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Research Article

Effect of trichoderma and compost manure on the growth and yield of onion

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Abstract

An experiment was conducted at the Agriculture Research Institute Mingora, Swat, Pakistan. The experiment was designed in Randomized Complete Block Design (RCBD) having three replications. The experiment consisted of two factors. i.e *Trichoderma harzianum* (0, 20 and 40 kg ha^{-1}) and compost manure (0, 500, 1000 kg ha^{-1}) that were applied as a single dose. The mean data showed that compost manure and *Trichoderma* significantly affected all growth parameters. Plants treated with 1000 kg ha^{-1} compost manure had maximum plant height (63.46 cm), number of leaves plant^{-1} (11.88), leaf length (39.62 cm), leaf width (1.05 cm), bulb diameter (6.88 cm), bulb neck height (5.6 cm) and yield (32.88 tones ha^{-1}), but the parameters; plant height, number of leaves plant^{-1}, leaf length and leaf width were statistically similar to the plots treated with compost @ 500 kg ha^{-1}. *Trichoderma* @ 40 kg ha^{-1} showed maximum leaf length (39.56 cm), leaf width (1.09 cm), bulb weight (87.39 g), bulb diameter (7.06 cm) and yield (34.44 tones ha^{-1}) . Plant height, number of leaves and bulb neck height were statistically similar to the plots which were treated with 20 kg ha^{-1}*Trichoderma*. Whereas the lowest plant height (61.37 cm), number of leaves per plant (9.88), leaf length (37.21cm), leaf width (0.86 cm),bulb diameter (5.9 cm), bulb weight (77.14 g) and yield (27.22 tones ha^{-1}) were recorded in untreated plots. It is concluded from the results that compost manure is a best soil amendment should be used @ 1000 kg ha^{-1} and *Trichoderma* @ 40 kg ha^{-1} for better growth and maximum onion production.

Keywords: Trichoderma; compost; onion

Introduction

Onion (*Allium cepa* L.*)* belongs to the Alliaceae family. It is cited by our religious book "Holy Quran" and is also mentioned in the Bible that it is one of the oldest vegetable [1]. The onion was originated in the area of Pakistan, Iran, and the mountainous areas to the north [2]. Onion is winter vegetable; shallow rooted and mostly cross pollinated biennial crop. The onion is categorized in the short days and long days, dependent on the photoperiod requirement of onion for bulb formation. It is an important vegetable crop and is grown widely almost anywhere in the world. In Pakistan, it is an important seasoning and is widely used in all households. It is used as a part of most Pakistani curry dishes; onions are grown and used as food throughout history. They are consumed in their early green stage and also

after the bulbs mature. Onion contained nutrients, vitamins, minerals and organic compounds. It is a rich source of vitamin C and dietary fiber. It also contains sulfuric compounds and quercetin which are used in the application of several medicines. Its pungency is caused by the presence of allyl propyl disulfide, volatile oil [3].The cultivated area of onion is 130532 hawith total production of 1671012 tons Onion cultivation in the province of Khyber Pakhtunkhwa occupies 11394 ha with total production of 185524 tons whereas in Sindh, Baluchistan and Punjab, it occupies 49934, 27294 and 41910 ha with total production of 666764, 515486 and 303238 tons respectively. [4] *Trichoderma* is a saprophytic fungus. It is a producer of many antifungal metabolites including enzymes, antibiotics. *Trichoderma* excreted several antibiotics such as gilotoxin, virindin and trichodermine, which were proven to have antifungal activity for controlling various soil borne pathogens such as *Rhizoctoniasolani*, *Pythium* plant spp, *Fusarium, Sclerotiumrol fsii*etc [5]. The application of *Trichoderma* spp uses the organic matter in its vicinity as a food source and continues to grow for a period of time. This beneficial fungus establishes itself in close association to the plant roots and the surrounding soil. In this process of growth and establishment the *Trichoderma* spp accelerates the decay of organic matter, solubilizes insoluble minerals and captures nutrients such as phosphorus, iron and other tightly bound elements. In addition some types of *Trichoderma* species also promote growth and development of several crops such as bean (*Phaseolus vulgaris* L), cucumber (*Cucumissativus* L), pepper (*Capsicum annum* L), Carnation (*Dianthus caryopyllus* L), Maize (*Zea mays* L) [6, 7]. Moreover, [8] the application of *Trichoderma* significantly increased the yield of bell pepper, cucumber and strawberries. In recent years, bio-fertilizers, products containing living cells of different types of microorganisms, are used in the integrated nutrient supply system. Biofertilizers can convert nutritionally valuable elements that are not available to usable form through biological processes leading to improved crop yields. Compost is a form of decomposed organic matter, which is used as a source of organic fertilizer. In organic farming, it is a key component as it provides the essential macro and micronutrients [9] Compost improves soil physical condition and prevents crusting surface, thus, improving soil aeration, water infiltration and plant root penetration. It also preserves the nutrients contained in livestock manure, sewage sludge, and similar materials. Research studies showed that in agriculture the use of compost is beneficial to crops, soil and environment [10] Compost primarily serves as soil conditioner and spread in a layer on the surface of the soil or digs in. Compost, regularly added to garden soil, makes the soil able to drain efficiently and retains air and reserves nutrients that plant can uptake. Soil amendment also tends to produce crops with rare insect and disease problems. The compost boosts beneficial soil microorganisms in a large population, which prevent injurious microorganisms. Compost nurture healthy growth of the plant and healthier plants are capable to resist pests. Compost contains all the nutrients which a living plant needs. It is a slow-release fertilizer, made of a variety of components, which provides an even more nutritious meal to growing plants. Adding compost to a garden is an enduring investment. Compost improves the soil structure and nourishes the future plantings in years to come. The use of inorganic fertilizer continuously affects the soil structure. Therefore organic compost can be used an alternative to mineral fertilizer to improve the structure and microbial biomass of the soil [11] It has been reported that combined application of organic manure,

chemical fertilizer and biofertilizer resulted in maximum yield as compared to the extensive application of chemical fertilizer [12]. The usage of Biofertilizer enriched with beneficial fungus and organic manure offers several benefits to producers. It is an environment friendly cultivation method. It also overcomes the cost of production. Agricultural products produced through organic farming are good for human health and fetches higher prices in the market. Keeping the facts and importance of organic fertilizer and fungus enriched biofertilizer (*Trichoderma*), the experiment was aimed to investigate the effect of compost manure and biofertilizer (*Trichoderma harzianum*) on the growth and yield of onion with the objectives to determine the effect of *Trichoderma harzianum* and compost manure on the growth and yield of onion, to find out the optimum level of compost manure and *Trichoderma harzianum* for growth and maximum onion production and to investigate the interactive effect of compost manure and *Trichoderma harzianum* on the growth and yield of onion.

Materials and methods

The field experiment entitled "The effect of *Trichoderma harzianum* and compost manure on the growth and yield of onion was conducted at Agriculture Research Institute North Mingora (ARINM) during the winter season 2015-16.

Soil analysis

The soil was analyzed for different chemical composition before transplantation. The soil samples were randomly collected before transplantation from the experimental field at a depth of 10 cm by using agar. The analysis of soil was done in the laboratory of Agriculture Research Institute North Mingora (Table 1).

Table 1. Soil analysis before transplantation

Sand	**44.4 %**	**OM**	**1.035 %**
Silt	52 %	Lime	0.5 %
Clay	3.6 %	Soil texture	Silt loam
pH	6.8	Phosphorous (P)	11.91 %
Nitrogen (N)	0.025 %	Potassium (K)	112.5 %

Experimental design

The experiment was laid out in 2-factorial randomized complete block design (RCBD) having three replications. Factor (A) consisted of Biofertilizer (*Trichoderma harzianum*) and factor (B) consisted of compost manure. The plot size was 9 m x 9 m having row to row and plant to plant distances 25 cm and 10 cm, respectively. The treatments detail is as follows.

Composition of compost manure

Compost manure is the decomposed form of organic matter and used as fertilizer and soil amendment. Compost provides vital micro and macronutrients. Compost manure was prepared by Agriculture Research Institute Mingora from mixture of grass clippings, vegetable peels, rotted fruits and farm yard manure.

Biofertilizer

Biofertilizer enriched with beneficial fungi *Trichoderma harzianum* microscopic fungi which form a symbiotic relationship with plant roots was used in experiment (Table 2).

Land preparation

Before transplantation, the field was thoroughly prepared. Fertilizer was applied at the rate 50:25:25 kg ha^{-1}. Nitrogen was applied in split doses while full doses of potash and phosphorus were applied to the soil before transplanting. The field was divided into plots, where the treatments combinations were assigned.

Transplanting of seedlings

The healthy and vigorous disease free seedlings were selected from the nursery bed and were transplanted into the well prepared

experimental field. Transplantation was done in the month of November.

Table 2. Shows factors

Factor A: ***Trichoderma harzianum***	**Factor B: Compost manure**
T1: Control	C1: Control
T2: 20 kg ha^{-1}	C2: 500 kg ha^{-1}
T3: 40 kg ha^{-1}	C3: 1000 kg ha^{-1}

Trichoderma **and compost manure application**

Single dose *Trichoderma harzianum* powder was mixed with the sand and was broadcasted into the field. While in treatments combination *Trichoderma harzianum* was mixed with compost manure and was broadcasted into the experimental field, where the seedlings were transplanted. After application the field was thoroughly irrigated.

Parameters studied

1. Plant height (cm), 2. Number of leaves plant^{-1}, 3. Leaf length (cm), 4. Leaf width (cm), 5. Bulb diameter (cm), 6. Neck height (cm), 7. Bulb weight (g), 8. Yield tons ha^{-1} 9. Cost Benefit ratio.

Statistical analysis

Data collected on various growth and yield parameters were subjected to the analyses of variance test using MSTAT-C and significant means were separated where appropriate by the least significance difference at 0.05 probability level.

Results and discussion

Plant height (cm)

The data concerning plant height is presented in (Table 3). data showed that Composted manure and *Trichoderma harzianum* had significant effect on plant height while interactive effect was found non-significant. The experimental results indicated that maximum plant height (63.46 cm) were noticed in plants treated with compost manure (1000kg ha^{-1}), followed by 62.99 cm recorded in plants treated with compost manure (500kg ha^{-1}), which are statistically similar, while minimum plant height were observed in control. In case of *Trichoderma harzianum* treated plots, the maximum plant height (63.81cm) were noticed in plants which received *Trichoderma*@ 40 kg ha^{-1}, followed by (62.83 cm) observed in plants treated with *Trichoderma* @ 20kg ha^{-1}, while minimum (61.75 cm) were noticed in untreated plots. The observed results are in agreement with the findings [13] Who stated that organic manures increased the vegetative growth parameters significantly, the improvement in plant height might be due to the supply of more nitrogen and phosphorous by organic manure. Similarly the same results were noticed by[14] who reported that organic manure improved physical properties of the soil which was good for plant growth and led to increase plant height. *Trichoderma* is used as a biological control. It inhibits the growth of the pathogens. *Trichoderma* also produces phytohormones, vitamins and solubilize minerals which lead to increase the growth in terms of plant height [15] also approved that *Trichoderma* had significant control against soil borne pathogens and nematode in tomato plants [16, 17] reported that the range of plant height increased with the use of *Trichoderma* to stimulate the growth of tomato plants.

Number of leaves plant^{-1}

Data regarding number of leaves plant^{-1} is presented in (Table 3). Compost manure and *Trichoderma harzianum* significantly affected number of leaves plant^{-1} of onionwhile theie interactive effect was found non-significant. In compost manure treated plots, the highest number of leaves plant^{-1} (11.88) were recorded in plants treated with

1000 kg ha^{-1}, followed by plants (11.33) treated with 500 kg ha^{-1} which is statistically similar to the plants treated with 1000 kg ha^{-1}. The lowest number of leaves plant^{-1} (9.11) were recorded in control. In case of *Trichoderma* treated plants the maximum number of leaves plant^{-1} (11.44) were found in the plants which received 40 kg ha^{-1} *Trichoderma*, while the lowest number of leaves plant^{-1} (9.88) was recorded in control plots. These results are in agreement with **[18]** who observed that application of bio-fertilizers with organic amendments resulted in promoting the number of leaves plant^{-1}. These results indicate that *Trichoderma* significantly affected the growth of the plant. It may be due to the reason that *Trichoderma* solubilizes insoluble minerals and captures more nutrients which plants can easily uptake. These results are linked with the work of **[19]** who stated that *Trichoderma* increased the root surface allowing the roots to explore larger volume of soil in the rhizosphere; therefore, more nutrients were made available for easy uptake. In case of compost manure, results showed that composted manure significantly affected number of leaves plant^{-1}. These results were also supported by **[9]** who reported that compost significantly increased the number of leaves per plant in onion. Similar results were also reported by **[20]** who revealed that compost manure significantly increased the number of leaves per plant as compost manure contains all the essential nutrients which could increase the growth of onion crop.

Leaf length (cm)

Data recorded on a leaf length is presented in (Table 3). Data shows that *Trichoderma harzianum* application and compost manure had significant affect on the leaf length of onion, whereas their interaction was non-significant. Mean table regarding leaf length shows that the highest leaf length (39.56 cm) was recorded in plants received 40 kg ha^{-1} *Trichoderma harzianum*, followed by plants (38.26 cm) which received 20 kg ha^{-1} *Trchoderma harzianum*. Whereas the lowest leaf length (37.21cm) was noted in control treatment. In case of compost manure, the maximum leaf length (39.62 cm) was noted in plants treated with 1000 kg ha^{-1} compost manure, followed by plants (39.01 cm) treated with 500 kg ha^{-1} compost manure, whereas the lowest leaf length (36.41 cm) was recorded in control treatment. These results are linked with the work of **[21]**, who reported that biofertilizer increased growth of the plants significantly as compared to uninoculated plants in growing season. The results are also in the conformity with **[22, 23]** who observed increase in leaf length of onion as a result of inoculation with bio fertilizer. The increase in leaf length of onion might be due to the fact that the organic manure provided nutrients to the soil. In compost manure the nutrients leaching did not occur and it provided best soil structure, which helpd in improved leaf formation of the crop. The application of organic manure gave more nutrients to the plant for the leaf growth. The plants absorbed these nutrients specially nitrogen which helped in the vegetative growth of plant. **[24]** Reported that nitrogen is the main component of protein and the protein helps in more carbohydrate formation which may help in increasing the leaf size.

Leaf width (cm)

The data regarding leaf width is given in (Table 3). Results showed that leaf width was significantly influenced by the Compost manure and *Trichoderma harzianum* application while it's interactive effect was non-significant. The experimental results showed that highest leaf width (1.05 cm) was observed in plants where 1000 kg compost ha^{-1} was applied, followed by plants (0.96 cm) where 500 kg compost ha^{-1} was applied. The minimum leaf width (0.90 cm) was observed in control treatment. In case of

Trichoderma harzianum the mean value for leaf width indicated that the maximum leaf width (1.09 cm) was noted in plants where 40 kg *Trichoderma*ha^{-1} were applied, followed by plants (0.95 cm) where 20 kg *Trichoderma* ha^{-1} was applied, while the minimum leaf width (0.86 cm) was noticed in control plots. The leaf width was significantly increased due to the application of compost manure. Compost manure improved the leaf width of onion crop as it provided the essential nutrients to plants which increased the vegetative growth of plant and more leaf width was observed. These results are in confirmation with [12] who investigated that the application of organic manure increased the vegetative growth as well as the production of onion crops as compost improved the structure of the soil and provided essential nutrients that were easy to uptake by the plant. Similar results were revealed by [25] who studied that organic fertilizer affected significantly the leaf width of onion crop.

Bulb neck height (cm)

Data concerning bulb neck height is shown in (Table 3). *Trichodrma* and compost manure significantly affected the bulb neck height of onion crop, while their interaction was found non-significant. Data shows that maximum bulb neck height (5.7 cm) was found in plants treated with 40 kg ha^{-1} *Trichoderma*, followed by plants (5.5 cm) to which 20 kg ha^{-1} *Trichoderma* were applied, while the minimum bulb neck height (5.0 cm) was noticed in control. The application of compost manure had also significant effect on the bulb neck height of onion crop. The mean values indicated that maximum neck height (5.6 cm) was recorded in plants where 1000 kg ha^{-1} compost manure was applied, followed by 5.4 cm recorded in plants where 500 kg ha^{-1} compost manure was applied, while the minimum bulb neck height was observed in plant of control treatments. Organic fertilizer is environment friendly fertilizer. It increases the fertility of the soil by providing more nutrients as compared to chemical fertilizer which is hazardous for the environment. The organic fertilizer is easily accessible to plant because there is no problem of nutrients leaching. That is why the crop might get a lot of nutrients which are essential for better growth of plant. These facts are supported by the [26] who studied that compost significantly affected the growth and yield parameters of onion crop as compared to control. Similarly [27] reported that organic manure with N, P and K improved the onion plant growth and also increased the bulb neck height of onion. Biofertilizer, *Trichoderma* is a saprophytic fungus which controlled various phyto pathogenic fungi through antagonistic action [28] which inhibit the growth of the plant. Same is the case in onion crop; vegetative parameters were significantly increased as *Trichoderma* controlled the pathogenic fungi resulting in high growth of the plant. These results are linked with [7] who investigated that *Trichoderma* enhanced the vegetative growth and development of cucumber and bell pepper.

Bulb weight (g)

The mean data of bulb weight is presented in (Table 3). *Trichoderma* and compost manure application had significant affect on the bulb weight, while the interactive effect was found non-significant. Mean table showed that maximum bulb weight (87.39 g) were obtained from plots treated with 40 kg ha^{-1} *Trichoderma*, followed by plants (78.80 g) noticed in 20 kg ha^{-1} *Trichoderma*, while minimum bulb weight (77.14 g) was recorded in control plots. In case of composted manure treated plots, maximum bulb weight (84.75 g) was recorded where 1000 kg ha^{-1} compost manure was applied, followed by plants (83.07 g), which received 500 kg ha^{-1} compost manure, while minimum bulb weight (75.52 g) was noted in control plots. The improvement in bulb weight is due to the

increased organic matter in soil. Addition of organic manure might have improved the soil structure and enhanced the availability of macro and micro nutrients. The soil may become more fertile and provide more organic matter to the crop. The yield and bulb weight may be increased due to the availability of organic matter which increased the uptake of many nutrients by plants i.e. nitrogen, phosphorus and potassium. The NPK enhanced the cell division of the plant tissue and hence increased the rate of photosynthesis. These results are in confirmation with [14] who reported that the organic matter increased the bulb weight as it provided NPK, which increased the vegetative growth of the plant and resulted in more number of leaves, leaf length and width, which later on increased the bulb weight. Similarly [26] results are also in line with our findings, who reported that organic fertilizers increased number of leaves and leaf length compared to control plots, which later on increased the bulb weight in onion crop.

Bulb diameter (cm)

Mean table of bulb diameter is presented in (Table 3). Means table shows that the compost manure and *Trichoderma* application had significant affect on the bulb diameter of onion. In compost manure maximum bulb diameter (6.88 cm) was noted in plants where 1000 kg compost ha^{-1} was applied, followed by plants (6.43 cm) treated with 500 kg ha^{-1} compost whereas minimum bulb diameter (6.00 cm) was noted in control plots. In case of bio-fertilzer, *Trichoderma*, maximum bulb diameter (7.06 cm) was noted in plants which received 40 kg ha^{-1} *Tricoderma,* followed by plants (6.34 cm) which received Trichoderma @ 20 kg ha^{-1}, while minimum bulb diameter (5.90 cm) was noted in control plots. Bulb diameter of onion could be affected by compost manure as it increased the organic matter of the soil. Onion is heavy feeder crop and it gives good response to rich soil as a result the vegetative growth increased in terms of bulb diameter. These results are in agreement with [29] who suggested that organic manure improved the bulb growth by enhancing the soil physical properties and reduced the leaching of nutrients from the root zone. These results are also in line with [30] who argued that organic manure enhanced the physical properties of the soil and improved the bulb diameter of onion.

Total yield ha^{-1} (tones)

Data regarding yield (tones ha^{-1}) is presented in (Table 3). Composted manure and *Trichoderma harzianum* significantly affected yield (tones ha^{-1}) of onion,while there interactive effect was found non-significant. The maximum yield (32.88 tons ha^{-1}) was recorded in plants which received 1000 kg ha^{-1} compost manure, followed by the plants (30.63 tones ha^{-1}) which were treated with 500 kg ha^{-1} compost manure, while the minimum yield (28.44 tones ha^{-1}) was noted in control plots. In case of *Trichoderma*,maximum yield (34.44 tones) was obtained in plants which were applied 40 kg ha^{-1} *Trichoderma,* followed by plants (30.30 tons) which received 20 kg ha^{-1} *Trichoderma*, while the lowest yield (27.22 tones) was noted in control plots. The maximum yield (34.44 tones) was obtained in plants which received 40 kg ha^{-1} *Trichoderma* among all the other treatments as it attained maximum number of leaves $plant^{-1}$, plant height, leaf length, leaf width, bulb weight and diameter and hence resulted in maximum yield ha^{-1}. In case of compost @ 1000 kg ha^{-1}, yield was maximum (32.88 tones) as 1000 kg ha^{-1} also attained maximum values in all growth parameters i.e number of leaves $plant^{-1}$, plant height, leaf length, leaf width, bulb weight and diameter and hence resulted in maximum yield ha^{-1}. These results are in confirmation with who reported that the increase in yield is due to the application of organic manure as it increased the water

holding capacity of the soil and provided the nutrients for long duration due to less leaching of nutrients. Similarly, [31, 32] reported that with the usage of organic fertilizers, the plant roots grew easily to take more nutrients. In addition, more water was available to plants as organic manure increased the water holding capacity of the soil. This resulted in increased rate of photosynthesis and more food assimilation.

Table 3. Plant height (cm), Number of leaves plant^{-1}, leaf length (cm), leaf width (cm) Bulb Neck height (cm), Bulb weight (g), Bulb diameter (cm), Total Yield tons ha^{-1}

	Plant Height (cm)	No.of leaves plant^{-1}	Leaf Length (cm)	Leaf Width (cm)	Bulb Neck Height (cm)	Bulb Weight (g)	Bulb Diameter (cm)	Total Yield (tons ha^{-1})
Trichoderma (kg/ha)								
0	61.37 b	9.88 b	37.21 c	0.86 b	5.00 b	77.14 c	5.90 c	27.22 c
20	62.83 a	10.88 a	38.26 b	0.95 b	5.50 b	78.80 b	6.34 b	30.30 b
40	63.81 a	11.44 a	39.56 a	1.09 a	5.70 a	87.39 a	7.06 a	34.44 a
LSD (0.05)	1.36	1.051	1.08	0.104	0.21	1.60	0.42	2.08
Compost Manure (kg/ha)								
0	61.55 b	9.11 b	36.41 b	0.90 b	5.20 b	75.52 c	6.00 c	28.44 c
500	62.99 a	11.33 a	39.01 a	0.96 ab	5.40 a	83.07 b	6.43 b	30.63 b
1000	63.46 a	11.88 a	39.62a	1.05 a	5.60 a	84.75 a	6.88 a	32.88 a
LSD (0.05)	1.36	1.051	1.08	0.104	0.21	1.60	0.42	2.08

Cost benefit ratio

Data related to cost benefit ratio is given in the (Table 4). The cost of *Trichoderma* application and Compost manure application at different levels were taken in to consideration while calculating cost benefit ratio. The cost of all cultural practices was same for all treatments which had fixed cost. In compost manure the maximum cost benefit ratio was noted in plants which were treated with 1000 kg ha^{-1} compost (17.41), followed by plants (12.16) treated with 500 kg ha^{-1} compost manure. The cost benefit ratio (17.41) will mean that the farmer will earn Rs. 17.41 for spending Rs. 1 on the treatment applied. In case of *Trichoderma* treated plots, the maximum cost benefit ratio (4.43) was noted in plots which received 40 kg ha^{-1} *Trichoderma*, followed by plants (3.60) which were treated with 20 kg ha^{-1} *Trichoderma*. The maximum cost benefit ratio noticed in *Trichoderma* application (4.43), which means that if a farmer spends Rs. 1 on the treatment will earn Rs. 4.43.

Table 4. Cost benefit ratio

Factor A (Compost manure)	Added cost ha^{-1}	Yield increase over control (kg ha^{-1})	Net Income ha^{-1}	Cost benefit ratio
1000 kg ha^{-1}	10200	4440	177600	**17.41**
500 kg ha^{-1}	7200	2190	87600	**12.16**
Control	4200	---	---	---
Factor B (*Trichoderma harzianum*)				
40 kg ha^{-1}	64200	7120	284800	**4.43**
20 kg ha^{-1}	34200	3080	123200	**3.60**
Control	4200	---	---	---

Onion price in Rs = 40 kg^{-1}
Price of 50 kg bag of Compost in Rs = 300
Price of 1k g *Trichoderma*spp powder in Rs = 150

Conclusions and recommendations

Maximum plant height, number of leaves per plant, leaf length, leaf width, bulb neck height, bulb weight, bulb diameter and yield ha^{-1} and cost benefit ratio were observed in plots treated with compost at the rate of 1000 kg ha^{-1}. In case of *Trichoderma* application maximum plant height, number of leaves $plant^{-1}$, leaf length, leaf width, bulb weight, bulb neck height, bulb diameter, yield ha^{-1} and cost benefit ratio were observed in plots treated @ 40 kg ha^{-1}. Control plots showed poor results in all parameters of the study as compared to other plots. It is recommended that compost manure is a best soil amendment and should be used @1000 kg ha^{-1} along with *Trichoderma harzianum* @ 40 kg ha^{-1} for better onion production. Further research is suggested to investigate different *Trichoderma species* with different organic fertilizers.

Authors' contributions

Conceived and designed the experiments: Dawood & N Ara, Performed the experiments: Dawood, MN Khan & S Sattar, Analyzed the data: Dawood, I Irfan, SQ Shah & B Said, Contributed materials/ analysis/ tools: M Bakhtiar & S Sattar, Wrote the paper: Dawood & MN Khan.

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