the grain yield of mung bean. These findings are analogous to the results of numerous researchers who reported significant increase in mung bean yield due to pressmud application [17, 18].

Maximum dry matter yield of 20.85 g plant^{-1} was recorded in fertilizer (NPK) treated plants, which was significantly different from all other treatments. However, this was followed by P_6, P_5, P_4, P_3, P_2 and P_1 treatments. These results are in agreement with the work of other researchers who found significant increase in mung bean dry matter yield due to organic amendments (pressmud) [19]. Increased yield of mung bean and high sulphur content of soil treated with pressmud has been reported by other scientists [20].

Effect of Pressmud on Growth Parameters of Lentil

The data on germination % age showed significant differences among various treatments. The treatments getting NPK fertilizer recorded maximum germination followed by P_6. The % age was lower in P_1, P_2, P_3 followed by P_4 and control treatments. Application of pressmud alters soil physico-chemical properties favorably therefore, increase in germination % age is also evident due to different doses of pressmud.

The data given in Table-3 reveals that there are also significant differences among various treatments when plant height is considered. Upper limit (24.58 cm) for plant height was recorded in treatment getting fertilizer which was followed by P_6, P_5 and P_4. These results are in line with the work carried out by researchers who reported increased plant height in lentil crop due to pressmud application [21].

Root length data showed that there were significant differences among various treatments. Maximum (18 cm) root length was recorded in fertilizer treatment that was statistically different from all other treatments. It is also evident from some other experiments that growth parameters in green gram were also increased by doses of organic amendments including pressmud [22].

The data pertaining to the number of branches plant^{-1} of lentil as affected by different doses of pressmud and chemical fertilizer are presented in Table-3. Statistical analysis of data showed that there were no significant differences among all the treatments including control.

Table-3: Effect of pressmud on growth and yield parameters of lentil.

Treatments	Germination %	Root Length (cm) *	Plant Height (cm) *	No. of Branches Plant^{-1} NS	No. of Pods Plant^{-1} *	No. of Grains Pod^{-1} NS	1000 Grain wt (g) *	Dry Matter Yield Plant^{-1} (g)*	Grain Yield Plant^{-1} (g)*
Control	77.40 cd	10 c	15.78 e	9.58	39 b	1.25	24.25 c	5.68 d	2.62 c
Fertilizer	79.80 a	18 a	24.58 a	13.83	71.57 a	2.00	35.25 a	10.63 a	5.38 a
P_1	76 d	12.77 b	16.13 e	10.33	39.75 b	1.50	25.25 c	5.88 d	2.62 c
P_2	76.5 d	13.13 b	16.4 de	10.87	51.5 ab	1.75	25.5 c	6.08 d	2.87 c
P_3	76.60 d	13.5 b	17.13 de	10.96	53.45 ab	1.75	25.62 c	6.49 d	2.98 c
P_4	76.80 cd	13.87 b	18.13 cd	11.13	53.75 ab	1.50	27.75 b	6.74 cd	3.14 c
P_5	78.60 bc	14.37 b	19 c	11.87	55.75 ab	1.75	28.5 b	7.62 c	3.15 c
P_6	79.40 ab	14.52 b	21.93 b	12.25	59.5 ab	2.00	30.5 b	9.30 b	3.98 b
LSD (0.05)	1.86	2.28	1.48	5.066	20.26	0.66	3.21	0.92	0.59

* = Mean values followed by the same letters are not significantly different at α =0.05.

Table-4: Impact of pressmud on the physico-chemical characteristics of soil.

S. No.	Characteristics	Units	Soil Treated with Pressmud (t ha^{-1}) 0	2	4	6	10	15	20
1	Textural class		Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam
2	Dry bulk density	G cm^{-3}	1.34	1.34	1.34	1.30	1.30	1.28	1.25
3	Total porosity	%	51.00	51.00	51.20	51.20	51.30	51.40	51.40
4	pH		8.2	8.2	8.2	8.2	8.10	8.00	8.00
5	EC_e	dSm^{-1}	0.38	0.38	0.45	0.50	0.65	0.80	0.90
6	$Ca^{++} + Mg^{++}$	mg kg^{-1}	94	110	125	160	190	225	240
7	Cl^-	mg kg^{-1}	93	140	195	270	360	405	446
8	CO_3	mg kg^{-1}	26	26	26	27	28	28	28
9	HCO_3	mg kg^{-1}	100	150	220	260	310	365	425
10	SO_4	mg kg^{-1}	26	40	65	82	115	130	148
11	Soluble Na	mg kg^{-1}	69	69	85	110	118	122	126
12	Available K	mg kg^{-1}	172	190	210	235	260	276	293
13	O. M	mg kg^{-1}	8200	8280	8370	8410	8480	8530	8600
14	Total N	mg kg^{-1}	300	380	640	790	885	960	1070
15	Available P	mg kg^{-1}	7.5	20	58	95	140	210	280
16	Fe	mg kg^{-1}	5.4	5.4	6	7.0	7.5	7.5	8
17	Mn	mg kg^{-1}	11.0	11.0	11.00	11.00	11.00	12.00	12.00
18	Cu	mg kg^{-1}	6.5	6.5	6.5	7.0	8.0	8.0	9.0
19	Zn	mg kg^{-1}	6.2	6.2	6.2	7.0	8.0	9.0	10.0

Effect of Pressmud on Yield and Yield Parameters of Lentil

The statistical analysis of data given in Table-3 shows that there are no significant differences among the number of grains pod^{-1} affected by levels of pressmud and NPK. Maximum number of 71.57 pods plant^{-1} were recorded in the treatment having fertilizer (NPK) which was statistically at par with all other treatments except control and P_1.

The data also shows that 1000-grain weight was significantly increased due to various doses of pressmud and mineral fertilizer in comparison to control. Maximum(35.25 g)1000-grain weight of lentil was found in the treatment receiving chemical fertilizer (NPK) differing significantly from all other treatments. It is also clear from the studies of other researchers that grain weight and yield of lentil crop increased due to the application of different doses of pressmud [23, 24].

The data in Table-3 reveals that all the different doses of pressmud significantly increased the grain yield as compared to control. Maximum grain yield of 5.38 g was obtained from the treatment receiving NPK fertilizer. That was significantly different from all other treatments while, lowest (2.62 g) grain yield plant^{-1} was produced in the control which was at par with all other treatments except P_6 and fertilizer. These findings are analogous to the results of other researchers who reported significant increase in lentil yield and other important yield parameters of the crop due to pressmud application [18, 25, 26].

The data on dry matter yield plant^{-1} of lentil shown in Table-3 also reveals that maximum yield (10.63 g) was recorded in the fertilizer (NPK) treatment, which was significantly different from all other treatments. These results are also partially in line with the findings of researchers who found significant increase in the micronutrient contents of soil and dry matter yield of crops in the pressmud amended soil [27].

Impact of Pressmud on Physico-Chemical Characteristics of the Soil

The soils of D. I. Khan are calcareous in nature and are particularly low in organic matter, N, P and micronutrients especially Zn and B (Table-1). The analysis of the soils treated with pressmud showed that there was a progressive increase in EC, % organic matter, Na^+, HCO3, Cl^{1-} & SO_4^{2-} with increase in the levels of pressmud. The concentration of NPK, Zn, Cu, Fe and Mn in the treated soil samples also increased and was maximum where pressmud was applied @ 15 & 20 t ha^{-1}. Growth of the mung bean & lentil was higher in NPK treatments followed by P_5 & P_6 as compared to other treatments.

The results given in Table-4 revealed that application of pressmud affected the physico-chemical characteristics of the soil positively. The soil pH decreased from 8.2 to 8.0 while, EC was increased from 0.38 to 0.90 dSm^{-1} with the increasing doses of pressmud. The available NPK, Zn, Cu, Fe and Mn contents increased with application of pressmud. The highest amount of nitrogen (1070 mg kg^{-1}), phosphorus (280 mg kg^{-1}), potassium (293 mg kg^{-1}) and zinc (10 mg kg^{-1}), copper (9.0 mg kg^{-1}), iron (8.0 mg kg^{-1}), and manganese (12.00 mg kg^{-1}) were recorded in the treatments getting pressmud @ 20 t ha^{-1}. Studies have also revealed that addition of organic residues (including pressmud) generally raised concentrations of exchangeable cations and extractable P and increased the electrical conductivity of the amended soil [28].

Soil textural class remained the same while dry bulk density and total porosity were positively affected by pressmud. The data also reveal that organic matter content of the soil increased from 8200 mg kg^{-1} up to 8600 mg kg^{-1} with increasing levels of pressmud. In general, the dry bulk density showed a continuous decrease while total porosity was continuously increased with the successive increasing doses of pressmud.

NPK and micronutrients content of the soil amended with different doses of press mud increased because press mud was rich in these nutrients. Other researchers have also found press mud a good nutrient source [29, 30]. Increase in organic matter content, total porosity of the soil and decrease in bulk density might have improved the nutrients availability, soil physical qualities, water holding capacity and population of soil microorganisms. These are extremely important changes because increase in organic matter contents of soil due to press mud might have improved soil physical conditions reducing soil bulk density and increasing porosity. The reduction in bulk density helps in better root development and proliferation. On the other hand increased soil porosity helps in better soil aeration and water retention. These results are also in accordance with the findings of researchers who reported an increase in macro and micronutrient contents of the soil after treatment with mixture of sugar cane trash + pressmud [27, 31].

Experimental

The 3-years research project entitled "Utilization of pressmud as organic fertilizer to improve soil fertility and crop yield" was initiated at Faculty of Agriculture, Gomal University, D. I. Khan during 2005-06. Samples of soil used in the study were collected from 0-30 cm depth before and after crop harvest. These soil samples were air dried, ground and passed through 2mm sieve. Pressmud used, as organic fertilizer was collected from the waste disposal site of Chashma Sugar Mills (Pvt) Ltd., D. I. Khan. Four samples of pressmud from the homogenized heap were taken from sides and top and after thorough mixing were transferred to the laboratory. All the samples were analyzed for their physico-chemical characteristics, according to the described methods [32] or otherwise mentioned below.

Soil and Press Mud Sample Analysis

Pressmud used in the investigations was taken from the waste disposal site of Chashma Sugar Mills (Pvt) Ltd; D. I. Khan, Pakistan. These samples were air dried and passed through 4mm sieve. The pH of the saturated extract of pressmud and soil samples was determined electrometrically by a combined glass/reference electrode. Electrical conductivity of the saturated extract of the samples was determined with the help of a conductivity meter and was expressed in dSm^{-1} at 25 ^{0} C. Filtrate from pressmud and soil samples extracted by ammonium acetate solution was used for determination of Na by Flame Photometer [33]. Ca^{++} + Mg^{++} were determined by EDTA titration where NH_4Cl-NH_4OH buffer solution and eriochrome black T indicator were used. CO_3^-, HCO_3^- and Cl^- were determined as

stated by Richard [33]. Sulphur was determined in the extractants by 0.15% calcium chloride dihydrate with spectrophotometer [34]. Organic matter content in pressmud and soil samples was determined by dichromate method recommended by MAFF [35]. Total N was determined by the Kjeldahl procedure [36]. Available K was determined by ammonium acetate method [37]. Phosphorus was determined by ammonium molybdate-vanadate method by producing a blue color [38]. Available potassium was determined by ammonium acetate method with flame photometer [37]. Micronutrients (Zn, Cu, Fe and Mn) were extracted with 0.005 M DTPA extractant [39] and concentration determined by Atomic Absorption Spectrophotometer.

Pot Experiments

Well prepared 20 kg of soil was added to each pot and pressmud was applied @ 2, 4, 6, 10, 15 and 20 t ha^{-1} to the pots. Treatment having recommended dose of N: P_2O_5: K_2O (30:60:45 kg ha^{-1}) was also included in the experiment. Ten seeds of lentil (*Lens culinaris*) and mung bean (*Vigna radiata* L. Wilczek) were sown in each pot. Mung bean was sown on 30th June, 2005 while the lentil was sown on 10th November, 2005. The experiment was laid out in a completely randomized design and each treatment was replicated four times. All the pots were irrigated with tap water. Normal cultural practices and pesticide treatment were carried out during the growing period of the crop. After germination, thinning was done and only three plants were left in each pot. Plants were irrigated till maturity according to the requirement of the crops. Harvesting of the mung bean and lentil was done on 4th October, 2005 & 14th February, 2006, respectively.

Data on different plant parameters like germination count, number of branches $plant^{-1}$, plant height (cm), number of pods $plant^{-1}$, number of branches $plant^{-1}$, no of grains pod^{-1}, 1000-grains weight (g), grain yield $plant^{-1}$ (g), dry matter yield $plant^{-1}$ (g) and root length (cm) were recorded and statistically analyzed according to the methods described by Steel and Torrie [40].

Treatments

C = Control (without NPK and pressmud), F = fertilizer (only NPK) @ 30:60:45 kg ha^{-1}

P= Pressmud

$P_1 = 2$ t ha^{-1}, $P_2 = 4$ t ha^{-1}, $P_3 = 6$ t ha^{-1}, $P_4 = 10$ t ha^{-1}, $P_5 = 15$ t ha^{-1}, $P_6 = 20$ t ha^{-1}.

Conclusions

It could be concluded from these studies that pressmud is rich in organic matter, NPK and micronutrients like Zn, Cu, Fe and Mn which more likely caused improvement in the physico-chemical characteristics of the soil and influenced the soil environment favorably. All the important yield parameters of mung bean and lentil like, number of grains pod^{-1}, 1000-grain weight (g) and grain yield $plant^{-1}$ (g) were increased significantly depending on different doses of pressmud. It could also be inferred from the study that pressmud application @ 15 and 20 tonnes ha^{-1} could be recommended as the most suitable doses for mung bean and lentil production in the calcareous soils of Pakistan.

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