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Research Article

Foliar sulphur- with split soil N application on yield performance of maize in Peshawar-Pakistan

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Abstract

Efficient use of soil N fertilizer with foliar application of Sulphur has been widely used and accepted as an essential part of the present plant production. Increased fertilizer e.g. N in combination with reduced level of atmospheric S has raised the need of S application to the crops for sustainable optimum production e.g. maize (*Zea mays* L.). Objective of this study was to compare yield performance of maize varieties through foliar Sulphur application with soil N-split application. Experiment was conducted at Agronomy Research Farm, the University of Agriculture Peshawar during the crop growth season 2010. Randomized complete block, in split plots with four replications was used. Varieties were allotted as main plot while N and Sulphur as subplots treatments. ANOVA results revealed that grain yield, biological yield and harvest index were significantly affected by foliar Sulphur and N-rates. Varieties also differed significantly for grain and biological yield including harvest index. Maximum grains yield (3221.45 kg ha^{-1}) was recorded in plots receiving 120 kg N ha^{-1} at sowing and 20 kg S ha^{-1}as foliar application at tasseling. Cultivar "Jalal" performed the best for the area. It can be concluded that N 120 kg $ha^{-1}$with S 20 kg ha^{-1} at tasseling stage could results the highest grains yield of maize for Peshawar and adjacent localities with similar climate.

Keywords: Maize,Nitrogen, Sulphur foliar application, maize varieties, Yield and Yield traits

Introduction

Maize (*Zea mays* L.) is an important cereal crop of the cropping system in Pakistan and the world. It ranks 3rdafter wheat and rice in the world production ranking on the basis of annual area planted under this crop. Maize grains consumed as a staple food of human being in addition to a high class feed for livestock conserved as hay and silage. With value addition, seed is also used as a raw material for industry delivering many corn products for daily uses. In Pakistan,

maize occupies a special position in the cropping system to support the national economy, being a source of poor'sfood and feed, variety of food with value addition and excellent fodder. Its grains itself are valuable sources providing protein (10.4%), fat (4.5%), starch (71.8%), vitamins and minerals (i.e.Ca, Pand S etc.). Yield of maize is low in Pakistan compared to other countries (e.g. Nepal, India, China etc.) and very low in the province Khyber Pakhtunkhuwa (KP) when compare with the national averages. The reasons of low maize production in KP than Pakistan are many e.g. in appropriate variety selection to the area's climate, water scarcity and high temperature fluctuation, improper mineral nutrition application and substandard cultural practices. Optimum N and S have shown better growth and yield potential. The reason is that it is considered to be least important in maize crop production. It is essential to synthesise amino acids e.g. cystine, cysteine and methionine, for vitamin A sources and to activate other enzyme in plant systems with optimum level of N and S for the crop growth and development [1]. Sulphur fertilization significantly improves yield and quality when available adequate in the field during growth and development [2-5].

Importance of S has been expressed in the recent past due to intensive cultivation of high yielding varieties (Hybrids and OPV) with imbalance use of complex fertilizers (e.g. N, P and K), which led to express S deficiency in soils [6]. Sulphur was not considered as a plant nutrient in fertilization practices for maize production in Pakistan. However, little is known about S status in soils for promoting growth and yield of maize. Research finding of [7] showed that lower SO_4 contents in soils under rainfed have supressed growth which resulted in lower maize productivity.

Nitrogen being a key element has increased grain yield and quality of maize [8]. In recent past emphasis has been given to increase fertilizer use efficiency (FUE) with top dressing and/or split N-applications at par with the critical growth stages [9].

Keeping in view the future grain demand and biomass production efficiency of both open pollinated (OPV) and hybrids varieties, in addition to higher water demand and/or availability of increasing rainfall in moon-soon season with higher temperature of the crop growth period has to be adjusted with optimum N and S for optimum production. A pleasant weather for maize growth is available in Pakistan and KP; starting from Feb to Nov. lasting for about 10 months to get one and two crops from the cropping system. It is time to find out effective fertilizer management practices for adjusting S and N rates for maize production. This study was designed to identify a suitable variety with optimum N and S rates for profitable maize production in the local climate of KP.

Materials and methods

Site and location

Field experiment was conducted at Agriculture Research Farm, the University of Agriculture Peshawar, Pakistan during summer 2010. Experimental site is located17^0, 35` N and $35^0$, 41` W at an altitude of 450 m from sea level. The experimental location has warm to hot, semi-arid, subtropical climate receives less than 360 mm annual rainfall. Crop water demand is fulfilled through canal irrigation system available with periodic irrigation system available at the research farm for the crop growth periods.

Experimental design and treatments

Experiment was conducted during summer 2010 and the crop was planted on 23rdjune in a randomized complete block design, split plot arrangements replicated four times. Maize (cv. Azam and Jalal) was allotted to main plot and fertilizer rates i.e. {N 120 &180 kg ha-^{1} (i) single application at sowing (ii) two splits applications one at sowing and other at tasseling stages)}in addition to S (20 kg ha^{-1}) once at 6th leaf stage and other at tasseling stage were added as subplot treatments. Sulphur was applied manually as foliar application using a spray pump. Ammonium sulphate was

used as a source for sulphur application. The quantity of S solution for spray was determined by pre-spraying water in an experimental unit (3.5m x 4.2m) covered by maize canopy. All inputs and agronomic practices were kept uniform during the crop growth and development.

Measurements and observation

Grain and biological yield (kg ha^{-1}) was recorded by harvesting plants from three central rows, bundled, sun dried for about x days and subsequently weighing in a sub-plot. The data were converted into kg ha^{-1}.Grain yield was measured from three rows in a plot by removing all ears, shelled and weighed.

Statistical analysis

Data were statistically analysed according to design and layout of the experiment [10] appropriate for randomised complete block design; split plot arrangements. Means found significant were separated using least significant difference (LSD) test($p \leq 0.05$).

Results and discussion

Days to tasseling

Analysis of data showed that varieties (V) nitrogen (N) and sulphur (S) were non-significantly affected and interaction between (V x NS) were significant on days to tasseling (Table 1). Maximum (54.97) days to tasseling was obtained in Jalal variety. Minimum (54.34) days to tasseling was obtained in Azam variety. The highest (56.00) days to tasseling was obtained in plots receiving 180 kg N ha^{-1}, 90 kg N ha^{-1} at sowing and 90 kg N ha^{-1} at tasseling and the lowest (53.63) days to tasseling were recorded in plots receiving 120 kg N at sowing + 20 kg S at tasseling.These results are in accordance with the findings of [11, 12].

Table 1. Days to tasseling, Days to silking, Biological yield, Grain yield, and harvest index of different maize cultivars as affected by various nitrogen levels and sulphur

	Days to tasseling	Days to silking	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest index
Cultivars					
Jalal	54.97a	64.56a	9455b	2842a	28.61b
Azam	54.34b	64.25a	9724a	2519b	29.23a
LSD	0.7512	0.6665	264.97	147.86	0.371
Treatments					
T1	54.13abc	64.13ab	10090.09a	2806.12b	29.41a
T2	54.75abc	64.50abc	9592.35abc	2628.08bcd	29.66a
T3	54.00bc	64.38cd	9110.37cd	2628.62bcd	29.59a
T4	56.00a	63.00d	9658.68abc	2732.15bc	28.81ab
T5	55.00abc	65.38a	8945.23d	2530.90cd	28.64ab
T6	55.38ab	64.13bcd	10045.77ac	2531.26cd	27.28b
T7	53.63c	65.25bcd	9740.02ab	3221.45a	28.80ab
T8	54.38bc	64.50abcd	9534.79bc	2369.43d	29.15a
LSD	1.5161	1.2637	874.35	259.92	ns

Days to silking

Varieties (V) nitrogen (N) and sulfur (S) non-significantly affected days to silking, while and interaction between (V x NS) were significant (Table 1) Maximum (64.56) days to silking was obtained in Jalal variety. Minimum (64.25) days to silking was obtained in Azam variety. The highest (65.38) days to silking was obtained receiving 120 kg N ha^{-1} at sowing + 20 kg S ha^{-1} and the lowest (63) days to silking was recorded in plots receiving 180 kg N, 90 kg N ha^{-1} at sowing and 90 kg N ha^{-1} at tasseling. These results are in line with the

findings of [11, 13] who reported that the application of nitrogen delayed the silking of maize crop.

Biological yield kg ha^{-1}

Analysis of data showed that varieties (V) Nitrogen (N) Sulphur(S) and their interaction (V x NS) were significant for biological yield (Table 1). Maximum (9723.88 kg ha^{-1}) biological yield was obtained for cv. Azam and the minimum (9455.45 kg ha^{-1}) for cv. Jalal. The highest (10090 kg ha^{-1}) biological yield was recorded in plots treated with120 kg ha^{-1} N at sowing, followed by (10045.77 kg ha^{-1}) in plots treated with 180 kg N at sowing + 20 kg S at V6 with the lowest (8945.23) received N 120 kg ha^{-1} in two splits at sowing and S application of 20 kg S at growth stage V6. These results are similar with the findings of [14], who stated that biological yield increased with nitrogen and Sulphur application [15].

Grain Yield kg ha^{-1}

Varieties (V) nitrogen (N) sulphur (S) and their possible interaction (i.e. V x NS) were significant for grain yield (Table 1). Maximum (2842.24) grain yield was obtained in Azam variety. Minimum (2519.76) grain yield was obtained in Jalal variety. The highest (3221.21) grain yield was obtained in plots receiving 120 kg N at sowing + 20 kg S at tasseling treatment and the lowest (2369.43) grain yield was recorded in plots receiving 180 kg N ha^{-1} at sowing + 20 kg S at tasseling. The interaction between (V*NS) showed the maximum grain yield was recorded in Jalal receiving 120 kg N at sowing + 20 kg S at tasseling while the minimum grain yield was recorded in Azam receiving 180 kg N at sowing + 20 kg S at tasseling. These results are in line with [16], who observed maximum grain yield was recorded in plots receiving 120 kg N at sowing + 20 kg S at tasseling.

Harvest index

Varieties (V) nitrogen (N) sulphur (S) and interaction between (V x NS) on harvest index were significant on harvest index (Table 1). Maximum (29.23) harvest index was obtained in Azam variety. Minimum (28.61) harvest index was obtained in Jalal variety. The highest (29.66) harvest index was obtained in plots receiving 180 kg N ha^{-1} at sowing and the lowest (27.28) harvest index were recorded in plots receiving 180 kg N at sowing + 20 kg S ha^{-1} at V6.The interaction between (V*NS) showed that maximum harvest index was recorded in Jalal receiving 180 kg N at sowing while minimum harvest index was recorded in Azam variety receiving 120 kg N at sowing + 20 kg S at V6. [17] agreed with these results and reported that nitrogen levels enhanced harvest index linearly because of increase in ratio of grain and biomass yield. [18] reported that sulphur significantly affected the grain yield and ultimately harvest index.

Conclusion

Highest grain yield was obtained from plot that received 120 kg N ha^{-1} + 20 kg S ha^{-1} at tasseling. Jalal gave highest grain yield. Overall 120 kg N ha^{-1} + 20 kg S ha^{-1} at tasseling and maize variety Jalal is recommended for high yield under the agro climatic condition of Peshawar.

Authors' contributions

Conceived and designed the experiments: M Adil, K Azeem & A Shah, Performed the experiments: M Adil, GR Khan & MAl Younis, Analyzed the data: M Adil & MR Khan, Contributed materials/ analysis/ tools: M Adil, M Ilyas & N Ahmed, Wrote the paper: M Adil & T Naseem.

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