Greener Journal of Agricultural Sciences
ISSN: 2276-7770; ICV: 6.15
Vol. 2(7), pp. 316-322, November, 2012

http://gjournals.org/GJAS

Research Article

Influence of Gypsum application on Wheat (*Triticum aestivum*) yield and Components on Saline and Alkaline Soils of Tigray region, Ethiopia

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ARTICLE INFO

Article No.: *100912100*
DOI: *10.15580/GJAS.2012.7.100912100*

Submitted: *10/09/2012*
Accepted: *20/09/2012*
Published: *30/11/2012*

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Keywords:
Gypsum, Wheat, Yield and Components, Saline, Alkaline, Sodium, Calcium and Sulfur

ABSTRACT

Green house trials were conducted at Mekelle University main Campus, Tigray region, Ethiopia, during the early season of the year 2008. The research aimed at investigating the influence of different rate of gypsum effects on the yield and components of Wheat (Triticum aestivum) on saline soil. Wheat seeds were grown in pots with different levels of gypsum concentration (0, 50,100 and 150kg/pot) and irrigated with the same quantity of water. Base line soil analysis results shows that the soil is salty, heavy clay structure and high EC value confirming its salinity. A complete randomized design with three replicates was used. Data were analyzed for variance and LSD at 5% level of significance. Results showed that gypsum application significantly enhanced all parameters taken. Result indicated that the use of 100kg/pot responded better at early stage while 50kg/pot improved yield and growth latter. The use of 50kg/pot enhanced the crop performance in all characters considered with the least result from the control. The significant effect on germination percentage, root-dry weight, fresh weight, days to heading of plant and plant height confirmed that the use of gypsum on saline soils is a better option for improving productivity on alkaline soils. A better response of 100kg/pot at early stage and 50kg/pot latter indicates that salinity effect reduces with time. However, for proper recommendation and improvement of significance, there is need to re-investigate the experiment on the field and calibrate with green house result with proper irrigation, drainage and leaching to minimize salt accumulation in the root zone and improve nutrient uptake.

INTRODUCTION

Wheat is an important cereal crop in most dry regions of the world and it is characterized as being moderately tolerant to salinity (Allen et al.; 1998). The crop is also one of the major cereal crops in Ethiopia. This is because it thrives well between 6 and 15°N; 35 and 42°E and from 1500 to 3200m of altitude. Its cultivation has been estimated to cover about 88400ha coverage of land (CLIMMYT 1996) under rain fed production. However, there are numerous problems that decrease Wheat production in Ethiopia especially in relationship to the fertility of the soil for most crops, of which major causes are salinity and moisture (Bello and Haftom, 2008).

Soil salinity is a major constraint to food production because it limits crop yield and restrict use of land previously uncultivated. It has being estimated that approximately 20% of agricultural land and 50% of crop land in the world is salt stressed (Flowers and Yeo, 1995). Salts in the soil water solution can reduce evapo-transpiration by making soil water less available for plant root extraction (Allen, et al. 1998).

Salinity has also been identified as the major seedbed factor influencing the establishment of crops in arid and semi-arid regions (Almansouri et al.; 2001). Germination and seedling growth are reduced in saline soils with varying responses for species and cultivars (Hampson and Simpson, 1990).

Salinity may also affect the germination of seeds by creating an external osmotic potential that prevents water uptake or due to the toxic effects of Na and CL- ions on the germinating seed (Khajeh Hosseini et al. ; 2003). Although substantial salinization potential is realized through natural weathering and dissolution of soil parent materials, and these salt contributions will attenuate or augment irrigation water ionic constituents.

A saline soil deprives the soil of calcium and sulphur and this reduces the productivity of Wheat hence, the addition of gypsum, adequate leaching and proper draining must be installed in the field to ensure optimum production on saline soils (Gelderman et al. ; 2004). Gypsum, calcium sulfate (Caso4, 2H20), is a naturally occurring mineral that is mined for many purposes. Gypsum has a calcium content of 23% and sulphur content of 19%. It is usually used for treating Sodium affected soils on farm. The calcium in the applied gypsum enables sodium displacement on the cation exchange capacity of the soil. However, large amounts of Calcium are required thus it is a mass action process (Gelderman, et al. 2004). Salts accumulation in root zone occurs by two processes hence, to control salinity from high saline water tables, demands proper draining while salts that accumulate in the root zone with irrigation are leached (Stephen, 2002). Apart from sodium salts (NaCL, NaSo4 and Na2Co3). Gypsum also, supply calcium Sulfur although, it is an expensive source.

Smyth and Cravo, 1992 opined that low calcium levels and soil PH may constrain crop production in highly weathered soils of major areas of the world. Therefore, crops grown in nutrient poor media or situations that limit Ca uptake produce lower yields than crops grown with continuous and adequate Ca nutrition (Frost and Kretchmann, 1989). To this ends, seeds produced by plants grown with inadequate Ca levels in rooting media often have seed quality problems such as reduced germination and vigor (Keiser and Mulen, 1993). Calcium is thus, a crucial regulator of growth and development in plants. This is because the ion participates in growing and in almost all aspects of plant development (Bothwell and Ng, 2005).

The hazard to crops, which are susceptible to Ca2+ related disorders, becomes greater under saline conditions. As the concentration of salt in the root zone increases, plant requirement for Ca2+ also rises (Berstein, 1975). Consequently the uptake of Ca2+ from the substrate may be depressed because of ion interactions, precipitation, and increases in ionic strength. Hence, the above mentioned reduces the activity of Ca2+ in solution thereby decreasing Ca2+ availability to the plant (Saurez and Grieve, 1988). Severity of the calcium disorder depends on the kinds of ions that contribute to salinity and environmental conditions.

Sulphur, is a building block of protein and a major ingredient during chlorophyll formation (Duke and Reisenaue, 1986) therefore, a soil depleted of S will not allow its crop to reach maximum growth but with reduced protein content in return (Zhao et al. ; 1999C).

Sulfur deficiency in Wheat production, was rare as reported by the Withers et al. The reason is that crops need is provided from S deposited from wet deposition of S compounds and supply from organic matter. Thus, Zhao et al. 1999 stated that averagely, 10-12kgha-1 of soleplate S can be obtained from rainfall, and this is slightly less than the Wheat crop requirement of 15-20kgha-1. Although soil was found to contain adequate available S for most crops (Johnson et al. 2000), and the N: S ratio is a reliable index for detecting deficiency and evaluating S- use efficiency of crops (Rasussen, 1996). However, the ratio varies from zone to zone depending on soil types.

Currently, environmental quality issues related to S02 and other green house gases have led to the reduction in the release of these chemicals into the environment. This reduction led to S deficiency on crop farms, since organic source is inadequate for the total requirement of the crops.

With these challenges, research findings towards confirmation of S deficiency and response in crop production have been undertaken (Spancer and Freney, 1980). Hence, Wheat crop has been confirmed as a crop that needs high amount of supplemental S due to incompatibility of conditions with its period of most rapid growth during the dry- season, when the rate of S release from soil organic matter is quite slow (Johnson, 1999).

These investigations thus, demonstrated that the addition of gypsum affects seed germination, growth and development on saline soil. The objectives of this study were to determine:

- The effects of different rate of gypsum application on Wheat seed germination on saline soils.
- The effects of both high and low ca and S levels in wheat production in soils with high salt concentration.

MATERIAL AND METHODS:

The Study was carried out at the Department of Crop and Horticultural Sciences, Green House Mekelle University Ethiopia. The Wheat seed cultivars (Shahan variety), was obtained from Illala Research center Mekelle Ethiopia.

The base line analysis of the soil sample was carried out to confirm the alkalinity and salinity content of the soil using the basic methods of soil analysis. The soils were then sieved and filled into plastic pots (diameter of 2.7m and 2.3m in length) up to the same levels in all pots and soaked with equal volume of water. The pots were perforated at the bottom to enables proper drainage of water. Solutions of each treatment were prepared using gypsum (0, 50, 100 and 150g/pot) with control and added into the soil accordingly.

The following day, ten numbers of uniform seeds of Wheat were planted in each pot and were arranged in a randomized complete block design (RCBD) with three replications. The plastic pots were then covered with polythene sheet to minimize loss of moisture by evaporation.

Uniform quantity of the same volume of water was added continuously at two days interval to prevent the effect of moisture shortage and the germination count was taken after five days of sowing. Data on dry weight of plant, root dry weight, fresh root weight and fresh weight plant were taken at harvest per pots. Measurements of plant height (PLH), Leaf number per plant, Days to heading, spike length and root length were taken three days interval after 20days after-planting (DAP) till harvesting period.

Collected data were subjected to analysis of variance using the JMP V5 soft wears. Means comparisons was done with the use of Tukey –Kramer HSD approach.

RESULT AND DISCUSSIONS

Baseline information from Table 1 shows nutrient composition, salt content, PH and EC value of the soil. There were more salt concentration (Na, Ca, Mg and K), with PH of 8.7 and high EC value (432.87) which indicates Alkalinity and Salinity of the soil. This observed result from the soil analysis may affect the nutrient statue of the soil and affect further, the development of the crops. Results in Table I, also ascertain the use of gypsum as a means of ameliorating the soil for production which is in line with the findings of Gordon Johnson, 1990.

The effect of gypsum application was highly significant (P value<0.05) on all characters considered (germination %, plant height, days to heading, leaf number/plant, spike length, root length, fresh weight, dry weight of plant, fresh root and root dry weight of the plant,[Table 4]. This confirms the work of John and Keith, 2002). The highly significant effect of treatment three (100gmCaso3) over treatment two (50gmCaso3) at the early seedlings of the Wheat growth for germination %, plant height and leaf number per plant inferred that salinity effects reduces with time and similar to the assertion of Lal,1985. This early growth stages (germination %& plant height) shows the trend to be t3>t2>t1 (table 4), which infers greater response with higher gypsum rate and control the least while t2>t4 is due to toxicity.

RESULTS:

Table 1: Soil analysis result

Characters	Value
PH	8.2
Temp.	22.5
EC	432.87
Av. P(Mg/k soil)	25.74299
% O.C	0.907475
%O.M	1.564488
%TN	0.078617
Na (mol/kg)	1.08
K "	0.07
Ca "	20.2
Mg "	13.1
CEC (mol/kg soil)	61.75
CaCo3%	1.6224

Table 2: Means for one-way Anova for plant germination.

Level	Number	Mean	Std Error	Lower 95%	Upper
t1	3	63.3333	4.3033	52.804	73.86
t2	3	90	4.3033	79.47	100.53
t3	3	96.6667	4.3033	86.137	107.2
t4	3	73.3333	4.3033	62.804	83.86

Table 4: Means comparison effect of gypsum application on Wheat performance and yield Early growth stages, Later growth stage and periods of the plant

Treatments gypsum rate(g/pot)	Plant germination Percentage (%)	Plant height (cm)	Root length (cm)	Fresh weight (kg)	Dry weight (kg)
T1 (00)	63C	52.67B	3.33B	3.93C	0.97BC
T2 (50)	90BC	61.67A	7.43A	8.4A	2.00A
T3 (100)	97AB	63A	4.77B	7.2B	1.37B
T4 (150)	73C	52.67B	3.90B	2.97D	0.80C

Means with the same letters in the column are not significantly different at 5%

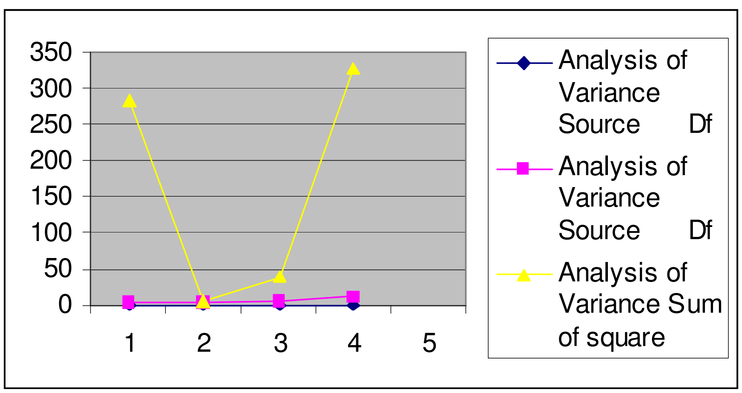

Fig 1: Analysis of Variance features for plant height

Table 8: Analysis of variance of days to heading

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob>F
Treatment	3	72.6667	24.2222	14.7797	0.0035
Replication	2	2.16667	1.0833	0.661	0.5502
Error	6	9.8333	1.6389		
.Total	11	84.6667			

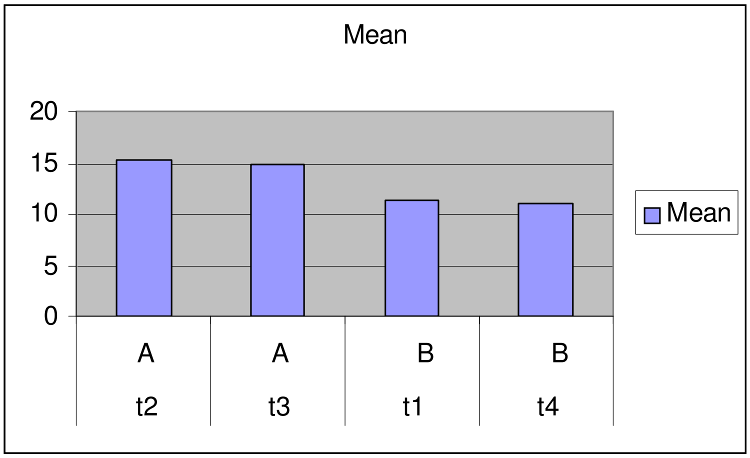

Fig 2: Mean Comparisons of Spike length of Wheat plant.

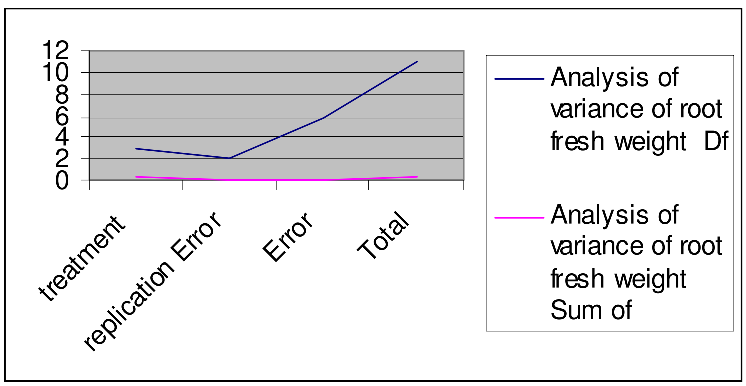

Fig 3: Analysis of Variance features of Fresh root weight

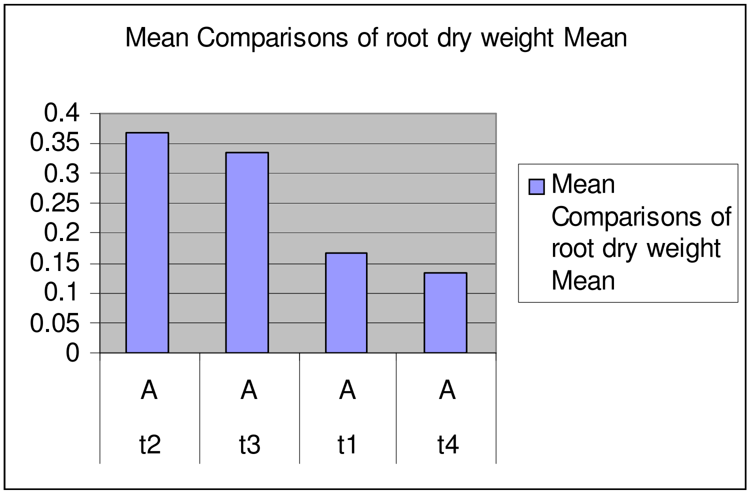

Fig 4: Mean comparison features of root dry weight

Also, at later growth periods (spike length, root length, fresh weight of plant, fresh root weight, dry weight and root dry weight of plant) of the plant, the result t2>t4>t1 (fig 2&4) indicates that t2 (50gmgypsum) is appropriate especially on well drained irrigated farm land and similar with the recommended findings rate of Ray Lamond, 1992) in his work.

The decrease subject to the amount applied, indicates toxicity and nutrient imbalance which negatively affects nutrient use efficiency. Result of t4 < t2 (150> 50gm salinity) is the effect of salinity on nutrient use efficiency and t3>t4 (100gm>150gm) is due to toxicity.

However, the response of treatment two(50gmgypsum) over the control means that gypsum application increased soil sulfate levels in the soil used and Calcium was able to displace sodium on the soil Cation exchange capacity site. It also reduces the deficiency of both Calcium and Sulfur for Wheat growth. The higher response of gypsum over the control observed in this study could partly be explained by the higher sodium content and the EC value of the soil as reported by other workers (Gelderman et al, 2004 and McGrath and Zhao, 1995).

The result of mean comparisons as shown in Table 4 and figs2&4; shows that the use of gypsum at 50gm is preferred. This was because, under Salinity and alkalinity, the use of gypsum will correct salinity effects and add sulfur and calcium to Wheat plant accordingly.

In line with Riley et al (2000) discovery, micronized elemental S and Sulfate fertilizers resulted in 36% increase of Wheat grain yield. This could account for the control of salinity and supply of Calcium and Sulfur in gypsum treated pots over the control pots

CONCLUSIONS

Generally, significant improvement is usually expected in the use of gypsum on saline soils as sources of Ca and S

With reclamation of the soil in Wheat production, the improvement in yield and components is due to the displacement of sodium by calcium and increase in nutrient use efficiency of the crop.

Saline soils and alkali soil can be reclaimed by following a definite series of management steps design to leach out the salts or sodium. The order includes verifying the problem through soil testing so as to identify the causes of salinity, improving the internal soil drainage by leaching out the soil, addition of organic matter to improve water movement with the soil and addition of gypsum when the salinity is slick-spots in nature.

To ensure sustainability of the reclaimed land, deep tillage should be avoided and cover should be establish on the soil.

For gypsum to be effective for sodium affected soils, adequate sub surface drainage must be present. It is therefore, suggested that for optimum performance of Wheat production, gypsum could be used by the subsistence farmers to improve the nutrient uptake of the plant on saline and alkaline soils.

However, the result of these findings is a pre trial and needs to be calibrated with Field trial for proper and adequate recommendation following the steps mentioned above with effort to lower the water table at the site to enable the sodium movement down and out of the soil profile easily by adequate leaching and effective drainage system.

In conclusion, future field trials backed up with this result will ensure a means to reclaiming Saline and Alkaline soils at the site or areas with the same climatic conditions similar with the location of the experiment.

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Cite this Article: Bello W.B. (2012). Influence of Gypsum application on Wheat (*Triticum aestivum*) yield and Components on Saline and Alkaline Soils of Tigray region, Ethiopia**.** Greener Journal of Agricultural Sciences, 2(7): 316-322, http://doi.org/10.15580/GJAS.2012.7.100912100**.**