Research Article

Effect of Trichoderma Applied with Different Sulfur Levels on Yield and Sulfur Uptake by Onion (*Allium cepa* L.)

Faheem Akbar[1], Naveed Ahmed[4]*, Maria Mussarat[1], Imtiaz Ahmed[4], Dost Muhammad[1], Toseef Ahmad[2], Muhammad Afaq Akbar[1], Shehryar Rafique[3], Seemab Ali[4], Sohail Aslam[4], Basharat Hussain Shah[4], Fayaz Ahmad[4] and Muhammad Abbas Khan[4]

[1]Department of Soil and Environmental Sciences, Faculty of Crop Production Sciences, The University of Agriculture, Peshawar, Khyber Pakhtunkhwa, Pakistan; [2]Department of Horticulture, Faculty of Crop Production Sciences, The University of Agriculture, Peshawar, Khyber Pakhtunkhwa, Pakistan; [3]Department of Agronomy, Faculty of Crop Production Sciences, The University of Agriculture, Peshawar, Khyber Pakhtunkhwa, Pakistan; [4]PARC, National Tea and High Value Crops Research Institute (NTHRI) Shinkiari, Mansehra, Khyber Pakhtunkhwa, Pakistan.

Abstract | In 2022, a field trial was carried out to investigate "Effect of trichoderma applied with different sulfur levels on yield and sulfur uptake by onion (*Allium cepa* L.)". The field trial was arranged in split plot design over randomized complete block design in which four levels of trichoderma i.e. (0, 1.5, 3 and 6 kg.ha^{-1}) were placed in main plots while five different levels of sulfur i.e.(0,25,50,75 and 100 kg.ha^{-1}) were used on subplots. The results indicated that addition of both trichoderma and sulfur considerably improved onion plant height, leaf area, bulb weight, fresh yield and as well as sulfur contents in onion bulbs and phosphorous concentration in onion leaves. When the data were averaged over trichoderma levels, these parameters showed linear increases with sulfur levels up to 50 kg ha^{-1} and then remained unchanged or showed declining trend with further increase in sulphur levels. The mean onion fresh bulb yield increased from 14.11 t ha^{-1} o 18.91 t ha^{-1} with 50kg.ha^{-1} sulphur. Similarly, application of 3kg.ha^{-1} trichoderma seemed to be optimum level as further increases in trichoderma did not show further increases in yield or growth parameters of onion. However, the sulfur and Phosphorus contents in soil were more in treatments receiving higher levels of Sulfur and trichoderma but the total uptake was of sulphur and phosphorus were higher in treatments receiving 50.kg sulphur ha^{-1} along with 3.kg trichoderma ha^{-1}. These results suggested that addition of trichoderma (3kg.ha^{-1}) and sulfur (50kg.ha^{-1}) seemed to be more effective in growth and yield contributing characteristics of onion and hence suggested for higher production of onion under the agro-climatic condition of Mansehra, Khyber Pakhtunkhwa.

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***Correspondence** | Naveed Ahmed, PARC- National Tea and High Value Crops Research Institute (NTHRI) Shinkiari, Mansehra, Khyber Pakhtunkhwa, Pakistan; **Email**: naveedahm89@gmail.com
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Introduction

Onion is belonging to the family *Amaryllidaceae*. It has a high economic worth due to its usage as a vegetable, spice, medical purposes and may be consumed either in dry or fresh form. Onions dried bulbs and green leaves are a rich source of vitamins, minerals, proteins, carbs, and various therapeutic benefits. In addition, onions are frequently utilized as natural remedies for conditions including the flu, chicken pox, measles, and cardiovascular issue (Imtiaj and Tae, 2008). Onions are a necessary and significant vegetable item that are utilized in every kitchen, their demand is consistently high all year round (Malik, 1994). Onions are grown on 148408 hectares of land in Pakistan, yielding an average yield of 13.98 tons.ha^{-1} and a total production of 2,075,984 tons. In Khyber Pakhtunkhwa (KP) province onion are produced on 11974 hectares of an area with a total yield of 223957 tons, whereas an average yield of 18.70 tons ha^{-1} (MNFSR, 2020).

For getting higher yield various fertilizers applied to the crop which is very dangerous to human health. Conventional agricultural methods are gradually being influenced more by different like diseases, pests, droughts, reduced soil fertility because of use harmful chemical pesticides contaminations as well as world-wide warming. That's why we have to use eco-friendly biocontrol agent to reduce the pollution of soil as well as environment. Biocontrol is the use of precise microbes which obstruct with the plant pests and pathogens, it is an environmental pleasant, biological approach to reduce troubles by universal procedures of plant protection (Harman *et al.*, 2004). *Trichoderma species* also produce a diversity of biologically active complexes, including cell wall disintegrating secondary metabolites and enzymes, among other things (Vinale *et al.*, 2008). A promising method for better growth of plants is to increase nutrient transport to roots that can be colonized by trichoderma. *Trichoderma* spp. is a type of fungus that solubilize the insoluble micronutrients in loam soil and improved translocation and uptake of nutrients that are important for plants development and their proper growth (Altomare *et al.*, 2015).

In order to improve proper growth of plants, fourth secondary macronutrient sulphur is required. It's an important part of the vitamin A, which performs a vibrant function in the stimulation of numerous enzymes of the plants. It plays a key part in the production of different amino acids, like methionine and cystine (Havlin *et al.*, 2004). Sulphur depletion is a continuous pattern that results from diminished soil and plant S uptake, resulting in worldwide sulphur deficit (Aulakh, 2003). In Pakistan, incorrect doses of high-analysis chemical fertilizers such as Urea, TSP, and MOP increase cropping intensity while limiting the use of organic manures, resulting in soil sulphur shortage (Islam, 2008). Application of sulfur not only enhances the quality but its application with *Trichoderma* will protect the bulb from various pest and pathogens and diseases. Considering the significance of sulfur application for increasing the yield of onion the field trial was conducted to determine the best level of sulfur and *Trichoderma harzianum* for maximum growth and onion production.

Materials and Methods

In the year 2022, field trial was initiated on "Effect of trichoderma applied with different sulfur levels on yield and sulfur uptake by onion (*Allium cepa* L.)" at NTHRI, Mansehra. It is situated at Latitude 34°47'19N, and Longitude 73°27'06E. The experimental trial was designed using a Randomized Complete Block (split plot) design with three replications for each component. Factor A (main plot) biofertilizer (*Trichoderma harzianum*) having four treatments i.e (0, 1.5. 3 and 6 kg ha^{-1}), whereas factor B (sub plot) Sulfur having five levels i.e. (0, 25, 50, 75 and 100kg.ha^{-1}). For sulfur treatment sulfonate fertilizer were applied containing 90% of Sulfur because the sulfur status of the soil is poor. To calculate the S absorbance Standard solution was used at 420 nm (Bardsley and Lancaster, 1960). Total phosphorus in plant samples were evaluated using Benton *et al.* (1991). AB-DTPA extractable P concentration in the soil was determine by placing a 10 g specimen of soil in a flask with AB-DTPA 20 mL and vibrate it for 15 minutes on reciprocating shaker. Then suspension was filtered through Whattman (paper No. 42) filter. A colour reagent "ammonium molybdate" and a Spectrophotometer at an 880 nm wavelength were used for phosphorus evaluation, Soltanspour and Sehwab (1977).

Statistical analysis

To examine the differences and interactions between various treatments, the experimental data was subjected to the analysis of variance (ANOVA)

method by using randomized complete block (split plot) design. The mean difference was calculated using the least significant difference (LSD) at the 1% level of significance (Steel *et al*., 1997). The data was analyzed using the statistical program STATISTIX 8.1.

Results and Discussion

Effect of Trichoderma (0,1.5,3 and 6kg.ha^{-1}) and Sulfur (0,25,50,75 and 100 kg.ha^{-1}) on onion was investigated at PARC-National Tea and High Value Crops Research Institute Shinkiari, Mansehra during 2022. Various growth and yield contributing parameters were examined during the research. The findings of the experimental results are discussed and presented below. Table 1 displays the experimental field's physicochemical features.

Table 1: *Physico-chemical properties of the experimental field before transplanting onion.*

Determination	Quantity
Sand (%)	30.4
Clay (%)	17.7
Silt (%)	51.9
Soil Texture	Silt loam
pH	7.5
EC (dS m^{-1})	0.091
AB-DTPA extractable P (mg kg^{-1})	3.3
Sulfur (mg kg^{-1})	11.3
Organic matter (%)	0.58

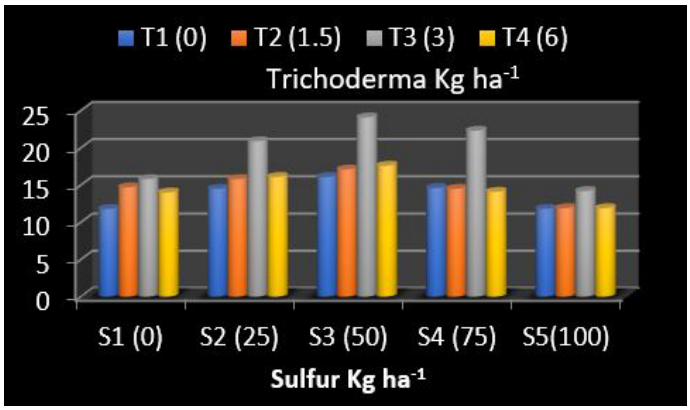

Figure 1: *Plant height (cm) as affected by trichoderma and sulfur interaction.*

Plant height (cm)

Different levels of trichoderma greatly influenced the onion plant height. Maximum plant height of onion (67.93 cm) was obtained by the inoculation of trichoderma 3kg.ha^{-1} followed by (58.80 cm) by the application of 1.5 kg.ha^{-1}, whereas, minimum plant height of onion (53.66 cm) was recorded for 6 kg.ha^{-1} trichoderma application. The plant height of onion was considerably altered by different concentration of sulfur. Maximum plant height of onion (69.58 cm) was obtained by the addition of sulfur 50 kg.ha^{-1} followed by (64.00 cm) by the application of 75kg. ha^{-1}, whereas, the minimum (50.75 cm) plant height was measured for control treatment. The combination of trichoderma and sulfur greatly influenced onion plant height. The maximum (80.66 cm) plant height was recorded for the application of trichoderma and sulfur 3 kgha^{-1} and 50 kgha^{-1}, respectively. Whereas, the lowest plant height (46.66 cm) was reported for the control plot. Our findings are comparable to those of Mishu *et al*. (2013).

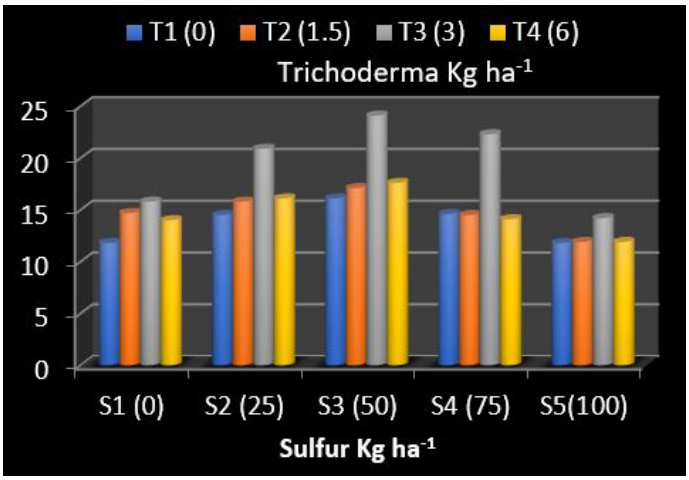

Figure 2: *Bulb diameter (mm) as affected by trichoderma and sulfur interaction.*

Bulb diameter (mm)

Tables 2 and 3 are shown data on onion bulb diameter (mm). Different levels of Trichoderma and sulfur had a substantial effect on onion bulb diameter. Maximum bulb diameter (66.40 mm) were recorded by the application of Trichoderma 3 Kg.ha^{-1}, whereas, minimum bulb diameter (48.86 mm) were recorded in control plot. Maximum bulb diameter (64.75 mm) were recorded by the application of Sulfur 50 Kg ha^{-1} followed by (59.83 mm) by the application of 75 Kg ha^{-1}, whereas, the lowest (47.33 mm) bulb diameter were recorded for control treatment. The interaction of trichoderma and sulfur significantly affected the bulb diameter of onion. The maximum bulb diameter (76.67 mm) was recorded for the application of trichoderma and sulfur 3 kg ha^{-1} and 50 kg ha^{-1} respectively. Whereas, the minimum bulb diameter (41.66 mm) were recorded for control plot. Our findings are consistent with the findings of Verma *et al*. (2020).

Table 2: *Plant height, bulb diameter (mm), single bulb weight (g), number of leaves, leaf length (cm), sulfur content in bulb (%), phosphorus concentration (%) and yield (ton ha^{-1}) of onion as affected by trichoderma application.*

Trichoderma kg ha^{-1}	Plant height (cm)	Bulb diameter (mm)	Single bulb weight (g)	Number of leaves	Leaf length (cm)	Sulfur content in bulb (%)	Sulfur content in soil (mg kg^{-1})	Phosphorus in soil (mg/kg)	Phosphorus Conc. (%) in leaves	Yield (t/ha)
0	54.60 c	48.86 c	79.93 c	10.46 c	39.60 c	0.10 c	16.13 c	6.08 d	0.10 c	13.90 c
1.5	58.80 b	54.46 b	85.33 b	11.73 b	43.80 b	0.11 b	17.10ab	6.66 c	0.12 b	14.84 b
3	67.93 a	66.40 a	112.3 a	13.33 a	52.93 a	0.13 a	16.59 bc	7.91 b	0.14 a	19.53 a
6	53.66 d	54.53 b	85.00 b	10.73 c	38.66 d	0.11 b	17.68 a	8.81 a	0.11 b	14.78 b
LSD	0.78	0.74	0.80	0.52	0.78	0.02	0.72	0.27	0.01	0.21

Single bulb weight

Data concerning weight (g) of a single onion bulb are shown in Tables 2 and 3 shows that trichoderma and sulfur had a highly significant (P ≤ 0.01) impact on bulb weight of onion. As well as their interaction were also significant. Maximum single bulb weight (112.33 g) was documented by the inoculation of trichoderma 3Kg.ha^{-1} followed by (85.33 g) by the application of trichoderma 1.5 Kg ha^{-1}, whereas, minimum single bulb weight (79.93 g) were recorded in control plot. Maximum single bulb weight (108.67 g) were recorded by the application of Sulfur 50 kg ha^{-1} followed by (97.08 g) by the application of 25 Kg.ha^{-1}, whereas, minimum single bulb weight (71.83 g) were recorded for the application of sulfur 100 Kg ha^{-1}. The maximum single bulb weight (139.00 g) was recorded for the application of trichoderma and sulfur 3 and 50kg.ha^{-1}, respectively. Whereas minimum single bulb weight (68.00 g) were recorded for control plot.

Number of leaves

Onion number leaf data are shown in Tables 2 and 3, demonstrates that sulfur and trichoderma had a highly significant (P≤0.01) impact on onion number of leaves. Additionally, their interactions were significant. The application of trichoderma 3 Kg ha^{-1} produced the leading number of leaves (13.33), followed by trichoderma 1.5 Kg ha^{-1}, which produced the minimum/lowest number of leaves (11.73), while the untreated plot had the least number of leaves (10.46). Maximum numbers of leaves (13.41) were recorded by the application of Sulfur 50 Kg.ha^{-1}, followed by (12.25) with the addition of 75 Kg.ha^{-1}, whereas minimum number of leaves (10.00) were recorded for the application of sulfur 100 Kg ha^{-1}. The maximum number of leaves (16.33) was recorded for the application of trichoderma and sulfur 3 kg ha^{-1} and 50 kg ha^{-1}, respectively. Whereas the minimum number of leaves (9.33) were recorded by the application of Trichoderma (6kg) and sulfur (100kg) per hectare. These findings suggest that Trichoderma had a major impact on the plant's growth. Trichoderma may be the cause because it solubilizes insoluble minerals and absorbs more nutrients that plants can readily absorb (Yedidia *et al*., 2001).

Leaf length (cm)

Table 3 contains information about onion leaf length, Sulphur and Trichoderma significantly (P ≤ 0.01) effected the onion leaf length. Onion leaf length was strongly impacted by various degrees of Trichoderma. Trichoderma 3 Kg.ha^{-1} application produced maximum/ longest leaf length (52.93 cm), and Trichoderma 1.5 Kg ha^{-1} application lead to longest leaf length (43.80 cm), whereas minimum leaf length (38.66 cm) was recorded by the application of trichoderma 6 Kgha^{-1}. Maximum leaf length (54.58 cm) was recorded by the application of Sulfur 50 Kgha^{-1} followed by (49.00 cm) by the application of 75 Kg ha^{-1}, whereas minimum leaf length (35.75 cm) was recorded for control plot. The interaction of trichoderma and sulfur significantly affected the leaf length of onion. The maximum leaf length (65.66 cm) was recorded for the application of trichoderma and sulfur 3 kgha^{-1} and 50 kgha^{-1}, respectively. Whereas the minimum leaf length (31.33) were recorded for control plot. The outcomes also line up with Barakat and Gaber (1998), Rather and Chattoo (2003), who saw an increase in onion leaf length after being inoculated with bio fertilizer.

Sulfur contents in onion bulb (%)

Table 3 contains information about the sulphur content of onion bulbs expressed as a percentage. Means data showed that trichoderma and sulfur had a significantly (P≤0.01) high impact on content of sulfur in onion bulb as well as their interaction was also significant. The treatment of trichoderma 3Kg. ha^{-1} produced the maximum/highest content of sulfur

Table 3: *Plant height, bulb diameter (mm), single bulb weight (g), number of leaves, leaf length (cm), sulfur content in bulb (%), phosphorus concentration (%) and yield (ton ha^{-1}) of onion as affected by sulfur application.*

Sulfur kg ha-1	Plant Height (cm)	Bulb diameter (mm)	Single Bulb weight (g)	Number of leaves	Leaf length (cm)	Sulfur content in bulb (%)	Sulfur content in soil (mg kg^{-1})	Phosphorus in Soil (mg/kg)	Phosphorus Conc. (%)	Yield (t/ha)
0	50.75 e	47.33 e	81.17 d	10.41 c	35.75 e	0.09 d	12.58 e	4.85e	0.07 e	14.11 d
25	55.83 d	57.75 c	97.08 b	11.75 b	40.83 c	0.12 b	15.12d	6.47 d	0.10 d	16.88 b
50	69.58 a	64.75 a	108.6 a	13.41 a	54.58 a	0.14 a	16.54	7.68 c	0.12 c	18.89 a
75	64.00 b	59.83 b	94.50 c	12.25 b	49.00 b	0.11 bc	19.20b	8.64 b	0.15 a	16.43 c
100	53.58 d	50.66 d	71.83 e	10.00 c	38.58 d	0.11 c	20.93 a	9.18 a	0.14 b	12.49 e
LSD	0.40	0.66	0.75	0.53	0.40	0.01	0.61	0.24	5.84	0.17

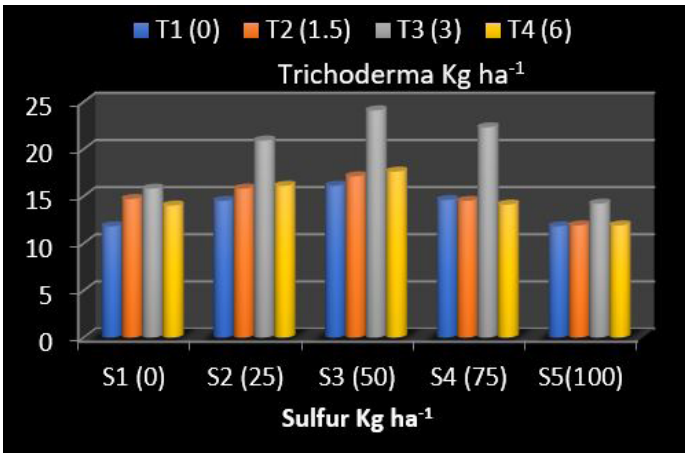

Figure 3: *Single bulb weight (g) as affected by trichoderma and sulfur interaction.*

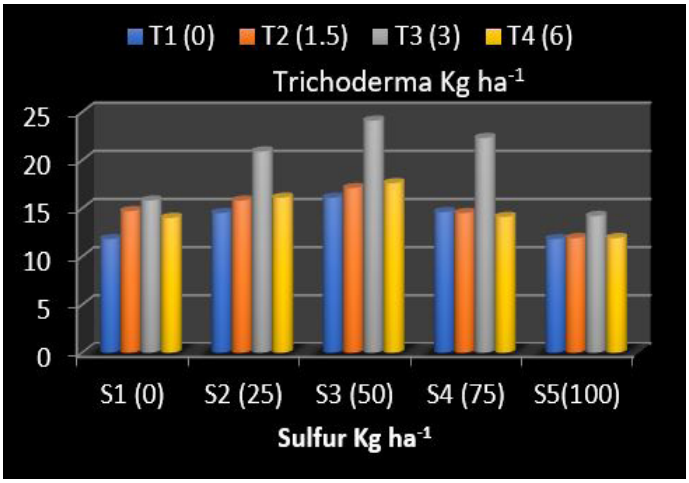

Figure 4: *Number of leaves as affected by trichoderma and sulfur interaction.*

in the onion bulb (0.13%), which was followed by trichoderma 1.5 Kgha^{-1} (0.11%), whereas minimum sulfur content (0.10 %) was recorded for controlled plots. Maximum content of sulfur in onion bulb (0.14 %) was documented by the addition of Sulfur 50Kg.ha^{-1} followed by (0.12 %) by the treatment of 25 Kg.ha^{-1}, whereas minimum content of sulfur in onion bulb (0.9 %) was recorded for control plot. The interaction of trichoderma and sulfur significantly affected the quantity of sulfur in onion bulb. The maximum content of sulfur in onion bulb (0.19 %) was recorded for the application of trichoderma and sulfur 3kg.ha^{-1} and 50kg.ha^{-1}, respectively. Whereas the minimum sulfur content in onion bulb (0.8 %) was recorded in control plots. Earlier with the application of S, a rise in leaf S concentration with S addition was recorded (Mahaptara *et al.*, 2000; Toatia *et al.*, 2000).

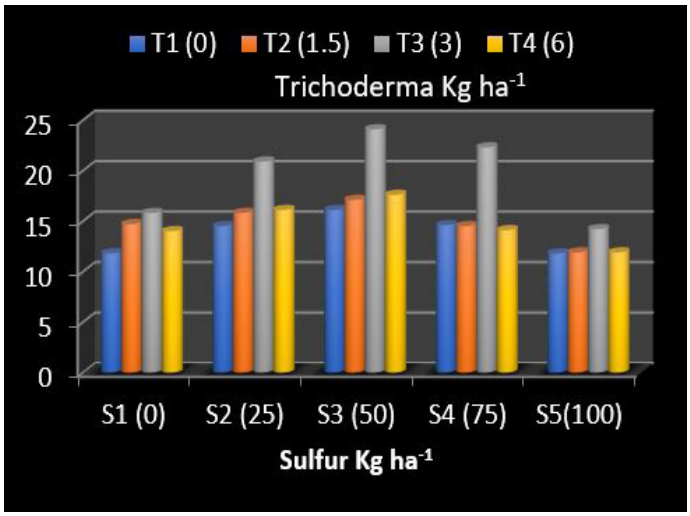

Figure 5: *Leaf length (cm) as affected by trichoderma and sulfur interaction.*

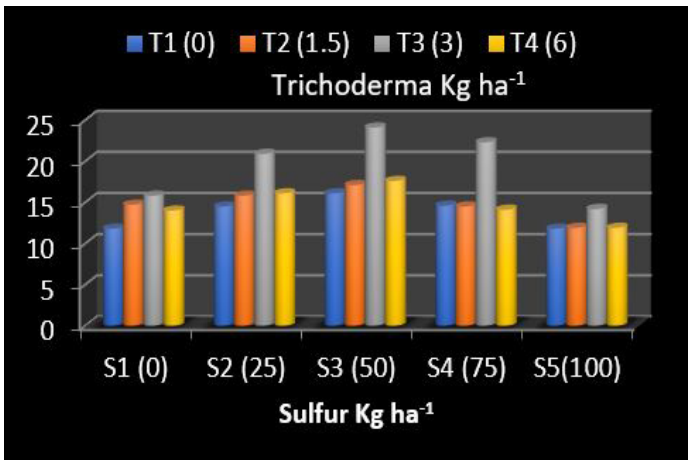

Figure 6: *Sulfur content (%) in onion bulb as affected by trichoderma and sulfur interaction.*

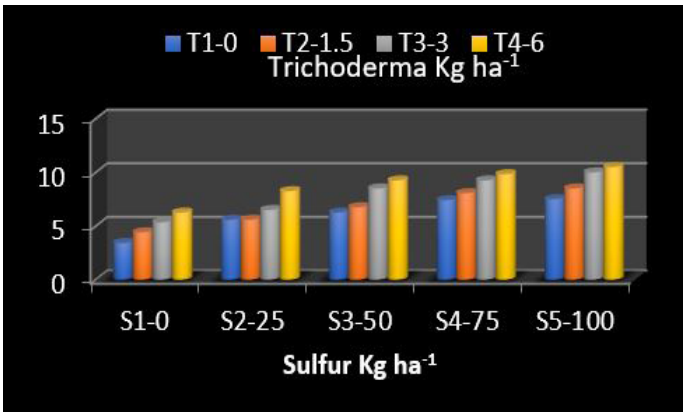

Figure 7: *Sulfur content in soil (%) as affected by trichoderma and sulfur interaction.*

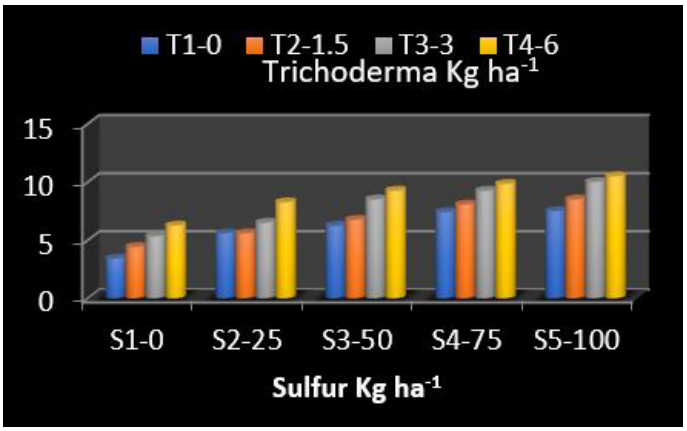

Figure 8: *Phosphorous content in soil as affected by trichoderma and sulfur interaction.*

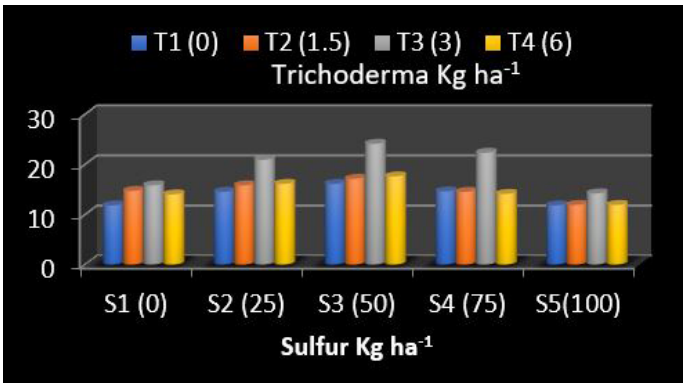

Figure 9: *Phosphorus concentration (%) as affected by trichoderma and sulfur interaction.*

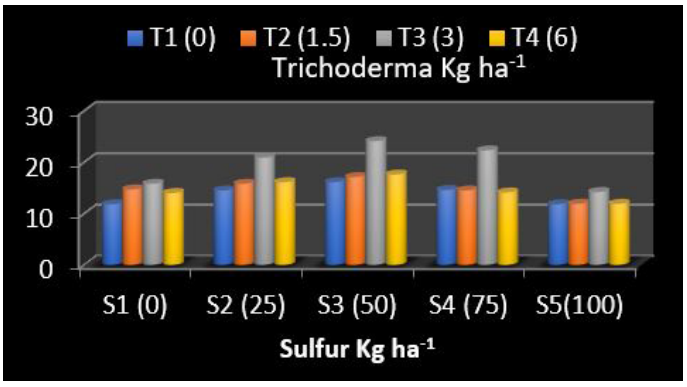

Figure 10: *Yield ton ha^{-1} as affected by trichoderma and sulfur interaction.*

Sulfur content in soil (mg kg^{-1})

Tables 2 and 3 contains information about the content of sulfur in soil demonstrates that trichoderma and sulfur had a highly significant impact on the content of sulfur in soil. Maximum content of sulfur in soil (17.683 mg/kg) was recorded for trichoderma (6 Kgha^{-1}) application, followed by (17.100 mg/kg) with the addition of trichoderma (1.5 Kgha^{-1}), however, minimum sulfur content (16.133 mg/kg) was noticed through the addition of 0 Kgha^{-1} trichoderma. Different levels of Sulfur significantly affected the content of sulfur in soil. Maximum content of sulfur in soil (20.937 mg/kg) were noted with the addition of Sulfur (100 Kgha^{-1}), followed by (19.200 mg/kg) with the addition of 75(Kgha^{-1}), whereas, minimum content of sulfur in soil (12.583 mg/kg) was recorded for control plot. The interaction of trichoderma and sulfur significantly affected the content of sulfur in soil of onion field. The maximum content of sulfur in soil (21.250 mg/kg) was recorded for the application of trichoderma and sulfur 6 kgha^{-1} and 100 kgha^{-1} respectively. Whereas, the minimum sulfur content in soil (12.00 mg/kg) were recorded for trichoderma application and sulfur application with the proportion of 3 and 0 kgha^{-1}.

Phosphorus in soil (mg/kg)

Different levels of trichoderma significantly affected the concentration of phosphorus in soil. Maximum concentration of phosphorus in soil (8.81 mg/kg) was noticed for trichoderma (6 Kg.ha^{-1}) application, followed by (7.91 mg/kg) by the application of trichoderma 3 Kgha^{-1}, whereas minimum phosphorus concentration (6.08 mg/kg) was recorded 0 Kgha^{-1} trichoderma application. Different levels of sulfur significantly affected the phosphorus concentration in soil media. Maximum phosphorus concentration (9.18 mg/kg) in soil were perceived through phosphorus (100 Kgha^{-1}) addition, followed by (8.64 mg/kg) with 75 Kgha^{-1}, whereas, minimum concentration of phosphorus in soil (4.85 mg/kg) was recorded for control plot. The interaction of trichoderma and sulfur significantly affected the concentration of phosphorus in soil of onion field. The maximum concentration of phosphorus in soil (10.50 mg/kg) was recorded for the application of trichoderma and sulfur 6 kgha^{-1} and 100 kgha^{-1}, correspondingly. Whereas, the minimum phosphorus concentration in soil (3.42 mg/kg) was noted in untreated plots.

Phosphorus in onion leaves (%)

Table 2 contains information about the percentage of phosphorus found in onion leaves, mean data shows that trichoderma and sulfur had a highly significant ($P \leq 0.01$) effect on concentration of phosphorus in onion bulb as well as their interaction were also significant. Maximum concentration of phosphorus (0.14%) and (0.112%) in the bulb, respectively, were found in plots where trichoderma was supplied at rates of 3 Kg ha^{-1} and 1.5 Kg ha^{-1}, whereas minimum phosphorus concentration in onion bulb (0.10 %) was recorded in controlled plots. Maximum concentration of phosphorus in onion bulb (0.15 %) was perceived by the usage of Sulfur 75 Kg.ha^{-1} followed by (0.14 %) by the dosage of 100 Kg.ha^{-1}, whereas minimum concentration of phosphorus in onion bulb (0.7 %) was recorded for control plot. The interaction of trichoderma and sulfur significantly affected the concentration of phosphorus in onion bulb. The maximum concentration of phosphorus in onion bulb (0.18 %) was recorded for the application of trichoderma and sulfur 3 kg.ha^{-1} and 75 kg.ha^{-1}, respectively. Whereas the minimum phosphorus concentration in onion bulb (0.5 %) was recorded in control plots. *Trichoderma* spp. is a type of fungus that solubilize the insoluble micronutrients in loam soil (Altomare *et al.*, 2015) and improved translocation and uptake of nutrients for plants development and growth (Baker, 1989).

Yield tons ha^{-1}

Tables 2 and 3 contains information about onion yield (tones ha^{-1}). Mean values demonstrates that sulfur and trichoderma had a statistically significant ($P \leq 0.01$) effect on yield (tons ha^{-1}) of onion, as well as their interaction were also significant. The yield (tons ha^{-1}) of onions was considerably impacted by different levels of trichoderma. Trichoderma 3 kg ha^{-1} produced the highest yield (19.53 tons ha^{-1}), which was followed by applications of trichoderma 1.5 kg ha^{-1} and 6 kg ha^{-1} respectively, yielding 14.84 tons ha^{-1} and 14.78 tons ha^{-1}., whereas minimum yield (13.90 tons ha^{-1}) was recorded in control plots. Through the aforementioned trichoderma application onion production increased upto 40.50 % over the control. The yield (tons ha^{-1}) of onions was impacted heavily by different sulphur levels. Maximum yield (18.89 tons ha^{-1}) was reported for the application of sulfur 50 kg ha^{-1}, followed by (16.88 tons ha^{-1}) and (16.43 tons ha^{-1}) for the use of sulfur 25 and 75 kg per hectare, respectively, whereas minimum yield (14.11 tons ha^{-1}) were recorded for the control plots. Likewise, trichoderma, sulfur application @ 50kg ha^{-1} increased the yield 33.87% over the control plot. The use of trichoderma and sulfur (3 kgha^{-1} and 50 kg ha^{-1}, respectively) produced the highest yield (24.1 t ha^{-1}) 104%. Whereas for the control plot, the minimal yield (11.8 tons ha^{-1}) was noted. Our experimental findings are similar up to greater extent with Mishu's *et al.* (2013) They found that the best yield was achieved by the sulfur dose at 40 (kg.ha^{-1}), and that the yield reduced at 60 and 80 kg ha^{-1} Nasreen and Haque (2017) It has been said that raising the sulfur content to 50 kg ha^{-1} causes the onion plant to take in more nitrogen, which enhances plant growth and results in proper onion root (bulb) size, which raises onion production at 50 Kg ha^{-1}, Similar to this, plants took in the least amount of nitrogen when the sulfur level was increased. Thus, the size was inadequate. Our findings in the instance of Trichoderma are consistent with those of Mishu *et al.* (2013), who claim that four forms of auxin, gibberellin, cytokinin, abscisic acid, and ethylene are necessary for the growth of Trichoderma. There is a possibility that the *Trichoderma* spp. hormone ethylene is one of those, which can encourage plants to blossom. Similarly, Roco and Perez (2001) claimed that the Trichoderma harzianum fungus can induce plants to create significant amounts of specific hormones, including benzyl amino purin (BAP), indole acetic acid (IAA) and gibberellic acid (GA3). Gibberellins and auxin hormones in plants help to stretch the roots and stems, promote the growth of flowers and fruits, and accelerate plant growth. Hence, From the studies mentioned above, it is evident that trichoderma aids in plant vegetative and reproductive growth as well as onion yield-increasing properties.

Conclusions and Recommendations

To minimize the need of commercial fertilizer the integrated application of trichoderma @ 3kg.ha^{-1} along with the addition of Sulfur @ 50kg.ha^{-1} are recommended for the better growth and yield of onion, nutrients availability and soil physiochemical properties for the agro-climatic conditions of Shinkiari, Mansehra.

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Novelty Statement

Inoculation of trichoderma and application of sulfur boosted the growth and yield contributing parameters of onion.

Author's Contribution

Faheem Akbar: Conducted the research trial.
Maria Mussarat: Supervised the trial.
Naveed Ahmed and Muhammad Abbas Khan: Co-supervised the trial.
Dost Muhammad, Imtiaz Ahmed and Seemab Ali: Technical assistance for lab analysis.
Toseef Ahmad: Statistical analysis.
Muhammad Afaq Akbar and Shehryar Rafique: Helped in all field and Lab work.
Basharat Hussain Shah, Fayaz Ahmad and Sohail Aslam: Proof reading and final editing.

Conflict of interest
The authors have declared no conflict of interest.

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