Research Article

Impact of Foliar NPK and NAA Blended with Organic Material on Tomato Yield Attributes and Properties of Soil

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Abstract | Tomato are perishable fruit and its growth, yield and quality depends on the management practices. Tomato attributes were studied under controlled condition using manures and pressmud incombination with foliar spray of macro-nutrients and naphthalien acetic acid (NAA) and compared with inorganic soil applied fertilizers. The results of the study showed significantly higher number of branches, chlorophyll content in the treatment recieving inorganic fertilizers, the manures in combination with foliar NPK was comparable. The yield attributes showed that ten fruit weight were greater in the soil applied inorganic fertilizer and it was statistically at par with treatments recieving manure with foliar NPK. Number of fruits per plant were recorded highest in the pots recieving poultry manure either with Foliar NPK or NAA. The yield of tomato was found greater in the treatments recieving soil applied NP, which was statistically similar in the treatment recieving poultry manure with foliar NPK. The treatments in the current study have shown to influence the qualitative parameter of tomato as total soluble solids, while the water content and fruit pH were non significantly changed. Soil properties including soil pH, bulk density, soil organic matter, total nitrogen and extractable phosphorus was significantly altered amongst the treatments. Tomato showed positive response to the organic fertilizers applied along the foliar nutrients in terms of growth, yield and quality. It may be concluded that poultry manure applied along with NAA was comparable with the inorganic fertilizer in improving the growth and yield of tomato, but had the advantage over the inorganic fertilizer in improving the soil properties.

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Introduction

Tomato (*Lycopersicum esculentum*) belongs to family solanaceae, is an important vegetable grown on vast area in the world and is ranked 2nd amongst the other vegetables. Tomato is used in the daily diet for its nutritive qualities as a rich source of lycopene, vitamins and several other minerals. Tomato is a perishable crop but can be stored as a post-harvest. In Pakistant the area under tomato cultivation during 2014 – 15 was 1689 ha, with production of 142113 tons (GOP, 2014-15). Tomato crop show good response to manures and inorganic fertilizer (Ramyabharathi et al., 2014). The inorganic fertilizers are considered important for enhancing yield of crops. But due to increase in price (Jagadeesha, 2008) and certain types

of environmental hazards related to inorganic fertilizer, have triggered the use of organic fertilizer (Song et al., 2017).

Organic manures have been used for years, but the yield obtain through these is far below the chemical fertilizers. Organic materials i.e. farm yard manure and compost from crop residues, are insufficient to overcome nutrient deficiency of a crop (Ilupeju et al., 2015). It has been found that tomato applied with manures, compost etc. in the later stage of growth require a supplementary nutrition that can be supplied through foliar spray of nutrients (Kołota and Osińska, 2000). Havlin et al. (2013) reported that fruit and vegetables require adequate amount of potassium to improve the qualitative properties i.e. size, taste, color etc. Potassium applied through foliar application influence the lycopene contents of tomato fruit (Lester et al., 2007). Moderate concentration of other nutrients through foliar application may have beneficial influence on the growth and quality of tomato (Souri and Dehnavard, 2017). Foliar nutrition is rapidly utilized by the plants. It has been also emphasized that the application through soil may lead to certain types of contamination to the ground water, so application of plant through foliar supplement with the soil fertilization is more beneficial (Krishnan et al., 2014).

Also the foliar application of Plant growth regulators (PGRs) are being extensively used for improving the growth and yield of horticultural crops (Batlang, 2008 and Serrani et al., 2007). They are the biological stimulants required in a very minute quantity for different bio – chemical processes, which finally results in the growth and yield of plants. The plant growth regulators are used to enhance the efficiency of metabolic process (Golzade et al., 2011). The PGR are organic naturally occurring substances they have the ability to effect the plant growth and physiological processes i.e. cell division, differentiation and development, stress responses and reproductive activities. The most common types of PGRs belonging to auxins family which are naturally occurring are indole-acetic acid (IAA) and Indole Butyric acid (IBA) while naphthalene acetic acid (NAA) and 2,4-diclorophenoxyacetic acid (2,4-D) are the synthetic auxin. The other PGRs include gibberellin and cytokinins.

Current study has been designed with objective to investigate the effect of integrated use of manure, pressmud with foliar NPK and NAA and compare with sole NPK in soil and as foliar spray on the qualitative and quantitative traits of tomato.

Materials and Methods

To investigate the effect of organic amendments fortified with foliar NPK and NAA on soil properties, quality and yield attributes of tomato a study was carried out at Institute of Soil and Environmental Sciences, Gomal University, Dera Ismail Khan (Pakistan). The experiment was carried out in earthen pots of size 20319.82 cm^3. Each pot was filled with 20 kg air dried soil brought from the bank of indus river. The organic amendments used in the experiment as the Farm yard manure and poultry manure were locally available from the dairy and poultry sheds respectively. Pressmud was obtained from Chashma Sugar Mills D. I. Khan.

The experiment was laid out in Complete Randomized Design (CRD) with nine treatments i.e. T_1: 160 kg N ha^{-1} and 120 kg P ha^{-1}; T_2: Farm Yard Manure @ 5 t ha^{-1} + Foliar application of NPK; T_3: Poultry Manure @ 5 t ha^{-1}+ Foliar application of NPK; T_4: pressmud@ 10 t ha^{-1}+ Foliar application of NPK; T_5: Farm Yard Manure @ 5 t ha^{-1} + Growth Regulator (NAA); T_6: Poultry Manure @ 5 t ha^{-1} + Growth Regulator (NAA); T_7: pressmud @ 10 t ha^{-1} + Growth Regulator (NAA); T_8: Foliar application of NPK sole; T_9: Control. Each treatment was replicated three times.

Tomato verity Rio – grande early was used. The seed were sown on 21st November and nursery was transplanted to the respective pots in the 2nd week of February. Foliar application of NPK was purchased from the local market containing NPK @ 19:19:19 (power super) and NAA @ 0.02% were used as foliar spray after 30 days of transplantation, flowering and fruiting stage.

Growth, Yield and Quality Parameters of Tomato

Growth, yield and quality parameters studied in the experiment were number of branches per plant, Chlorophylles content, ten fruit weight, number of fruit per plant, fruit yield, total soluble solid, fruit mositure content and fruit pH. Fruit yield was measured in gram per pot and was converted to t ha^{-1} using the area of the pots.

Physico – chemical analysis of soil

Physico – chemical characteristics of soil including texture (Gee and Bauder, 1982), electrical conductivity (ECe), pH (Ryan et al., 2001), bulk density (Blake and Hartage, 1986), organic matter (Nelson and Sommer 1982), Soil total nitrogen (Bremner, 1996)

and extractable phosphorus (Olsen et al., 1954). The composition of original soil, manures and pressmud are given in Table 1. The quantitative and qualitative parameters of tomato were also measured.

Table 1: *Physico – chemical characteristics of soil.*

Parameters	Soil
Total Organic Carbon (%)	0.28
pH	7.86
EC (μSm^{-1})	843
N (%)	0.022
Extractable P_2O_5 (mg kg^{-1})	5.89
Soil Texture	Sandy Clay loam

Chemical analysis of FYM, poultry manure and pressmud

Chemical analysis of FYM, poutry manure and pressmud were carried out using procedure given by Tandon et al. (2005) for pH, EC and Organic matter. Nitrogen was determined by Kjeldhal method (Ryan et al., 2001) using digestion mixture of K_2SO_4 + $FeSO_4$ + $CuSO_4$ in 85: 10: 5 (g), respectively. Phosphorus and potassium was measured in samples by wet digestion using nitric acid-per chloric acid (HNO_3-$HClO_4$) (Jackson, 1960) and absorbance was recorded for phosphorus using spectrophotometer at 410 nm while potassium was analyzed using flame photometer (Table 2).

Table 2 : *Composition of manures and pressmud used in the experiment.*

Parameters	Farmyard Manure	Poultry Manure	Pressmud
Total Organic Carbon (%)	21.73	28.79	25.25
pH	8.10	7.04	7.86
EC (μSm^{-1})	990	678	1023
N (%)	0.94	1.08	0.96
C:N	23.11	26.65	26 .30
Phosphorus (%)	0.24	0.96	0.56

Statistical analysis was carried out by using the techniques and procedures as suggested (Steel et al., 1997). LSD test was applied to compare the different means of treatments.

Results and Discussion

Number of branches and cholorphyll content as affected by the treatments

In the study significantly ($P<0.05$) different number of branches per plant were recorded in the treatments. Among the treatments maximum number of branches were found in the treatment receiving NP fertilizers @ 160 and 120 kg ha^{-1} (T_1) which was 20.33, it was statistically at par with the treatments receiving different manures along with the foliar NPK. While the lowest value for number of branches per plant was recorded in the control having value of 9.3 (Table 3). Significantly increased number of branches by the application of different levels of poultry manure (Ewulo et al., 2008). The effect was due to application of manure on the growth parameters.

Table 3: *Effect of various treatments on Number of Branches and Chlorophyll content.*

Treatments	No. of branches per plant	Chlorophyll content (µ g m^2)
T1: 160 kg N ha^{-1} and 120 kg P ha^{-1}	20.33a	46.65a
T2: Farm Yard Manure @ 5 t ha^{-1}+ Foliar application of NPK	14.16ab	48.3a
T3: Poultry Manure @ 5 t ha^{-1}+ Foliar application of NPK	14.33ab	47.06a
T4: Pressmud@ 10 t ha^{-1}+ Foliar application of NPK	15.83ab	46.35a
T5: Farm Yard Manure @ 5 t ha^{-1} + Growth Regulator (NAA.	13.5ab	43.93abc
T6: Poultry Manure @ 5 t ha^{-1} + Growth Regulator (NAA)	11.33b	44.76ab
T7: Pressmud @ 10 t ha^{-1} + Growth Regulator (NAA)	16.33ab	48.28a
T8: Foliar application of NPK sole	13.66ab	39.25bc
T9: Control	9.3 b	38.65c
$LSD_{0.05}$	7.968	5.851

Means followed by different letter(s) in a column are statistically significant at 5 % probability level; **NS:** *Non Significant.*

Chlorophyll content of tomato leaves were significantly affected by the application of treatments. The results showed greater chlorophyll content of 48.3 µ g cm^2 in the treatment receiving FYM @ 5tons ha^{-1} along with the foliar application of NPK. It was at par with rest of the treatments, except the treatments where sole NPK was applied (Table 3). While the lowest was recorded in the control yielding 38.65 µ g cm^2. The application of manures with the foliar spray and growth regulators have increased the vigour and greenness of the plants. Significant increase in total Chlorophyll (µg cm^{-2}) at 60 days after transplanting, maximum chlorophyll was found by application of NAA and minimum was found in control (Subhash et al., 2014).

Table 4: *Effect of various treatments on yield attributes of tomatoes.*

Treatments	Ten Fruit Weight (g)	No. of fruits per plant	Yield of Tomatoes (t ha^{-1})
T1: 160 kg N ha^{-1} and 120 kg P ha^{-1}	501.33a	20.66bc	11.843a
T2: Farm Yard Manure @ 5 t ha^{-1}+ Foliar application of NPK	439.66ab	21.33bc	8.808cd
T3: Poultry Manure @ 5 t ha^{-1}+ Foliar application of NPK	405.33abcd	35.33a	10.596ab
T4: Pressmud@ 10 t ha^{-1}+ Foliar application of NPK	440.66ab	24.5b	9.864bc
T5: Farm Yard Manure @ 5 t ha^{-1} + Growth Regulator (NAA)	282cde	23bc	10.108bc
T6: Poultry Manure @ 5 t ha^{-1} + Growth Regulator (NAA)	285.33cde	34.66a	9.295bcd
T7: Pressmud @ 10 t ha^{-1} + Growth Regulator (NAA)	418.66abc	23.66b	8.049de
T8: Foliar application of NPK sole	269.33de	21.33bc	8.184de
T9: Control	248 e	18.16 c	6.938 e
$LSD_{0.05}$	139.27	2.4433	0.720

Means followed by different letter(s) in a column are statistically significant at 5 % probability level.

Table 5: *Effect of various treatments on qualitative parameters of tomatoes.*

Treatments	Total soluble solids (%)	Total water content (%)	Fruit pH
T1: 160 kg N ha^{-1} and 120 kg P ha^{-1}	3.16b	88.97^{Ns}	4.02^{NS}
T2: Farm Yard Manure @ 5 t ha^{-1}+ Foliar application of NPK	3.43b	86.99	3.95
T3: Poultry Manure @ 5 t ha^{-1}+ Foliar application of NPK	3.30b	87.31	3.99
T4: Pressmud@ 10 t ha^{-1}+ Foliar application of NPK	5.43a	85.86	3.96
T5: Farm Yard Manure @ 5 t ha^{-1} + Growth Regulator (NAA)	4.00ab	85.03	4.03
T6: Poultry Manure @ 5 t ha^{-1} + Growth Regulator (NAA)	5.1a	87.99	4.02
T7: Pressmud @ 10 t ha^{-1} + Growth Regulator (NAA)	3.70ab	88.06	3.98
T8: Foliar application of NPK sole	2.63b	86.05	3.93
T9: Control	2.83b	90.36	4.01
$LSD_{0.05}$	1.849	NS	NS

Means followed by different letter(s) in a column are statistically significant at 5 % probability level; **NS:** *Non – significant.*

Yield parameters of tomato as influenced by the treatments

Ten fruit weight was found significantly different amongst treatments. Maximum fruit weight per plant was observed in T_1 (501.33 g) receiving soil applied NP fertilizers. Whereas, the lowest fruit weight was noticed in control 248 g (Table 4). Similar results for higher fruit weight by poultry manure over cow and sheep manures have been recorded (Mehdizadeh et al., 2013). Fruit weight of tomato was found significantly higher by application of NAA after 60 days of transplantation (Subhash et al., 2014).

Number of fruit per plant were significantly affected by the use of different treatments (P<0.05). The greater number of fruits were observed in treatment T_3 (Poultry manure+ foliar application of NPK) which was 35.33 t ha^{-1}, over control having 18.16 t ha^{-1} (Table 4). Higher number of fruits per plant of tomato were attained by the application manures and compost over the control receiving NPK commercial fertilizers (Kandil and Gad, 2010). Also application of inorganic fertilizers with and without bio-fertilizers were studied and it was found that integrated use of inorganic fertilizers with bio-fertilizer gave highest number of tomato fruit that those without biofertilizers (Jagadeesha, 2008).

The results indicated that yield of tomato was significantly (P<0.05) affected by the application of inorganic and organic fertilizers. Highest yield of 11.84 t ha^{-1} tomato was recorded in treatment NP @ 160-120 kg ha^{-1} (T_1), while the least value for yield of tomato was calculated 6.93 t ha^{-1} in the control without fertilizers and manures. The yield increased in the soil applied inorganic fertilizers treatments may be due to readily available nutrients, while in the poultry manure the physico – chemical characteristics have been improved and the foliar application of NPK supplemented in the nutrients content and enhance the yield of tomato. As nitrogen, phosphorus and potassium

Table 6: *Effect of various treatments on Physico chemical characteristics of soil.*

Treatments	Soil pH	Bulk Density (gcm^{-3})	Organic matter content (%)
T1: 160 kg N ha^{-1} and 120 kg P ha^{-1}	7.10b	1.23ab	0.47e
T2: Farm Yard Manure @ 5 t ha^{-1}+ Foliar application of NPK	7.62a	1.05c	0.69bcd
T3: Poultry Manure @ 5 t ha^{-1}+ Foliar application of NPK	7.12b	1.02c	0.8467ab
T4: Pressmud@ 10 t ha^{-1}+ Foliar application of NPK	7.30ab	1.09bc	0.6333cde
T5: Farm Yard Manure @ 5 t ha^{-1} + Growth Regulator (NAA)	7.80a	1.16abc	0.79abc
T6: Poultry Manure @ 5 t ha^{-1} + Growth Regulator (NAA)	7.30ab	1.10bc	0.92a
T7: Pressmud @ 10 t ha^{-1} + Growth Regulator (NAA)	7.60c	1.08c	0.78abc
T8: Foliar application of NPK sole	7.70a	1.16abc	0.5533de
T9: Control	8.20a	1.25a	0.44e
$LSD_{0.05}$	1.01	0.0706	0.0954

Means followed by different letter(s) in a column are statistically significant at 5 % probability level.

Table 7: *Effect of various treatments on soil total nitrogen and extractable phosphorus.*

Treatments	Total N (%)	Extractable P ($mgkg^{-1}$)
T1: 160 kg N ha^{-1} and 120 kg P ha^{-1}	0.027de	7.08 ab
T2: Farm Yard Manure @ 5 t ha^{-1}+ Foliar application of NPK	0.034bcd	6.62 abc
T3: Poultry Manure @ 5 t ha^{-1}+ Foliar application of NPK	0.042ab	7.93 a
T4: Pressmud@ 10 t ha^{-1}+ Foliar application of NPK	0.031cde	7.69 a
T5: Farm Yard Manure @ 5 t ha^{-1} + Growth Regulator (NAA)	0.039abc	7.67 a
T6: Poultry Manure @ 5 t ha^{-1} + Growth Regulator (NAA)	0.046a	7.18 ab
T7: Pressmud @ 10 t ha^{-1} + Growth Regulator (NAA)	0.039abc	6.98 ab
T8: Foliar application of NPK sole	0.023e	5.50 bc
T9: Control	0.022e	4.85 c
$LSD_{0.05}$	0.00467	0.9229

Means followed by different letter(s) in a column are statistically significant at 5 % probability level.

are macronutrients required in greater quantity, which cannot be fulfilled by foliar applications as higher quantity causes burning and desiccation. Similarly, higher yield of tomato was recorded by application of chicken manures over the control. Chicken manure treatment gave approximately 50% greater yield than the control (Agyeman et al., 2014).

Qualitative parameters of tomato as influenced by the treatments

The result showed significantly higher Total Soluble Solids (TSS) in treatment T_4 which was 5.43% (Table 4) with the lowest of 2.83% found in control (T_9). The highest value of TSS in the pressmud + foliar NPK and growth regulator treatments may be due to the enhancement of growth stimulating substance, which increased the qualitative characters as carbohydrate, vitamins etc. A study was conducted to determine the effect of growth regulators i.e. Gibbrillic acid and 2,4-dichlorophenoxyacetic acid on tomato fruit and it was found that total soluble solids were increased when these growth regulators were sprayed alone or in combination (Gelmesa et al., 2010).

Water content of tomato is an important quality parameter which determines its perishability. Total moisture content was non - significantly influenced by the application of different treatments (Table 5). The highest water content was found 90.36% in the control which is at par with rest of the treatments except T_4 which was the lowest 85.03 %. It is evident from the results the application of nutrients and manure were effective in lowering of the moisture content. The greater moisture content in inorganic fertilizers treatments may be attributed to the nitrogen fertilizer which increases the succulence of the fruit. The uptake of water by tomato and its relation to the plant is complex phenomenon (Guichard et al., 2005). Lower moisture content of tomato in the organic amendment as compared with the conventional inorganic fertilizers was recorded in another study (Pieper and Barrett, 2008). The results regarding the fruit pH of tomato was

found non – significantly (P<0.05) altered by the application of different treatments. However the highest value for pH of 4.03 was recorded in the soil receiving Farmyard manure along with the growth regulators, while the lowest was found in T_8 which was treated with the foliar application of NPK alone (Table 5).

Comparing the effect of conventional inorganic fertilizer with organic method on qualitative parameters of tomato; it was found fruit pH was non significantly changed amongst the two methods (Pieper and Barrett, 2008).

Soil physico – chemical properties as influenced by the treatments

Soil pH was significantly changed by the application of different treatment. The results showed application of FYM along with the Nahthalien acetic acid (T_5) had the highest pH 7.80 which was statistically at par with T_8, T_2, T_4 and T_6 (Table 6). Significantly lowest pH of 7.10 was found in pots recieving inorganic soil applied fertilizer. This might have been due to the fact that single super phosphate contains sulfur which is effective in reducing the pH of the soil. Similarly, Poultry manure may have reduced the pH by production of organic acids. Using Farmyard manure has maintain the pH of soil. The pH of soil treated with manure did not show much difference from the control, however the inorganic fertilizers were effective in reducing the pH (Islam et al., 2011). Singh et al. (2015) found decresed in pH by using FYM and pressmud. The reduction in pH by the application of pressmud might be due to the sulphitation process.

The results regarding the bulk density of soil after the completion of experiment showed significant difference amongst the treatments (Table 6). The highest value for bulk density was recorded in the control, which was at with the treatment receiving soil NP and foliar application of NPK. Significantly lower bulk density was observed in the treatment receiving manure, waste water and pressmud. The decrease in soil bulk density by the manure may be attributed to improvement of soil aggregation and soil structure. Poultry manure was found effective in reducing the bulk density of soil (Ewulo et al., 2008).

The application of different treatments have significantly increased the organic matter content of soil (Table 6). The highest organic matter content was recorded in the poultry + NAA treated pots which was 0.92%, it was significantly at par with poultry + foliar NPK and pressmud along with NAA pots over the treatment of inorganic fertilizers which was 0.47%. Farmyard manure significantly influence soil organic matter content of soil as compared with the inorganic fertilizer (Khan et al., 2010). Significant increase in soil organic matter content by the application of poultry manure and goat manure has been reorted by Uwah et al., 2014. Sole application of cattle manure has been reported to influence the organic matter of soil significantly (Subhan et al., 2017).

Soil nutrient contents as affected by the application of treatments

Total nitrogen content of soil was significantly affected by the application of treatments (P<0.05). The results regarding total nitrogen content was found 0.042% in the treatments receiving poultry manure with NAA (Table 7). The least value for the total nitrogen content was recorded in the sole foliar NPK. In a study different rate of chicken manure, inorganic nitrogen fertilizer alone and along with poultry manure were applied, they were found to have greater effect on soil N content over control (Adekiya and Agbede, 2009). In another study the different organic manures were used and total soil nitrogen at the end of the experiment was 0.02%, 0.02 and 0.01% for compost, chicken manure and control respectively (Ibrahim and Fadini, 2013).

Phosphorus content of soil was also significantly (P<0.05) influenced by the application of various treatments. The results showed highest soil extractable P in the poultry and farm yard manures treated pots over sole foliar NPK. The greater amount of extractable P in the manure may be due to decomposition of organic matter which contains enormous amount of phosphorus. Higher concentration of extractable P has been found by the application farmyard manure and pressmud in saline sodic soils (Khan et al., 2010). Also poultry manure was found effective in enhancing the P concentration of soil (Dikinya and Mufwanzala, 2010), because the rate of decomposition of poultry manure is more rapid than the FYM (Ghoshal and Singh, 1995).

Conclusions

It may be concluded from the current study that integrated use of manures, pressmud with foliar NAA and NPK have been tested and found as a better nu-

trient management practice. The results showed that use of inorganic fertilizers applied to the soil gave higher growth and yield of tomato, however the results obtained from the pots recieving poultry manure along with NAA was analogous. The organic manures have superiority over the inorganic for improving the soil physico chemical characteristics.

Author's Contribution

Madiha Naz and Qudrat Ullah Khan: conceived the idea of the study, wrote the manuscript.
M. Jamil Khan and Aziz Ullah Sayal: Provided technical input.
Obaid Ullah Sayal: Statistical analysis.
Asim Afridi: Overall management of the article.

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