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Effect of gypsum application on Seed yield, total moisture use and moisture use efficiency (MUE) of soybean and chickpea

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Abstract
A field investigation relating to Studies on the Effect of gypsum application on Seed yield, total moisture use and moisture use efficiency (MUE) of soybean and chickpea. Was conducted at Agronomy farm, College of Agriculture, Nagpur. The field experiment was laid out in randomized block design (RBD) with a seven treatments replicated thrice. Treatments consisted of 1, 1.5, 2, 2.5, 3, 5 t gypsum per hectare and a control. The samples were taken from (0-30 cm) and (30-60 cm) depth for conducting study. However MUE of soybean significantly increased with increasing level of gypsum. Higher MUE was found with T_6 (3 t gypsum ha^{-1}) but T_3 (1.5 t gypsum ha^{-1}) is enough to increase MUE of soybean significantly over no gypsum. Increasing level of gypsum also increase the MUE of chickpea. The surface soil of experimental site was slightly alkaline in reaction clayey in texture, medium in organic carbon (6.21 kg^{-1}), low in available nitrogen (206.98 kg), medium in phosphorus (19.23 kg ha^{-1}), high in potassium (503.00 kg ha^{-1}) poor in hydraulic conductivity (1.06 cm ha^{-1}) 1.5 t gypsum ha^{-1} is enough to increase the yield of soybean significantly over control and increasing level of gypsum increases the yield of Chickpea linearly.

Keywords: gypsum, crop yield, soybean, chickpea, moisture use efficiency

1. Introduction

Increases in ESP and EMP with depth have adversely affected the hydraulic and other properties important for crop growth. Saturation of these soils, not only with Na^+ ions but also with Mg^{2+} ions leads to greater dispersion of clay, which is the opposite effect from that saturation with Ca^{2+} ions, which leads to the blocking of small pores in the soil. In other words, Mg^{2+} ions are less efficient than Ca^{2+} ions in flocculating soil colloids. However due to high evaporative demand for soil water in the semi-arid climatic condition, maintenance of a proper Ca/Mg ratio in the soil solution becomes difficult because Ca^{2+} ion get precipitate as $CaCO_3$ result in depletion of Ca^{2+} ions from the soil solution (Balpande *et al*., 1996) [1]. The Vertisols have enough $CaCO_3$ but the soluble calcium concentration in the saturation extract of the many Vertisols were is 0.6 to 3.6 mmol L^{-1} and this amount is not enough to inhibit the swelling of smectite by contracting the diffuse double layer. This indicates the inertness of calcite to inhibit the swelling of smectite. (Balpande *et al.*, 1997) [2].

Under rainfed condition yield of crop depends primarily on the amount of rain stored in soil profile and extend to which this water is released during crop growth. More over both retention and release of soil water are governed by the nature and content of clay minerals, and also by the nature of exchangeable cations.

The exchangeable polyvalent cations (e.g. Ca) near clay surfaces reduces the thickness of the diffuse double layer. The reduction in repulsive forces acting between clay particles (Emerson 1983) [4] helps for the flocculation of clays and increased resistance to dispersion (The Schultze- Hardy Rule). Calcium rather than Mg or K on the exchange complex was associated with stable aggregates in Australian subsoils (Emerson and Bakker 1973) [3]. Pojasok and Kay (1990) [9] found aggregate stability to increase with Ca concentrations in soil solution.

Soybean chickpea sequence is very common on these soils in Vidarbha. Soybean is an important rainy season crop and offers good potential in the cropping sequence being a short duration legume and energy rich oil seed crop next to ground nut. The total water requirement of soybean meets through rainfall received during rainy season. Maharashtra is the second largest soybean growing state in the country having 26.21 *lakh* ha area with production of 28.92 *lakh* tonne and productivity 1254 kg ha^{-1}. Chickpea is the most important *rabi* crop cultivated in Vidarbha. It is grown in *rabi* season after cessation of monsoon on conserved soil moisture, as it is capable of extracting moisture even from the deeper layer of soil due to its tap root system. In Maharashtra state the area under gram was 13.08 lakh ha with production 1.24 lakh tonne and average productivity 621.4 kg ha^{-1} (Anonymous, 2007).

The soil water storage capacity and the likelihood of moisture stress are dominant factor affecting the crop growth in rainfed areas. Available water storage is largely determined by soil physical properties and intensity and duration of rainfall. The Vertisols have high water storage capacity, however due to poor hydraulic conductivity both vertical and lateral entry of water in sub soil would be restricted and the water storage in soil is drastically affected and therefore rainy season crop suffers during moisture stress condition and *rabi* season crop fails due to lack of moisture.

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The dissolution of gypsum prevented the breakdown of aggregates in proportion to the amount of gypsum added. The more gypsum the less breakdown of aggregates. A shape factor for aggregates and pores decreased when ESP or pH increased indicating that chemical conditions affected not only the size but the shape management of the aggregates in the soil matrix. (Lebron *et al.* 2002) This intern helps in more transmission of rain water and sub soil storage of water increases which will be beneficial for soybean chickpea sequence. In the view of above consideration, field experiment entitled Studies on the Effect of Gypsum on Structural Indices of Soil was conducted with following objectives, Effect of Gypsum on Structural Indices of Soil.

2. Materials and Methods

The field investigation in relation to Studies on the Effect of gypsum application on crop yield in Soybean & Chickpea was conducted during Kharif and rabi season at Agronomy Farm, College of Agriculture, Nagpur. The details of material used and methods adopted during the period of investigation are given in this chapter under appropriate heads.

2.1 Experimental site

The field experiment entitled Effect of gypsum application on Seed yield, total moisture use and moisture use efficiency (MUE) of soybean and chickpea. Was carried out at Extra Assistant Director (EAD) farm, College of Agriculture Nagpur. The field selected for conducting experiment was fairly uniform and leveled.

2.2 Soil of experimental area.

The soil under the experimental study was fine montmorillonite of Typic Haplustert, In order to study the physical and chemical properties soil samples were taken from 0-30 and 30-60 cm depth with the help of screw auger from randomly selected spots over the experimental field before sowing. The soil of the experimental field was clay in texture. The result of the chemical analysis data indicate that soil was low in available nitrogen, medium in available phosphorus, very high in available potassium, medium in organic carbon, low in available sulphur soil pH was 8.10 and electrical conductivity recorded 0.20 dS m^{-1}.

2.3 Climate and Weather conditions

Nagpur is situated at 21º 10’ North latitude and 19º 19’ East latitude at elevation of 321.26 meter above sea level and lies under sub-tropical zone. Nagpur is characterized by hot and dry summer and fairly cold winter. This area shows wide diurnal fluctuation in temperature. The maximum and minimum temperature ranged from 43.3 to 8.5ºC respectively. Whereas relative humidity varied from 13% to 90%. During the crop growth period mean annual precipitation was about 928.8 mm and major amount of it is received from June to December within 46 rainy days.

2.4 Experimental details

2.4.1 Design of experiment and treatments

The experiment was laid out in randomized block design (RBD) with seven treatments each replicated thrice, the detail of treatment are presented below.

1	Location	Agronomy Farm, College of Agriculture, Nagpur.
2	Name of the crop (Kharif)	Soybean (JS-335)
	(Rabi)	Chickpea (JAKI -9218)
3	Design of experiment	Randomized Block Design (RBD)
4	No. of Treatments	7
5	No of Replication	3
6	Total no. of plots	21
7	Plot size	Gross 6 x 5.4 m
		Net 4x3.6 m
8	Spacing (soybean)	30 x 5 cm^2
	(Chickpea)	30 x 10 cm^2
9	Fertilizer dose (soybean)	30:75:00 NPK kg ha^{-1}
	(Chickpea)	25:50:00 NPK kg ha^{-1}
10	Seed rate (soybean)	80 kg ha^{-1}
	(Chickpea)	100 kg ha^{-1}
11	Method of sowing (soybean)	Drilling
	(Chickpea)	Drilling

2.4.2 Treatment details
T_1: Control (no Gypsum)
T_2: 1.0 t ha^{-1} gypsum
T_3: 1.5 t ha^{-1} gypsum
T_4: 2.0 t ha^{-1} gypsum
T_5: 2.5 t ha^{-1} gypsum
T_6: 3.0 t ha^{-1} gypsum
T_7: 5.0 t ha^{-1} gypsum

2.4.3 Fertilizer application
The fertilizer application was done as per recommended doses (experimental details) for both the crop. Nitrogen and phosphorus were applied through Urea and SSP respectively, fertilizers doses were applied to different plot at the time of sowing.

1.5 Methodology for gypsum application
Gypsum in powder form was applied to different plots as per treatments before sowing of soybean crop. The proper care was taken for equal mixing of gypsum in surface soil and for that after application of gypsum to soil it was equalized by turning surface soil.

2.5.1 Collection of soil sample for soil moisture study
The treatment wise soil samples were collected with the help of screw auger from (0-30 cm) and (30-60 cm) depth between the two rows at an interval of 15. These samples were immediately put in pre weighed aluminum boxes for determination of moisture content by gravimetric method.

2.5.2 Determination of moisture use efficiency (MUE)
Soil moisture studies
The initial weights of the soil sample along with aluminum boxes were recorded immediately on electronic balance. Then the aluminum boxes along with soil samples were kept in hot air oven at 105ºC up to constant weight obtained and final dry weights were recorded. The soil moisture was determined by gravimetric method. The moisture percent was calculated by using following formula.

$$\text{Gravimetric moisture content (\%)} = \frac{w_1 - w_2}{w_2} \; x\, 100$$

Where,
w_1: Initial weight of soil
w_2: Oven dry weight of soil

2.5.3 Soil moisture in profile during different period of crop growth.
Soil moisture up to depth 60 cm was calculated as follows.
1. Soil moisture (mm) in 0-30 cm layer depth =

$$\frac{\%\, Gravimetric\ moisture\ \ x\ bulk\ density}{100}\; x\, 300$$

2. Soil moisture (mm) in 30-60 cm layer depth =

$$\frac{\%\, Gravimetric\ moisture\ \ x\ bulk\ density}{100}\; x\, 300$$

2.5.4 Moisture use by crop during a period
Moisture use by crop during a period was calculated as follows.

$$\text{Moisture use (mm) during a period} = \text{Soil moisture (mm) up to 60 cm depth at initial stage} + \text{Rainfall during a period (mm)} - \text{Soil moisture (mm) up to 60 cm depth at subsequent sampling}$$

Soil moisture up to 60 cm depth at the first period is considered as initial soil moisture for second period and likewise.

Total moisture use (mm) = $\sum_{i=1}^{n}$ moisture use during different periods.

2.5.5 Moisture use efficiency (MUE)
Moisture use efficiency for each treatment was calculated on the basis of economic yield of the crop and total moisture use by that crop in given treatment by Michael and Ojha, (1983).

$$\text{MUE (kg ha}^{-1}\text{ mm}^{-1}) = \frac{Crop\ \ yield\ (kg\ ha^{-1})}{Total\ moisture\ use\ (mm)}$$

3. Result and discussion
The present investigation entitled Effect of gypsum application on Seed yield, total moisture use and moisture use efficiency (MUE) of soybean and chickpea. Were carried out by conducting a field trial of soybean and chickpea. The results obtained and inferences drawn were discussed under following head.

3.1 Seed yield, total moisture use and moisture use efficiency (MUE) of soybean and chickpea.
Considering total productivity and total moisture use of soybean and chickpea, moisture use efficiency was calculated and the data pertaining to moisture use efficiency (MUE kg ha^{-1} mm^{-1}) under different treatment are presented in table 1.
In soybean maximum moisture use was recorded under T_1 (no gypsum) and lowest moisture use was recorded under treatment T_7 (5 t gypsum ha^{-1}). Moisture use slightly decreases due to increase in level of gypsum.
Data indicated that there were significant effect of different gypsum treatments on the seed yield of soybean. Treatment T_6 (3 t gypsum ha^{-1}) recorded the highest soybean seed yield (19.25 q ha^{-1}) which was at par with treatment T_7 (5 t gypsum ha^{-1}) Application of 1.5t gypsum per hectare (T_3) gave 18.64 q ha^{-1} seed yield of soybean which was superior over no gypsum (T_1) and 1.0 t gypsum per hectare (T_2) and found at par with increasing levels of gypsum. Percent increase in the yield of soybean due to increasing level of gypsum was found in the range of 7.3 t 19.3 percent over no gypsum application. (Table.1)

Table 1: Effect of gypsum on seed yield and MUE of soybean and chickpea

Treatments	Soybean			Chickpea		
	Seed yield (q ha^{-1})	Total moisture use (mm)	MUE (kg ha^{-1} mm^{-1})	Seed yield (q ha^{-1})	Total moisture use (mm)	MUE (kg ha^{-1} mm^{-1})
T_1	15.53	691.6	2.24	9.56	176.41	5.42
T_2	16.75	648.0	2.58	10.69	224.78	4.75
T_3	18.64	626.3	2.97	11.11	182.3	6.09
T_4	18.62	641.9	2.90	11.38	194.74	5.84
T_5	18.73	628.3	2.98	11.71	197.79	5.92
T_6	19.25	620.4	3.10	11.69	199.49	5.85
T_7	18.85	613.6	3.07	12.22	169.14	7.22
SE (m)	0.13	-	0.54	0.13	-	0.07
C.D. at 5%	0.41	-	1.69	0.42	-	0.21

The increased in yield due to increase in level of gypsum might be due to better utilization of soil moisture under calcium saturation which in turn has favourable impact on aggregation. Similar observations were also made by Kadu *et al.* (2003) [7] in calcium saturated and Na^+, Mg^{2+} depleted Vertisols of Vidarbha.

Application of gypsum significantly increased the MUE of soybean, maximum MUE 3.10 kg ha^{-1} mm^{-1} was found under treatment T_6 (3 t gypsum ha^{-1}) which is significantly superior over treatment T_1 (no gypsum) and T_2 (1 t gypsum ha^{-1}) and at par with treatment T_7, T_5, T_4 and T_3. This indicated that treatment T_3 low level of gypsum (1.5 t ha^{-1}) was sufficiently maintaining electrolyte concentration in percolating water which helps in stabilization of soil structure to receive good yield and moisture use efficiency.

The highest moisture use efficiency under treatment T_7 was might be due to better physical condition, which intern helps in increasing the yield. Similar effect of gypsum was also noted by Sagare *et al*. (2001), in Vertisols of Purna valley.

In chickpea total moisture use recorded under different treatment varied between 169.14 mm to 224.78 mm. Maximum moisture use recorded under treatment T_2 (1.0 t gypsum ha^{-1}) 224.78 mm and minimum moisture use recorded under treatment T_7 (5 t gypsum ha^{-1}). However, moisture use slightly decreases with increase levels of gypsum while variation in total moisture use was not much.

Highest seed yield of the chickpea 12.22 q ha^{-1} recorded under treatment T_7 (5 t gypsum ha^{-1}) followed by treatment T_5 and minimum seed yield of the chickpea (9.56 q ha^{-1}) recorded under treatment T_1 (no gypsum). Gypsum application at the rate of 1.5 t per hectare (T_3) gave significantly higher yield over no gypsum treatment (T_1).

The maximum seed yield of soybean and higher MUE (3.10 kg ha^{-1}) was recorded in T6 (3 t gypsum ha^{-1}) which was at par with 1.5 t gypsum ha^{-1}. Therefore 1.5 t gypsum ha^{-1} was observed enough to increase seed yield and MUE of soybean to beneficial level i.e. to18.64 q ha^{-1} and 2.97 kg ha^{-1} mm^{-1} respectively. Increasing level of gypsum increased the yield of the chickpea and maximum yield (12.22 q ha^{-1}) and MUE (7.22 ha^{-1} mm^{-1}) was recorded with 5 t gypsum ha^{-1}. Similarly In gram higher yield and MUE was obtained in 1.5 t gypsum ha^{-1} than the control (no gypsum).

3.2 Total moisture use and moisture use efficiency (MUE) of soybean and chickpea.

Highest seed yield of the chickpea 12.22 q ha^{-1} recorded under treatment T_7 (5 t gypsum ha^{-1}) followed by treatment T_5 and minimum seed yield of the chickpea (9.56 q ha^{-1}) recorded under treatment T_1 (no gypsum). Gypsum application at the rate of 1.5 t per hectare (T_3) gave significantly higher yield over no gypsum treatment (T_1).

The maximum moisture use efficiency in chickpea was registered under treatment T_7 (7.22 kg ha^{-1} mm^{-1}) as against minimum recorded in control T_2 (4.75 kg ha^{-1} mm^{-1}). The maximum MUE recorded in T_7 mainly due to the maximum yield recorded under same treatment as there was not much variation found in moisture use. The MUE of chickpea recorded under Vertisol varied over 5.50 to 4.61 kg^{-1} ha^{-1} mm^{-1} as observed by Hajare *et al.* (1997) [6].

4. Conclusion

However MUE of soybean significantly increased with increasing level of gypsum. Higher MUE was found with T_6 (3 t gypsum ha^{-1}) but T_3 (1.5 t gypsum ha^{-1}) is enough to increase MUE of soybean significantly over no gypsum. Increasing level of gypsum also increase the MUE of chickpea. The surface soil of experimental site was slightly alkaline in reaction clayey in texture, medium in organic carbon (6.21 kg^{-1}), low in available nitrogen (206.98 kg), medium in phosphorus (19.23 kg ha^{-1}), high in potassium (503.00 kg ha^{-1}) poor in hydraulic conductivity (1.06 cm $ha^{-1)}$ 1.5 t gypsum ha^{-1} is enough to increase the yield of soybean significantly over control and increasing level of gypsum increases the yield of Chickpea linearly.

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