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Research Article

Response of organic and inorganic sources of nitrogen on tomato production in Parwanipur, Bara, Nepal

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ABSTRACT
An experiment was conducted to study the response of nitrogen (N) on tomato production using randomized completely block design (RCBD) design with two factorial arrangements of treatments in three replications at the research field of Directorate of Agricultural Research (DoAR), Parwanipur, Bara, Nepal in the winter seasons of 2020/21 and 2021/22. Factor A consisted of three genotypes (AVTO 1409, and AVTO 1306 and check Pusa Ruby). Factor B was comprised with five combinations of N application (i.e. 4 applications of N 100 and 50% of the recommended dose of fertilizers (RDF) through farm yard manure (FYM) and poultry manure (PM) with one control only RDF (200:150:120 kg N:P_2O_5:K_2O + 10 t ha^{-1} FYM). RDF of P_2O_5 and K_2O were applied equally in all treatment combinations. The plot was maintained at 9 m^2 (3 m x 3 m) and 28-day-old seedlings were transplanted at a 75 cm x 60 cm distance between rows and plants. The analysis of results observed highly significant variation for yield. However, their interaction effect was found non-significant. Whereas, Genotypes AVTO 1409 produced the highest plant height (71.20 cm,) and the earliest flowering (52 days). The earliest harvest (86 days) was found in AVTO 1306 along with the highest fruit weight. (47.9 g); fruit length (5.84 cm), fruit diameter (6.41 cm.), and the higher marketable yield (40.21 t/ha) followed by genotype AVTO 1409 (38.77 t/ha). The lowest yield (25.63 t ha-^{1}) was found in Pusa Ruby over the years. Likewise, the combined application of 50 % N from PM and 50% from inorganic fertilizer produced the highest plant height (74.20 cm) which was statistically at par with the control, the earliest harvest (89 days), diameter (5.92 cm) and length (5.98 cm) and average weight (41.6 g) of fruits and marketable yield (39.36 t/ha) while the supply of 100 % N only from FYM produced the lowest yield (31.21 t/ha) in the mean over the combined years. Based on the results, genotype AVTO 1306 and the application of 50% N from PM and 50% from inorganic sources were found promising in the sustainable production of tomato.
Keywords: Nitrogen, Response, Genotypes, Interaction and Tomato production

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INTRODUCTION
Tomato is one of the most popular commercial vegetable crops in the plains and hills of Nepal and is generally grown as an Autumn-Winter crop in Terai, inner Terai and foot-hills of Nepal (Ghimire *et al*., 2017). It has been proven as one of the most remunerative crops in

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these days. Tomato is the second most important vegetable crop after potato in the world with the production of 186.12 million tons of fresh fruit in 4.92 million hectares of land and achieving an average yield of 37.84 tons per hectare. China is the highest tomato-producing country 67.5 million tons with an average yield (59.86 t/ha) followed by India 20.69 Million tons and 24.55 t/ha production with an average yield respectively (FAOSTAT, 2022). Whereas in Nepal, tomato is ranked the third most commercially grown vegetable after cauliflower and cabbage which is cultivated in total 22,911 hectares of land and produces annually 4,22,703 tons with an average productivity 18.45 t/ha (MoALD, 2023). Which is far below the world average of other countries and even neighboring countries. In other seasons, tomato cultivation in Terai region is limited due to high summer temperatures, frequent heavy rains and humid weather which causes poor flower development, low fruit set and higher incidence of bacterial wilt (Chapagain *et al.*, 2020). As a result, tomato productivity in central terai i.e. Madesh Province, is significantly lower (14.96 t/ha) than the national average. Among the different factors for reasoning of low production and productivity of tomato in terai region is lack of suitable high yielding cultivars especially open-pollinated determinate types of genotypes and proper nutrient management practices etc.

Among nutrient, nitrogen is one of the most important nutrients required by tomatoes for higher yield and quality because many physiological processes and the conformational structure are related to nitrogen (Maathuis, 2009). It is the main constituent of protein and chlorophyll and helps in the utilization of phosphorus, potash and other elements in the plant (Gautam *et al.*, 2014). Due to the high demand and importance of nitrogen, over-fertilization is currently very common in tomatoes to achieve larger yield and profit as much as possible based on their experiences (Rhoads *et al.*., 1996; Thompson *et al*., 2007). However, the excessive application of nitrogen through inorganic sources has reduced the yield and quality, deteriorated soil structures, and added to environmental threats (Guo *et al.*, 2021). Generally, nitrogen is supplied through urea in most of crops in Nepal, which can quickly and efficiently N for crop growth. However, an excessive amount of urea applied to the field always causes large losses into the water and environment through leaching, ammonia volatilization, surface run-off or N_2O emission, rather than being utilized by crops. Similar findings were reported by (Liu *et al.*; 2021, Min *et al*., 2012; Thompson *et al*., 2020; He *et al*., 2009) as well as a reduction of absorption of other nutrients and synthesis of secondary metabolites (anthocyanin, vitamins) (Xing *et al*., 2001). To overcome environmental hazards posed by the non-judicious application of nitrogen through in-organic sources it is of utmost importance to replace in-organic sources of nitrogen with organic sources for sustainable tomato production. The advantage of the application of organic manures combined with inorganic fertilizers for vegetable production systems is beneficial reported in many studies (Khaitov *et al.*, 2019; Antonious *et al.*, 2020; Agbeda, 2021).

The optimum nitrogen requirements may vary depending on the soil types, crop varieties, location, season and purpose of crop grown. Despite the significant effect of nitrogen, very few studies have been conducted in Nepal focused on the organic and inorganic sources of nitrogen required for sustainable tomato production.

Therefore, present study was conducted with an objective to identify the effectiveness of nitrogen application through combined sources of organic manures and inorganic fertilizers and suitable open pollinated determinate tomato genotypes having high yield potential for plains area of central Terai region of Nepal.

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MATERIALS AND METHODS

An experiment was conducted in RCBD design with two factorial arrangements of treatments in three replications at Horticulture Research Farm of Directorate of Agricultural Research (DoAR), Parwanipur, Bara, Nepal in two consecutive winter seasons of 2020/21 and 2021/22. The experimental site is located at 27°.07'°N latitude and 84°.91' °E longitude with an elevation of 115 meters above mean sea level. The soil texture of the experimental area was silt loam. Additionally, soil p^H was moderately acidic. The organic matter, total nitrogen, available phosphorus (as P_2O_5) and available potassium (as K_2O) content were very low, low, very high and low, respectively. The meteorological data for cropping season was recorded from the meteorological station of RARS, Parwanipur, Bara, Nepal. The average minimum and maximum temperature and relative of growing was recorded 14.2 ºC, 28 ºC and 80.5% in first in first and 14.9 ºC, 27.7 ºC and 85.7% in second year respectively and lightly rainfall was noticed in second year. Factor A consisted of three (i.e. two promising open-pollinated determinate genotypes AVTO 1409, and AVTO 1306 and one local check Pusa Ruby), whereas Factor B was comprised with five combinations of nitrogen (N) application (four applications of N through combined sources of organic manures and inorganic fertilizer i.e. 1. 100% of N of RDF applied from farm yard manure (FYM), 2. 50 % of N of RDF from FYM + 50 % from inorganic fertilizer (IF), 3. 100% of N of RDF from poultry manure (PM), 4. 50 % of N of RDF from PM + 50 % from IF, and 5. Control only RDF- 200:150:120 kg $N:P_2O_5:K_2O$ + 10 t/ha FYM). Full doses of P_2O_5, K_2O of RDF were applied equally through inorganic fertilizers in all treatment combinations and manure and half dose of N at the time land preparation. The remaining half dose of nitrogen was equally top-dressed at 30 and 60 days after transplanting. Required cultural operation like weeding, irrigation, normal staking and spraying of insecticide and fungicides for controlling different insects and fungal diseases were carried out as per needed. The plots size was maintained at 9 m^2 (3 m x 3 m) and 28 days old seedlings were transplanted at a 75 x 60 cm distance between row to row and plant to plant. Observations were recorded on yield and yield attributing parameters that was described by Gotame *et al.*, (2019, 2021). All the collected data were processed by using MS Excel 2016 and analyzed by using Genstat 18th Edition. The mean separation was done by Duncan Multiple Range Test (DMRT) at 0.05 least significant difference (LSD) level.

RESULTS AND DISCUSSION

Plant height

The analysis of data on plant height showed highly significant differences in the response of genotypes and the combined sources of nitrogen through organic and IF on plant height in both years and combined data but the interaction was not significant (Table 1). Genotype AVTO 1409 obtained the highest plant height 69.21, 73.19 and 71.20 cm in first, second and combined years respectively. Likewise, the application of RDF responded the highest plant height 72.09, 76.30, and 74.20 cm followed by the application of 50 % nitrogen supplied through poultry manure + 50% from IF of RDF 70.67, 72.53 and 71.60 cm in first, second and combined years respectively which was significantly at par with each other and the lowest plant height was observed in the application of 50% N from FYM + 50 % N from IF 63.37, 66.38 and 64.87 cm in first, second and combined years results. The variation of plant height among the genotypes could be due to their genotypic character being influenced by the environment, while the variation of different doses could be due to nutritional effects. The higher plant height in 50% N through poultry manure and 50% through IF sources followed by inorganic sources could be due to readily available of available nutrients from the soil. The significant increase in plant height with a combination of organic and inorganic sources of N could be associated with

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stimulating more amount available nitrogen in IF. This finding is in disagreement with the finding of Timilsina *et al.* (2022). They reported combination of organic and inorganic sources of nitrogen did not affect the plant height in plastic house conditions in Pokhara. It could be due to the available sufficient amount of nitrogen in the soil under plastic houses. However, this finding is in line with the agreement of previous findings (Puli *et al.*, 2001; KC and Bhattarai, 2011, Tao *et al.*, 2022).

The analysis of data on plant height showed highly significant differences in the response of genotypes and the combination of sources of nitrogen fertilizers on plant height in both years and combined data but the interaction was not significant (Table 1). The application of 50%of nitrogen through poultry manure and 50% through IF produced the highest plant height which is statistically at par with control i.e. RDF treatment (Table 1). However, the interaction of genotypes did not show signification variation in plant height. The variation of yield among the genotypes could be due to their genotypic character being influenced by the environment, while the variation of different doses could be due to nutritional effects. The higher plant height in 50% N through Poultry manure and 50% through inorganic sources followed by inorganic sources could be due to readily available of available nutrients from the soil. The significant increase in plant height with a combination of organic and inorganic sources of N could be associated with stimulating more amount available nitrogen in inorganic fertilizers. This finding is in disagreement with the finding of Timilsina *et al.* (2022). They reported combination of organic and inorganic sources of nitrogen did not affect the plant height in plastic house conditions in Pokhara. It could be due to the available sufficient amount of nitrogen in the soil under plastic houses. However, this finding is in line with the agreement of previous findings (Puli *et al.*, 2001; KC & Bhattarai, 2011; Tao *et al.*, 2022)

Days to 50% flowering

Genotypes and combined application of organic and inorganic sources of nitrogen showed a significant variation in days to 50% flowering in both years and combined both years' data. The analysis of combined data showed that genotypes AVTO 1409 and AVTO 1306 were eight days earlier than Pusa Ruby and the application of 50 % N from PM and 50% N from IF influenced the earlier in days to 50% flowering (93 days) and control (i.e. RDF) also was found significantly at par with application of 50 % N from PM and 50% N from IF (Table 1).

However, the response of genotypes and their interaction with different sources of nitrogen did not show any significant variation on days to 50% flowering. These findings are in agreement with the findings of (Tao *et al.*, 2022). The earliness of flowering with the combination of organic and inorganic sources of nitrogen is in close conformity with the findings of Renuka and Ravi Shankar (1998). Similar findings were reported by Prativa and Bhattarai (2013). They reported that earliness in flowering could be faster vegetative growth and storing sufficient reserved food materials for differentiation of buds into flowers whereas delay in flowering in inorganic fertilizer treatments could be due to the extended vegetative phase of the plant by the availability of inorganic nitrogen. Our finding is in line with the agreement of the above finding.

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Table 1: Response of N on tomato genotypes in plant height and days to fifty percent flowering in Parwanipur in 2020/021 and 2021/022

	Plant height (cm)			Days to 50% flowering		
Factors	2020/21	2021/22	Combined	2020/21	2021/22	Combined
Genotypes						
AVTO 1409	69.21[a]	73.19[a]	71.20[a]	52[a]	52[a]	52[a]
AVTO 1306	64.45[b]	69.27[b]	66.86[b]	53[b]	50[a]	52[a]
Pusa Ruby	69.21[a]	68.49[b]	68.85[b]	62[b]	59[b]	60[b]
F-test	**	**	**	**	**	**
LSD (≤0.05)	2.93	3	2.02	2	2	1
Response of N application through organic and inorganic sources						
100% N from FYM of RDF	64.80[c]	67.10[c]	65.95[bc]	57	52	54.39
50% N from FYM + 50% N from IF of RDF	63.37[c]	66.38[c]	64.87[c]	56	53	54.78
100% N from PM of RDF	67.18[bc]	69.27[bc]	68.23[b]	56	55	55.28
50% N from PM + 50% N from IF of RDF	72.09[a]	76.30[a]	74.20[a]	54	53	53.78
Control i.e. RDF	70.67[ab]	72.53[ab]	71.60[a]	56	56	55.56
F-test	**	**	**	NS	NS	NS
LSD (≤0.05)	3.79	4	2.61	-	-	-
Interaction between Genotypes x Response of N through organic and inorganic sources						
Mean	67.62	70.31	68.97	57	54	56
F-test	NS	NS	NS	NS	NS	NS
LSD (≤0.05)	-	-	-	-	-	-
CV (%)	4.2	6.0	5.6	4.2	6.0	5.6

N: Nitrogen, FYM: Farm Yard Manure, PM: Poultry Manure, IF: Inorganic fertilizer, RDF: Recommended Dose of Fertilizer (200:150:120 kg $N:P_2O_5:K_2O$ + FYM 10 t/ha), CV: Coefficient of Variation, NS: Non-Significant, **P < 0.01

Days to first harvest

Days to the first harvest showed a signification variation due to the effect of genotypes and different sources of nitrogen in both years and combined data. The genotype AVTO 1306 showed the earliest harvest at 88, 84 and 86 days and the late harvest was in Pusa Ruby i.e. 104, 94 and 99 days in the first, second and combined data respectively (Table 2). In the case of the application of nitrogen sources, the application of 50 percent N of RDF through poultry manure + 50 % N from inorganic fertilizer was found the earliest in the first harvest 93, 86 and 89 days in the first, second and combined years respectively followed by control i.e. 93, 87 and 90 days in the first, second and combined years respectively (Table 2).

Average fruit weight

Data regarding to average weight of fruit depicted that the effect of genotypes and application of nitrogen through organic and inorganic sources showed highly significant differences among the tested genotypes and the combination of different sources for the application of nitrogen. Genotype AVTO 1306 produced the highest average fruit weight 45.6, 50.1 and 47.9 grams while the lowest fruit weight was found at genotypes Pusa Ruby 25.6, 23.8 and 24.6 grams in the analysis of first, second and combined years respectively (Table 2). Likewise, the application of 50 percent nitrogen of RDF through poultry manure + remaining dose through inorganic fertilizer recorded the highest average fruit weight followed by control. The lowest average fruit weight was observed in the application of 100 percent nitrogen of RDF through FYM + remaining recommended dose through FYM (Table 2). As in other parameters, the interaction effect between genotypes and the application of nitrogen through organic and inorganic sources resulted non-significant effect on average fruit weight. The variation of the average weight of fruits due to the effect of genotypes might be due to genotypic characteristics, whereas the highest average fruit weight in inorganic sources could be a readily available form of nitrogen through inorganic fertilizers. The significant variation in fruit weight due to the combined application of organic and inorganic sources of nitrogen is in agreement with the findings of Timilsina *et al.* (2022), Bahadur *et al.* (2004), Prativa and Bhattarai (2013).

Table 2: Response of N on tomato genotypes in days to first harvest and average fruit weight in Parwanipur in 2020/021 and 2021/022

	Days first harvest			Average fruit weight (g)		
Factors	2020/21	2021/22	Combined	2020/21	2021/22	Combined
Genotypes						
AVTO 1409	92[b]	89[b]	91[b]	42.4[b]	43.1[b]	42.8[b]
AVTO 1306	88[a]	84[a]	86[a]	45.6[a]	50.1[a]	47.9[a]
Pusa Ruby	104[c]	94[c]	99[c]	25.6[c]	23.8[c]	24.6[c]
F-test	***	***	***	***	***	***
LSD (≤0.05)	1	3	2	1.96	1.97	1.48
Response of N application through organic and inorganic sources						
100% N from FYM of RDF	97[c]	93[b]	95[d]	35.4[c]	36.5[b]	35.9[b]
50% N from FYM + 50% N from IF of RDF	96[bc]	91[b]	94[cd]	36.2[c]	38.1[b]	37.2[b]
100% N from PM of RDF	95[b]	89[ab]	92[bc]	35.9[c]	38.1[b]	37.2[b]
50% N from PM + 50% N from IF of RDF	93[a]	86[a]	89[a]	41.9[a]	41.8[a]	41.6[a]
Control i.e. RDF	93[a]	87[a]	90[ab]	39.4[b]	40.8[a]	40.1[a]
F-test	**	**	**	**	**	**
LSD (≤0.05)	2	4	2	2.53	2.54	1.91
Interaction between Genotypes x Response of N through organic and inorganic sources						
Mean	95	89	92	37.8	39	38.4
F-test	NS	NS	NS	NS	NS	NS
LSD (≤0.05)	-	-	-	-	-	-
CV (%)	1.7	3.4	3.8	1.7	3.4	3.8

N: Nitrogen, FYM: Farm Yard Manure, PM: Poultry Manure, IF: Inorganic fertilizer, RDF: Recommended Dose of Fertilizer ((200:150:120 kg $N:P_2O_5:K_2O$ + FYM 10 t/ha), CV: Coefficient of Variation, NS: Non-Significant, **P < 0.01

Length and diameter of fruit

The mean data pertaining to the effect of genotypes and application of nitrogen through organic and inorganic sources of treatments combination on the length of fruit is presented in Table 3. It was clearly observed from the data that the genotypes and application of nitrogen through organic and inorganic sources exerted highly significant effect on the length and diameter of fruit but in case of interaction between them showed non-significant differences among treatments in the analysis of first, second and combined years. The maximum length (5.86, 5.83 and 5.84 cm) and diameter (6.39, 6.43 and 6.41 cm) of fruit recorded at genotype AVTO 1306 in the first, second and combined years as compared to other genotypes respectively. The lowest length (4.82, 4.73 and 4.78 cm) and diameter (5.14, 5.04 and 5.09 cm) observed at local check Pusa Ruby (Table 3). In terms of the application of nitrogen through organic and inorganic sources depicted that the application of 50 % nitrogen from poultry manure + 50 % from inorganic fertilizer of RDF showed the highest length (6.03, 5.92 and 5.98 cm) and diameter (6.27, 6.03 and 5.92 cm) followed by control (RDF) in the first, second and combined years respectively

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which was significantly at par with each other in results of the first year (Table 3). At the same time, the lowest length of fruit (4.81 and 4.99 cm) obtained in the application of 100 % nitrogen from FYM of RDF in the first and combined years and 4.96 cm fruit length in the application of 50 % nitrogen from FYM + 50 % nitrogen from inorganic fertilizer of RDF in the second year. Likewise, the lower fruit diameter (5.43 and 4.96 cm) was noticed at the application of 50 % nitrogen from FYM + 50 % from inorganic fertilizer of RDF in the first and combined years and 4.81 cm diameter found in the application of 100 % nitrogen from FYM of RDF in the second year (Table 3.).

Table 3: Response of N on tomato genotypes in fruits length and diameter in Parwanipur in 2020/021 and 2021/022.

	Fruit length (cm)			Fruit diameter (cm)		
Factors	2020/21	2021/22	Combined	2020/21	2021/22	Combined
Genotypes						
AVTO 1409	5.50[b]	5.38[b]	5.44[b]	6.01[b]	5.81[b]	5.91[b]
AVTO 1306	5.86[a]	5.83[a]	5.84[a]	6.39[a]	6.43[a]	6.41[a]
Pusa Ruby	4.82[c]	4.73[c]	4.77[c]	5.14[c]	5.04[c]	5.09[c]
F-test	**	**	**	**	**	**
LSD (≤0.05)	0.25	0.30	0.27	0.25	0.30	0.19
Response of N application through organic and inorganic sources						
100% N from FYM of RDF	4.81[c]	5.00[bc]	4.90[c]	5.52[b]	4.81[c]	5.00[bc]
50% N from FYM + 50% N from IF of RDF	5.02[c]	4.96[c]	4.99[bc]	5.43[b]	5.02[c]	4.96[c]
100% N from PM of RDF	5.39[b]	5.27[bc]	5.33[bc]	5.99[a]	5.39[b]	5.27[bc]
50% N from PM + 50% N from IF of RDF	6.03[a]	5.92[a]	5.98[a]	6.27[a]	6.03[a]	5.92[a]
Control i.e. RDF	5.73[a]	5.41[b]	5.57[b]	6.03[a]	5.73[a]	5.41[b]
F-test	**	**	**	**	**	**
LSD (≤0.05)	0.32	0.39	0.18	0.33	0.32	0.39
Interaction between Genotypes x Response of N through organic and inorganic sources						
Mean	5.4	5.31	5.36	5.85	5.76	5.80
F-test	*	NS	NS	NS	NS	NS
LSD (≤0.05)	0.55	-	-	-	-	-
CV (%)	6.1	7.6	7.0	5.8	6.9	6.4

N: Nitrogen, FYM: Farm Yard Manure, PM: Poultry Manure, IF: Inorganic fertilizer, RDF: Recommended Dose of Fertilizer (200:150:120 kg $N:P_2O_5:K_2O$ + FYM 10 t/ha), CV: Coefficient of Variation, NS: Non-Significant, **P < 0.01

Number of fruits

Similar trends was observed in production of number of fruits per hectare as with number of fruits per plant. However, mean data concerning to number of fruit production showed the highly significant difference on genotype and non-significant was found in the application of nitrogen through organic and inorganic sources and the interaction effect between them. Whereas, the highest the number fruits produced by genotype Pusa ruby in first, second and combined years as compared to the rest of the genotypes. While the lowest was recorded at AVTO 1409 in first year and AVTO 1306 in second and combined years respectively (Table 4). The variation in the number of fruits and fruit weight could be due to the inherent characteristics of the variety and its interaction with growing conditions. Similar findings were reported by Timilsina *et al.*(2022) in Kaski. They reported the highest fruit numbers and weight from the treatment combination of half nitrogen from chemical fertilizer and half nitrogen from FYM treatment. The application

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of nitrogen through organic sources supplies an ample quantity of other macro and micronutrients and improves the physiological and biological conditions of the soil. It was reported that the increase in fruit weight by combined application of 16.66 t/ha FYM plus 8.33 t vermin compost/ha than other combinations of organic and inorganic sources of nitrogen might be due to the solubilization effect of plant nutrients by the added FYM and vermicompost leading to increased uptake of NPK as reported by Subedi *et al.* (1982), Prativa and Bhattarai (2013).

Marketable yield
Mean data regarding marketable yield revealed that the performance of genotypes and application of nitrogen through organic and inorganic sources showed highly significant differences in marketable fruit yield in the first, second and combined years data. The genotypes AVTO 1306 produced the highest mean yield of 40.12 t/ha followed by AVTO 1409 at 38.77 t/ha in combined years of data whereas the lowest yield (25.63 t/ha) was recorded in the recommended variety Pusa Ruby (Table 4). Similarly, the response of different sources of nitrogen showed significant differences in marketable fruit yield in the first, second and combined years data. The combined application of nitrogen 50% nitrogen through poultry manure and the remaining dose through inorganic fertilizers produced the highest fruit yield i.e. 40.72, 37.99 and 39.36 t/ha in the first, second and mean of the combined years (Table 4). This was followed by control treatment i.e. nitrogen sources supplied through inorganic fertilizers. The interaction effect of genotypes and sources of fertilizers did not show significant variation on the marketable yield of tomato though the yield ranged from 22.12 t/ha in Pusa Ruby with application 100% recommended nitrogen through FYM to 46.29 t/ha in AVTO 1306 with application of 50% recommended dose nitrogen through poultry manure and remaining recommended dose from inorganic fertilizers. The increase in the treatment of the combination of 50% poultry manure and 50% inorganic source of N could be due to readily available forms of N from soil (Table 4).

The increase in yield of these findings is in agreement with the findings of (Kumaran *et al.*, 1995; Azim & Dhuma, 2012; Tao *et al.*, 2022). He reported that chicken manure application has greatly increased fruit yield and quality by 43 and 23% in comparison with no manure application. This result suggested that the inorganic source of N could be replaced with poultry manures for sustainable tomato production. The shallow root system, short duration and subsequent weaker nutrient uptake capacity of most vegetables are dependent on quickly available forms of nutrients in tomatoes thus most vegetables are generally categorized as high-input requirement crops (Ti *et al.*, 2015). Sometimes Excessive N through inorganic sources and excessive irrigation is expected to reduce N use efficiency and greater N loss through runoff and leaching, which will ultimately deteriorate the environment (Bai *et al.*, 2014; Lam *et al.*, 2017; Xu *et al.*, 2012) and reduce the yield drastically. Hence, the combined application of organic and inorganic sources of N is suitable for maintaining agroecosystems and sustainable tomato production

Lot’s of research have been conducted to assess the role of organic manures in combination with inorganic sources of N fertilizers on crop productivity and results suggested that crop productivity, quality and shelf life can be sustained or even increased in comparison to the sole application of inorganic fertilizers. Similar findings were reported by (Chumyani *et al.*, 2012; Duan *et al.*, 2014; Satyjeet *et al.*, 2014; Makindle *et al.*, 2016; Yang *et al.*, 2015; Kumar *et al.*, 2017; Zhang *et al.*, 2019) in tomato.

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Table 4: Response of N on tomato genotypes in number and weight of fruit in Parwanipur in 2020/021 and 2021/022.

	No. of fruits/ha (000)			Marketable Yield (t/ha)		
Factors	2020/21	2021/22	Combined	2020/21	2021/22	Combined
Genotypes						
AVTO 1409	184.9[b]	178.6[b]	181.8[b]	39.04[b]	38.50[a]	38.77[a]
AVTO 1306	186.8[b]	151.5[c]	169.2[b]	42.58[a]	37.84[a]	40.21[a]
Pusa Ruby	211.0[a]	209.2[a]	210.1[a]	26.31[c]	24.94[b]	25.63[b]
F-test	*	**	**	**	**	**
LSD (≤0.05)	19.0	16.4	12.9	1.80	2.64	2.43
Response of N application through organic and inorganic sources						
100% N from FYM of RDF	183.7	170.3	177	31.86[d]	30.56[c]	31.21[d]
50% N from FYM + 50% N from IF of RDF	192.9	176.6	184.8	33.97[cd]	32.29[bc]	33.13[cd]
100% N from PM of RDF	202.4	179.7	191.1	35.64[bc]	32.44[bc]	34.04[c]
50% N from PM + 50% N from IF of RDF	197.8	190.3	194.1	40.72[a]	37.99[a]	39.36[a]
Control i.e. RDF	194.5	181.7	188.1	37.69[b]	35.52[ab]	36.61[b]
F-test	NS	NS	NS	**	**	**
LSD (≤0.05)	-	-	-	2.33	3.41	3.13
Interaction between Genotypes x Response of N through organic and inorganic sources						
Mean	194.2	179.7	187.0	35.98	33.76	34.87
F-test	NS	NS	NS	NS	NS	NS
LSD (≤0.05)	-	-	-	-	-	-
CV (%)	13.1	12.2	13.3	6.7	10.5	9.5

N: Nitrogen, FYM: Farm Yard Manure, PM: Poultry Manure, IF: Inorganic fertilizer, RDF: Recommended Dose of Fertilizer ((200:150:120 kg $N:P_2O_5:K_2O$ + FYM 10 t/ha), CV: Coefficient of Variation, NS: Non-Significant, **$P < 0.01$

CONCLUSION

Based on the results, genotypes AVTO 1306 and the application of 50 % N from PM and 50% from inorganic sources significantly recorded the earliest harvest, length, diameter, average fruit weight and marketable yield. Therefore, Genotypes AVTO 1306 and the application of 50 % N from PM and 50% from inorganic sources were recommended for sustainable production of tomato.

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Authors' contribution

J.N. Chaudhary designed and involved in laid out of experiment, collection of observation data, data analysis, and prepared a draft of the manuscript, A. Srivastava guided overall research and finalized the manuscript, I.P Gautam assisted in final data tabulation, interpretation and literature review and M.D. Sharma edited thoroughly and finalized the shape of paper.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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