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Response of Sulphur Fertilizer Application to Bread wheat (Triticum aestivum) growth and yield in Kulumsa, Arsi, Ethiopia

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Abstract

A field study was conducted during 2013/14 cropping season with the objectives of to study the response of bread wheat to different rates of sulfur fertilizer, to study the effect of sulphur fertilization on growth and yield of bread wheat and to suggest some recommendations about the optimal rates of sulfur fertilizer application for bread wheat as well as for further sulfur research works. The treatments applied as one factor of six levels of sulphur (0, 20, 40, 60,80 and 100 kg S ha-1.The treatments were replicated three times in a Randomized Complete Block Design. The experiment was carried out at the Kulumsa Agricultural Research Center on clay textured soil. Data were collected and statistical analysis was done on various characters of the crop. Soil Samples were also taken before and after the implementation of the experiment and chemically analyzed.

The analysis of variance for the results of the study revealed among the agronomic and yield parameters of wheat; Number of Seedling, Number of Tillers per Plant, 50% of flowering date, Plant Height, Number of Spikes, Number of Seeds per spike, Total Above Ground Biomass Yield and Harvest Index were non-significant ($p > 0.05$) influenced by rate of S whereas Thousand Grains Weight, and grain yield were significantly ($p \leq 0.05$) affected by rates of S. Application of 60 kg S/ha increased the grain yield of wheat by 12.64%, 11.39%, 6.44% and 2.52% respectively when compared with the no S application. However, more systematic investigation should be made based on the detailed analysis of soil fertility, crop characteristics and the economic feasibility of recommended treatments in different principal bread wheat growing areas of Ethiopia in order to reach a sound conclusion and recommendation.

Key words: Bread wheat; sulphur fertilizer; Yield

Introduction

Crops and cultivars within crops vary considerably in their S requirements. Spencer (1975) has divided crops into three broad groups. Group I includes Crucifers and Brassicas which have high S requirement (20 to 80 kg S ha–1). Group II includes plantation crops, which have moderate S requirements (10 to 50 kg S ha–1). Group III includes cereals, forages, and other field crops and has low S requirement (5 to 25 kg S ha–1). As a rule of thumb, Tandon gives the following S requirements (kg S Mg–1grain): 3 to 4 kg for cereals, 8 kg for grain legumes (beans), and 12 kg for oilseeds (rapeseed mustard, sunflower, groundnut, soybeans, etc.) [1].

Deficiency of S in agricultural crops, especially wheat, was reported as rare (Withers). This is due largely to the belief that the S requirement of crops is satisfied from S deposited from wet deposition of S compounds and release from organic matter. On average, 10–12 kg ha−1 of sulfate-S is obtained from rainfall, which is slightly less than the wheat crop requirement of 15–20 kg ha−1 (Zhao). While demand for sulphur depends on plant species, the amount and rate of sulphur uptake from the nutrient solution depends on many factors, including pH, temperature, access to energy, sulphate concentration and the presence of other ions (Siuta and Rejman-Czajkowska) [2].

With the increase in sulphate ions accumulation in the nutrient solution, their uptake by plants increases. Having reached a certain level, various for different plant species, further increase of concentration does not affect the uptake any longer. However, high sulphate concentrations may affect plant development and crop yield (Cerda) [3].

Wheat requires a relatively high amount of supplemental S due to incompatibility of conditions with its period of most rapid growth during early spring, when the rate of S release from soil organic matter is quite slow (Johnson). Significant yield increases of winter wheat in response to S additions have been reported elsewhere (Randall and Wrigley; McGrath and Zhao) [4].

In Pakistan, According to Arshad studies that Different rates of Sulfur which are 25 kg/ha, 50 kg/ha and 75 kg/ha on saline-sodic soil showed positively influenced on wheat growth and yield. Tillering, plant height, spike length, number of grain spike-1, 1000 grain weight, straw and grain yield were statistically significant. The highest numbers of tillers were recorded in treatment receiving 50 kg S ha-1 followed by treatments receiving 25 and 75 kg S ha-1. Plant height was the highest in treatment receiving 25 kg S ha-1 and spike length was highest in the treatment receiving 50 kg S ha-1 [5].

The highest 1000 grain weight, grain and straw yield were obtained with the application of 50 kg S ha-1 followed by 25 and 75 kg S ha-1, which is 26% higher than control treatment. The treatments receiving 50 kg S ha-1 registered the highest grain yield followed by treatments receiving 75 kg S ha-1 producing 13% higher yield as compared to control treatment. Gupta reported that S application significantly enhanced wheat yield and yield components. Therefore, this research project was proposed with the objective to study the response of bread wheat to different rates of sulfur fertilizer [6-8].

Materials and methods

Description of the Study Area

The study was undertaken at Kulumsa Agricultural Research Center (KARC), which is located in Tiyo Woreda of Arsi Zone in the Oromia National Regional State, Ethiopia. It is situated 160 km southeast of Addis Ababa and 8 km North of Asella town at an altitude of 2200 meters above sea level (masl) and 8° 01'10" N latitude and 39° 09' 11"E longitude. The study area falls in the moist 2 (tepid to cool moist mid to high altitude) agro-ecological zone (MoA, 2000). The weather data recorded from 1992 to 2013 indicates that the area receives an average annual rainfall of 820 mm. The rainfall pattern is uni-modal with extended rainy season from March to September. However, the peak rainy season is from July to August. The mean annual potential evapotranspiration is about 1300 mm. An average annual minimum and maximum temperatures are 10.5 and 22.8 °C, respectively. The center is located on very gently undulating topography with a gradient of 0 to 10% slope. In some places where the slope is very flat, flooding and water logging occur. The soil moisture regime can be classified as ustic and the soil temperature as Isothermic (Abayneh). Variations in climatic and vegetation cover with the differences in parent materials and relief led to the occurrence of different soils in the study area. The soils of the study area are largely developed from parent materials of volcanic origin, predominantly basalt. However, in certain parts, there are soils that were developed from alluvial materials. The dominant soil of the area is Luvisol (MoA) and wheat is the most widely cultivated crop in the area followed by barley [9,10].

Table1: Mean monthly rainfall as well as full and half pan evaporation of the study area in 2013.

months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall(mm)	19	67	86	120	82	90	122	135	107	38	11	9
PET	108.5	103.5	117.8	111	117.8	117	93	96	87	108.5	111	105.4

The composite surface soil samples at 0-30cm depth were collected from the experimental field just before planting of the crop and analyzed for some of their physical and chemical properties including texture, pH, organic carbon, total nitrogen, total phosphorus, exchangeable cations, micronutrients and available sulfur [11,12].

Table 2: Physical and chemical properties of soils of the experimental site before planting.

Soil properties	Sample 1	Sample 2	Sample 3	Mean
Particle size (%)				
Sand	20.72	34.21	27.46	27.46
Silt	30.38	19.38	22.89	24.22
Clay	48.9	46.41	49.65	48.32
Textural class	clay	clay	clay	clay
Total N (%)	0.24	0.11	0.23	0.19
Av.P (ppm)	19	21	21	20.33
Av. S (ppm)	9.42	20.47	12.57	14.13
OC (%)	1.58	1.63	1.54	1.58
pH	6.2	6.3	6.3	6.3
Exchangeable base(cmol/kg)				
Na	1.82	1.5	1.45	1.59
K	0.75	0.82	0.7	0.76
Ca	45.38	45.18	45.68	45.41
Mg	1.08	1.11	1.18	1.12
Micronutrients(cmol/kg)				
CU	1.87	1.87	1.97	1.9
Fe	26.61	20.03	27.48	24.71
Mn	28.18	25.5	23.99	25.89
Zn	0.68	0.64	0.7	0.68

Experimental Treatments, Design and Procedures

Kakaba' variety bread wheat was used for the experiment which is released in 2010 by EIAR in collaboration with DRRW, CIMMYT and ICARDA and popularized during 2011/12 crop seasons and it is highly adapted at altitude of 1500-2200 meters above sea level (masl).The origin name of Kakaba is called Picaflor #1 and the Pedigree of Kakaba is Kititati//Seri/Rayon. It is Rust resistance spring type bread wheat and early maturing variety with the maturity of 90-120 days (MOA) [13,14].

Six different rates of sulfur (0, 20, 40, 60, 80 and 100 kg S/ha) fertilizer applications were the treatments of the present study. Calcium sulphate ($CaSO_4$) was used as the source of sulfur fertilizer. The treatments were laid out in randomized complete block design (RCBD) with three replications. In accordance with the specification of the design, a field layout was prepared and each treatment was assigned randomly to experimental units within a block. Plot size of each replicated treatment was 5m X 5m, consisting 25 rows. The spacing between plots within blocks was 50 cm, while the spacing between blocks was 1m. At the recommended seeding rate, the seeds were drilled manually in 20cm apart open rows and covered with soil on-22/07/2013. Land preparation and other all agronomic practices were done as per their recommendations for wheat [15,16].

Data Collection

Apart from growth and yield components of wheat, nitrogen and sulfur uptakes by wheat plants were consider as study parameters of the present experiment. Data from these parameters were collected as per their respective standard sampling and measuring methods and procedures indicated here below.

Growth and Yield Components

Number of seedlings per meter square, number of tillers per plant, plant height, days to 50% flowering, number of spikes per meter square, spike length, number of seeds per spike, thousand grains weight, grains hectoliter weight, total biomass yield per hectare, grain yield per hectare and harvest index (HI) were considered as parameters to study the effect of different rates of sulfur fertilizer on growth and yield components of wheat. These growth and yield components were measured as the followings:

Number of Seedlings

The number of seedlings per meter square was recorded at individual plot levels. This was done by used quadrant to counting randomly selected row seedling within the harvestable area two weeks after emergence [17,18].

Days to 50% Flowering

The number of days to attain 50% flowering was recorded at individual plots by counting randomly selected flowering shoots within the harvestable net plot area.

Plant Height

Ten plants from net plot area were randomly selected to measure plant height at physiological maturity. Plant height of each selected plant was measured from the surface of the soil to the last fully opened/flag leaf with tape meter and the mean height per plot in cm was taken for further analysis.

Number of spikes per meter square

Number of spikes per meter square was recorded from individual plots. This was determined by counting number of spikes in randomly selected 1mx1m quadrant in the net plot area at maturity stages.

Number of Seeds per Spike

After Spikes had been counted from each of the ten randomly selected central row plants, grains were separated from spike to get the number of grains per plant. For each plant the number of grains per spike was calculated by dividing the total number of grains per plant to the number of spike per plant. Finally, the mean value of ten plants was taken as number of seeds per spike.

Spike Length

Spike length was measured as the length (in centimeters) of the spike of the main tiller of each plant from base to tip of the spike (excluding the awns). It was expressed as the average of ten spikes per plot.

Total Biomass and Grain Yield per Hectare

Plants from each net plot area were manually harvested and sun dried in the open air. Dried plants were weighed to determine the biomass yield on plot basis and converted into hectare basis to determine total biomass yield per hectare. After measuring the biomass, the dried wheat plants were threshed and weighed to determine the grain yield of each plot. Finally, yield per plot was converted and expressed as kg ha-1 basis. Grain yield was adjusted to 12.5% moisture content, indeed.

Harvest Index

Harvest index values for replicated treatments were computed as the ratio of the grain yield to biomass yield per hectare and expressed in percentile [19,20].

Data Analysis

All data were subjected to the analysis of variance using General Linear Model procedures of SAS (SAS institute), and significant mean differences were separated by least significant difference (LSD) at respective level of significance used for ANOVA [21-23].

Results and discussion

The findings of the research reported that different fertilizer treatments showed non-significant ($P > 0.05$) effect on Number of seedling per square meter, number of tiller per plant, days to 50% of flowering, plant heigh, Number of Spikes per Meter Square, number of seeds per spike, spike length , total biomass yield and harvest index [24-26].

Thousand Grains Weight

There was statistically significant difference ($p \leq 0.05$) on 1000 grains weight due to S application (Table4). Among the application of S the highest (42.43 gm) was recorded (Table4). From 1000 grains weight under the influence of applied S rates, the result obtained at 60 kg S /ha was the highest (42.43gm) followed by treatments receiving 40,20,80,0 (control) and 100kg S/ha whereas the lowest (40.12gm) was obtained at 100kg S/ha application. This result was similar by Gupta was reported that S application significantly enhanced wheat yield and yield components. This was the most probably due to soil type the reason for S was increased Ca and K availability and decreased Na contents resulting in healthy environment for plant growth. More over similar results have also been reported by Zhang, Prasad and Ali.

Grain Yield per Hectare

Grain yield is the important component of plant performance under a set of growing conditions. Any physiological or agronomic parameters at a given stage of growth would be of furthers use only when its effect is reflected on yield either way. Grain yield is a function of HI and dry matter production (Ludlow and Macho).

The mean grain yield of wheat was highly significantly (p≤ 0.01) affected by S rates (Table 4). The highest grain yield (5602.7 Kg/ha) was obtained from 60 kg S/ha followed by 40, 20, 80, 0(control), and 100 kg S/ha whereas the lowest grain yield (4122.8 kg/ha) was obtained from 100kg S /ha (Table 4). This information agreed with results obtained by other authors (FAO, 2004; Reussi Calvo). Furthermore, Anderson reported similar results, showing very high S grain responses in wheat. These results were might be S fertilizer increased the availability of other macro and micro nutrients with in crop production. In addition to this results Gupta reported that application significantly enhanced wheat yield and yield components. This was the most probably due to increased Ca and K and decreased Na contents resulting in healthy environment for plant growth. Similar results have also been reported by Zhang, Prasad and Ali. More over this results McGrath and Zhao, 1995; Randall and Wrigley, 1986 reported that S application significantly enhanced wheat yield and yield components.

Table 3: Effect of sulphur fertilizer application at different levels on yield components of wheat.

S level Kg/ha	SD	TIL	50% flowering date	PH (cm)	SPM	NSS	SPL	GY(kg/ha)	TKW(gm)	HI (%)	BY
0	176	3	60	91	1760	44.033	5.4	4339cd	40.15b	50.30	9976
20	159	3	61	91	1587	44.533	5.7	4983b	41.66a	50.86	10128
40	163	3	59	91	1633	42.633	5.8	5478a	41.98a	65.60	8361
60	159	3	63	90	1590	42.633	6.2	5603a	42.43a	81.20	7164
80	172	3	61	90	1723	43.333	6.1	4592cb	41.26ab	50.52	9200
100	174	3	61	100	1740	43.067	6	4123d	40.12b	38.14	11387
LSD	NS	NS	NS	NS	NS	NS	NS	465.93**	1.45*	NS	NS
CV (%)	12.2	10.29	3.61	2.22	12.22	4.06	4.2	5.27	1.93	27.18	28.5

Means within columns followed by the same letter are not significantly different within groups of levels by analysis of variance protected LSD test at (P ≤ 0.05)NS-non significant, *= significant at 0.01 < P≤0.05, ** = highly significant at P≤ 0.01

Recommendations

The application of 40 kg S/ha would be preferred to grow bread wheat on Kulumsa area for grow better grain yield and quality. Thus, farmers in the area might be advised to 40kg S/ha used to increase the productivity of this crop through increase the efficiency of S uptake.

However, it is too early to reach a conclusive recommendation since the experiment was conducted only on one soil type and crop variety in one location for one season.

Hence, studies involving more genotypes under various soil types, environmental factors, crop characteristics, methods and time of S application and the economic feasibility of recommended treatments in different principal bread wheat growing areas of Ethiopia and for many seasons should be conducted; otherwise the result could be unreliable.

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