


Performance of Tomato with Organic Manures in Plastic Tunnel

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ABSTRACT

Tomato is one of the most demanded vegetable with increasing trend of commercial cultivation in Nepal. As it is the heavy feeder crop thus soil nutrient management has been always challenging. Since, in modern world organic production has been favored by consumers for many reasons thus we aimed to compare the efficacy of various compost, mineral fertilizers and their combinations in tomato production and soil productivity. For the purpose a field experiment in plastic tunnel was carried out in Horticulture Research Division, Khumaltar in two consecutive years (2014 and 2015). Srijana, a popular tomato hybrid among commercial producers, was purposively selected. Eight treatments (control, recommended doses of chemical fertilizers, compost 15 t ha⁻¹ + cattle urine, compost 10 t ha⁻¹ + cattle urine, compost 12.5 t ha⁻¹ + cattle urine, compost 15 t ha⁻¹ + 1/4 recommended dose of chemical fertilizers, compost 10 t ha⁻¹ + 3/4 recommended dose of chemical fertilizer and compost 12.5 t ha⁻¹ + 1/2 recommended dose of chemical fertilizer) were laid out in randomized complete block design and replicated thrice. The result showed significant ($p < 0.05$) positive correlation between the plant height and yield of tomato. The treatment with compost dose of 12.5 t ha⁻¹ with half dose of recommended dose of chemical fertilizers produced the highest incremental yield (85% increment) over other treatments followed by compost 15 t ha⁻¹ with cattle urine. Addition of soil organic carbon, soil nitrogen, soil potassium by the increasing level of compost though not significant, but increment in carbon content, nitrogen content and potassium content of soil observed in successive years. For commercial producer at plastic tunnel, compost at the rate 12.5 t ha⁻¹ with half dose of recommended level of chemical fertilizer (100:90:40 kg N:P:K ha⁻¹) is recommended to apply in field, while for organic producer, application of 15 t ha⁻¹ compost with fermented cattle urine is recommended.

Keywords: Plastic tunnel, Compost, Cattle urine, Soil nutrients, Tomato productivity, Recommended doses of chemical fertilizer

सारांश

नेपाली बजारमा गोलभेडाको माग उच्च छ र यसको व्यवसायिक उत्पादन पनि तिब्र भैरहेको छ। गोलभेडाको बोटले माटोबाट बढी मात्रामा खाद्यतत्व लिने र यस वाली सपुन, मलखादको व्यवस्थापन जटिल मानिन्छ। हालका दिनहरूमा अर्गानिक तरकारीको माग उच्च रहेको सन्दर्भमा प्रचलनमा रहेका थरि थरिका अर्गानिक मल लगायत रासायनिक मलको प्रयोग र यिनीहरूको मिश्रणले गोलभेडाको उत्पादन र माटोको उत्पादकत्व अध्ययन गर्ने उदेश्यले बागवानी अनुसन्धान केन्द्र, खुमलटारमा दुई वर्ष (२०१४ - २०१५) निरन्तर परिक्षण गरियो। गोलभेडाको श्रृजना जात छानिएको थियो। आठ वटा उपचार (१ = कन्ट्रोल, २ = सिफारिस मलखाद मात्रा, ३ = कम्पोस्ट १५ टन प्र.हे + पशु मुत्र, ४ = कम्पोस्ट १० टन प्र.हे + पशु मुत्र, ५ = कम्पोस्ट १२.५ टन प्र.हे + पशु मुत्र, ६ = कम्पोस्ट १५ टन प्र.हे + १/४ सिफारिस मल, ७ = कम्पोस्ट १० टन प्र.हे + ३/४ सिफारिस मल र ८ = कम्पोस्ट १२.५ टन प्र.हे + १/२ सिफारिस मल) लाई RCBD मा तीन पटक सम्म दोहोराइएको थियो। विभिन्न मलखादको मात्राले गोलभेडाको बढोत्तर उत्पादनमा उल्लेख्य वृद्धि भएको पाइएको छ। १२.५ टन प्र.हे + १/२ सिफारिस मलको सबैभन्दा बढी बढोत्तर उत्पादन (८५%) छ र त्यस पछिको बढी उत्पादन कम्पोस्ट १२.५ टन प्र.हे + पशु मुत्रले दिएको छ। माटोको कार्बोन, नाईट्रोजन, पोटासमा पनि कम्पोस्ट र रासायनिक मलको राम्रो प्रभाव पाइएको छ तर फोस्फोरसमा खासै फरक भएको पाइएन। व्यवसायिक कृषकहरूलाई प्लाष्टिक टनेलमा गोलभेडा खेति गर्दा १२.५ टन कम्पोस्ट प्र. हे + १/२ सिफारिस मल (१००:९०:४० के. जि. ना.फो.पो. प्रति हेक्टर) का दरले बारीमा प्रयोग गर्न र प्रांगारिक कृषकलाई कम्पोस्ट १५ टन प्र.हे + कुहिएको पशु मुत्र प्रयोग गर्न सिफारिस गरिन्छ।

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the major commercial vegetable crops (Ghimire et al 2001) in Nepal. It is the fourth most important vegetable crop with an average productivity of 13.5 t/ha per crop life (MoAD 2015). Though tomato is best suited in lowland (Tarai) and mid hills, it is becoming increasingly attractive for cash generation in high hills as well (Pandey and Chaudhary 2004).

Open field cultivation of tomatoes during autumn-winter is common in Tarai (upto 200 masl), while in inner Tarai to foot hills (200-700 masl) cultivation inside plastic tunnels in summer-rainy season (June-July) is becoming popular. The tomato grown and produced in plastic tunnels are sold as off-season product fetching higher prices in general. Plastic house tomato cultivation is emerging farming practice among Nepalese farmer.

It is one of the viable alternatives for quality tomato production in Mid and High hills of Nepal (Chapagain et al 2011) because of relatively higher market potential due to appropriate size, bright color pattern and, shining appearance than the tomatoes produced in open area in the country. Such high quality products are also known to possess better export potentiality in international market. Many small and marginal farmers in hills are involving in the off-season plastic house tomato production (Chapagain et al 2011).

In open field, monsoon rain (June-August), several pests limit the production of quality tomato. The low cost (\$170.0) plastic tunnels can be used to protect the crops from excessive rainfall and provide the favorable environment for the production of better quality crops over the period of time (<http://www.icimod.org>). Organic production methods encourage the use of organic waste as a substitute for chemical fertilizers. In Nepal, organic manure could be a good option not only for the rural farmer, but also for other road head farmers as it saves investment, time, promotes local knowledge, use of local materials and increase production through increasing soil fertility. The use of quality compost can improve the physical, chemical, biological properties of soil and results improve the soil fertility even after several years, a constant quantitative improvement in crop production as well as in product quality (Allievi et al 1993).

Mineral composition of tomato depends on the amount and type of nutrients taken from the growth medium such as soil. Inadequate amount of nutrient availability can show deficiency symptom and influence poor yield and quality of tomato (Sainju et al 2003). So, as an economically potential crop, proper soil nutrient management scheme is essential for tomato production. However, it is critical to maintain the soil quality in continuously cropping sites (Reeves 1997). In Nepal, soil conditions vary spatially, therefore it is difficult to recommend specific amount of fertilizer use in tomato production (Andersen 2007). Since tomato can be produced organically in plastic tunnels, however, there are only limited studies performed to produce tomato organically inside the plastic house in Nepal, therefore we undertook to evaluate the efficacy of organic manures in plastic house on tomato yield and attributing characteristics.

MATERIAL AND METHODS

Site location

Present study was conducted at Horticulture Research Division, Khumaltar, Lalitpur Nepal, located at an altitude of about 1350 masl having a latitude and longitude of 27°39.2647'N, 85°19.6167'E respectively.

Experimental details

popular variety of tomato *Srijana* hybrid was selected for the study. The experimental design was set up in Randomized Complete Block Design (RCBD) with 8 treatments and 3 replications for two successive years (2014 – 2015). Details of the treatments have been given in Table 1. The total area covered by the experiment was 180 sq. m with individual plot size of 5.39 sq. m. Seedlings of 20 days were transplanted in row-row spacing at 60 cm distance with plant to plant space of 55 cm. The required amount of phosphorous (P), potash (K) and compost were applied in basal dose per plant with remaining dose of nitrogen (N) was applied 30 days after transplanting for topdressing. Compost was prepared with Farm Yard Manure (FYM), ash and oil cakes in the ratio of 2:1:0.5 respectively. Pit method was followed for compost preparation and took 45 days to prepare the final compost. The fermented cattle urine was sprayed in tomato field at 15 days' interval. The concentration of cattle urine and water was increased with crop maturity. Initially 1:8 (urine: water) concentration was sprayed in tomato, while in matured stage the ratio was 1:4 (urine: water).

Nutrient content of compost and urine

| Organic manures | N (%) | P (%) | K (%) | Remarks |
|-----------------|-------|-------|-------|------------------------|
| Compost | 2.8 | 3 | 3 | FYM, Ash, Oilcake |
| Urine | 1.2 | 0.03 | 0.6 | Fermented cattle urine |

Table 1. Treatment combinations details

| Treatment | Details |
|-----------|---|
| T1 | Control |
| T2 | Recommended dose of Chemical fertilizer (RDC) (200:180:80, N:P ₂ O ₅ :K ₂ O kg.ha ⁻¹) |
| T3 | Compost @ 15 t ha ⁻¹ + fermented cattle urine |
| T4 | Compost @ 10 t ha ⁻¹ + fermented cattle urine |
| T5 | Compost @ 12.5 t ha ⁻¹ + fermented cattle urine Cattle urine (Sprayed) |
| T6 | ¼ Recommended Chemical fertilizer + Compost 15 t ha ⁻¹ |
| T7 | ¾ Recommended Chemical fertilizer + Compost 10 t ha ⁻¹ |
| T8 | ½ Recommended Chemical fertilizer + Compost 12.5 t ha ⁻¹ |

Data collection and statistical analysis

Data recording on yield and yield attributes of tomato was done in every succeeding year. Soil samples were taken initially before plantation and after tomato harvest for analyzing available nutrients in the soil.

Data were recorded and analyzed using MS-Excel for correlation and regression analysis. Normality test was done with SPSS ver. 16.0. Normal data were used to analyze using one-way ANOVA and GenStat Discovery edition 4 software data.

RESULTS

Yield and yield attributes of tomato

In first year (2014) experiments yield and yield attributing characters (Plant diameter and plant height) were not significantly ($p = 0.053$ to 0.87) differed with the treatments. However, the highest yield was obtained from treatment with compost 15 t ha^{-1} followed by treatment with $\frac{1}{2}$ recommended dose chemical fertilizer + 12.5 t compost ha^{-1} (Table 2). The lowest yield on the first year and second year was obtained from the control. In second year, there was no significant ($p = 0.4$ and 0.9) results obtained from any compost and fertilizer levels (Table 2). The highest yield was obtained from treatment with $\frac{1}{2}$ recommended dose chemical fertilizer + 12.5 t compost ha^{-1} (Table 2).

Table 2. Yield and yield attributes of tomato influenced by different level of compost and fertilizer doses at Khumaltar, Lalitpur, 2014-2015

| Treatments | Plant diameter (cm) | | | | | Plant height (cm) | | | | Yield (t ha^{-1}) | |
|--|---------------------|---------|---------|---------|---------|-------------------|---------|---------|---------|------------------------------|-------|
| | 15 days | 30 days | 45 days | 60 days | 90 days | 15 day | 30 days | 45 days | 60 days | 2014 | 2015 |
| Control | 0.50 | 1.09 | 1.47 | 1.54 | 1.52 | 25.13 | 48.29 | 62.53 | 77.73 | 40.1 | 43.7 |
| RDC | 0.58 | 1.11 | 1.52 | 1.62 | 1.62 | 33.26 | 48.36 | 66 | 82.46 | 65.6 | 56.2 |
| Compost 15 t ha^{-1} +CU | 0.58 | 1.24 | 1.54 | 1.57 | 1.57 | 33.63 | 51.13 | 67.4 | 81.53 | 74.8 | 54.6 |
| Compost 10 t ha^{-1} +CU | 0.58 | 1.14 | 1.57 | 1.54 | 1.54 | 29.26 | 45.29 | 53.13 | 63.33 | 44.0 | 57.7 |
| Compost 12.5 t ha^{-1} + CU | 0.63 | 1.16 | 1.57 | 1.62 | 1.60 | 30.13 | 47.05 | 59.86 | 74.8 | 63.0 | 56.2 |
| $1/4$ RDC + 15 t ha^{-1} compost | 0.58 | 1.27 | 1.57 | 1.62 | 1.62 | 34.86 | 50.34 | 64.33 | 78.2 | 60.9 | 49.9 |
| $3/4$ RDC + 10 t ha^{-1} compost | 0.55 | 1.21 | 1.57 | 1.60 | 1.54 | 32.4 | 49.06 | 56.86 | 66.26 | 57.6 | 54.6 |
| $1/2$ RDC + 12.5 t ha^{-1} compost | 0.53 | 1.24 | 1.62 | 1.60 | 1.52 | 34.13 | 51.06 | 65.46 | 84.86 | 67.7 | 82.7 |
| P-value | 2.159 | 0.66 | 0.78 | 2.20 | 1.70 | 0.472 | 0.869 | 0.457 | 0.436 | 0.053 | 0.454 |
| CV(%) | 41.91 | 18.54 | 10.66 | 13.71 | 13.20 | 17.8 | 11 | 13.7 | 17 | 15.6 | 34 |
| LSD | 0.16 | 0.15 | 0.10 | 0.14 | 0.14 | 9.87 | 9.40 | 14.88 | 22.69 | 17.23 | 33.96 |
| SEm(\pm) | 0.093 | 0.07 | 0.05 | 0.07 | 0.07 | 5.64 | 5.37 | 8.50 | 12.96 | 9.84 | 19.39 |

Treatments 1 = Control, 2 = Recommended doses of chemical fertilizer (RDC), 3 = compost 15 t ha^{-1} + cattle urine (CU), 4 = compost 10 t ha^{-1} + CU, 5 = compost 12.5 t ha^{-1} + CU, 6 = compost 15 t ha^{-1} + $1/4$ RDC, 7 = compost 10 t ha^{-1} + $3/4$ RDC, 8 = compost 12.5 t ha^{-1} + $1/2$ RDC

The plant height did not significantly ($P > 0.05$) affected by the application of treatment. Height measured at 15 days is not significantly ($p > 0.05$) correlated with yield though positive. As the day progresses height of plant is positively correlated and shows very high level of significance ($P < 0.01$) with yield.

Incremental Yield

No significant ($p > 0.05$) yield was obtained in each treatments in successive years. When an aggregated yield was calculated over the years, the highest yield was obtained from the treatment $\frac{1}{2}$ RDC + 12.5 t ha^{-1} compost, which is at par with treatment, recommended dose of chemical fertilizer and compost @ 15 t ha^{-1} . In every treatment, there was increased in incremental yield, but the highest value was obtained from treatment with $\frac{1}{2}$ RDC + 12.5 t ha^{-1} (Table 2) comparing with control which is significantly ($p < 0.05$) greater than other treatments.

Benefit cost analysis

Benefit cost ratio was calculated by dividing the total benefit to the total cost. Total benefit was calculated by multiplying the tomato yield with market price of respective year (USD 0.75/kg in 2014 and USD 0.50/kg in 2015). Total cost was calculated by addition of fixed costs (tunnel materials like bamboo, plastics; drum, rope, water sprayer, sprayer tank), variable cost (seed materials, labor, fertilizer cost, cattle urine) and additional fixed cost (labor for watering and data recording). The benefit cost ratio analysis showed no significant ($p > 0.05$) changes in benefit cost ratio with the application of different fertilizers. The highest B:C ratio was obtained from $\frac{1}{2}$ RDC + 12.5 compost t ha⁻¹. Comparatively, higher B:C ratio was obtained in second year compared to first year in all treatments except control, where the yield was reduced in second year due to no additional supplement of nutrients replaced by plant uptake. In other treatments, yield was comparatively higher while fixed cost was reduced. So, there is net gain in second year. Due to the highest incremental yield the highest total revenue was obtained from treatment $\frac{1}{2}$ RDC + 12.5 compost t ha⁻¹ (Table 3).

Table 3. Benefit cost ratio on year 2013 and 2014

| SN | Treatments | B:C ratio (2013) | B:C ratio (2014) | Combined |
|----|---|------------------|------------------|----------|
| 1 | Control | 0.15 | 0.11 | 0.13 |
| 2 | RDC | 0.25 | 0.84 | 0.54 |
| 3 | Compost 15 t ha ⁻¹ + CU | 0.56 | 0.55 | 0.55 |
| 4 | Compost 10 t ha ⁻¹ + CU | 0.33 | 0.58 | 0.45 |
| 5 | Compost 12.5 t ha ⁻¹ + CU | 0.47 | 0.56 | 0.52 |
| 6 | 1/4RDC + 15 t ha ⁻¹ compost | 0.61 | 1.00 | 0.81 |
| 7 | 3/4 RDC + 10 t ha ⁻¹ compost | 0.49 | 0.73 | 0.61 |
| 8 | 1/2 RDC + 12.5 t ha ⁻¹ compost | 0.59 | 1.20 | 0.88 |

Change in soil properties

Soil properties like organic matter (SOM), N, P and K were analyzed after each harvest. There is increment in soil organic matter in successive year in each treatment (Table 4). Even in control increment in soil organic matter was observed. It is because of measurement of total carbon instead of liable carbon. Nitrogen, in other hand is also increasing in all treatments except control and treatments compost 12.5 t ha⁻¹ + cattle urine (CU), and compost 15 t ha⁻¹ + $\frac{1}{4}$ RDC. In these treatments the error value is too high which may aggregate to give negative values. Available phosphorous is also not significant ($p > 0.05$) in successive year and there is decreased level of P obtained except recommended doses of fertilizer. So, compost alone cannot provide sufficient P, additional dose of fertilizer is necessary. Mineralization of P takes more time and its availability is highly depending upon soil reaction which may be cause of decrement in P level in second year. K goes on increasing in successive year in all treatments. It is the most liable nutrients available in soil solution. So, addition of compost fulfilled the K demand of crops.

Table 4. Change in organic matter and nitrogen percent influenced by different level of compost and fertilizer doses at Khumaltar, Lalitpur, 2014-2015

| SN | Treatments | Organic matter (OM) % | | Change | Nitrogen % | | Change |
|----|---|-----------------------|------|--------|------------|------|--------|
| | | 2013 | 2014 | | 2014 | 2013 | |
| 1 | Control | 1.33 | 2.56 | 1.22 | 0.27 | 0.11 | -0.16 |
| 2 | RDC | 1.90 | 2.77 | 0.87 | 0.09 | 0.11 | 0.023 |
| 3 | Compost 15 t ha ⁻¹ + CU | 1.27 | 2.90 | 1.63 | 0.07 | 0.12 | 0.036 |
| 4 | Compost 10 t ha ⁻¹ + CU | 1.43 | 2.58 | 1.15 | 0.08 | 0.11 | 0.033 |
| 5 | Compost 12.5 t ha ⁻¹ + CU | 1.17 | 2.83 | 1.67 | 0.27 | 0.12 | -0.15 |
| 6 | 1/4RDC + 15 t ha ⁻¹ compost | 1.00 | 2.95 | 1.95 | 0.26 | 0.11 | -0.153 |
| 7 | 3/4 RDC + 10 t ha ⁻¹ compost | 1.50 | 2.58 | 1.08 | 0.08 | 0.11 | 0.026 |
| 8 | 1/2 RDC + 12.5 t ha ⁻¹ compost | 1.73 | 2.92 | 1.18 | 0.08 | 0.11 | 0.023 |

Table 5. Change in phosphorous and potassium level in soil

| SN | Treatments | Phosphorous (P ₂ O ₅), % | | Change | Potassium (K ₂ O), % | | Change |
|----|---|---|-------|--------|---------------------------------|-------|--------|
| | | 2013 | 2014 | | 2014 | 2013 | |
| 1 | Control | 617.6 | 635 | 17.3 | 267.6 | 375.6 | 108 |
| 2 | RDC | 555.6 | 688.3 | 132.6 | 186 | 617.3 | 431.3 |
| 3 | Compost 15 t ha ⁻¹ +CU | 560 | 427.6 | -132.3 | 186 | 429.3 | 243.3 |
| 4 | Compost 10 t ha ⁻¹ + CU | 552.3 | 439.6 | -112.6 | 144.6 | 411.3 | 266.6 |
| 5 | Compost 12.5 t ha ⁻¹ + CU | 557.3 | 395.3 | -162 | 158.3 | 420.3 | 262 |
| 6 | 1/4RDC + 15 t ha ⁻¹ compost | 492.6 | 453.6 | -39 | 185.6 | 398 | 212.3 |
| 7 | 3/4 RDC + 10 t ha ⁻¹ compost | 556 | 471.6 | -84.3 | 208.3 | 335 | 126.6 |
| 8 | 1/2 RDC + 12.5 t ha ⁻¹ compost | 617 | 575.3 | -41.6 | 204 | 366.3 | 162.3 |

DISCUSSION

Srijana, a tomato hybrid, is a popular variety preferred by most of the farmers in open field and poly house conditions (Pokharel and Thakur 2012). This variety is nutrient responsive thus, obviously an exhaustive type. In our present experiment, maximum yield was occurred in the treatment having combine application of 50% compost and 50% recommended doses of chemical fertilizer (Table 2). Kumar and Sharma (2004) showed almost similar findings. It is known that nutrient availability for the plants from organic sources take comparatively longer time than inorganic ones (Hug and Silva 2000). It has been shown by Allievi et al (1993) that annual availability of N, P, and K from the compost was taken to be equal to one third of the total N, P, and K contents (Allievi et al 1993). Based on this during first year only 40-50% of nutrients were available for the tomato plants in our treatments.

Thapa Magar et al (2016) studied the cost benefit analysis of *Srijana* variety of tomato grown in plastic tunnel of commercial farms and found B:C ratio 1.96:1, which slightly differed from our finding. In our study the highest B:C ratio was obtained 1.2:1 (Table 3). This variation was due to the price fluctuation of tomato in second season (First year price USD 0.75/kg in 2014 and USD 0.50/kg in 2015) and additional labor cost.

Though, there is no significant result obtained in plant and soil parameters. However, incremental yield and trend analysis of plant parameters and change in soil properties revealed the fact that the treatment with 1/2 recommended doses of fertilizer with compost 12.5 t ha⁻¹ performed better over other treatments, which can be recommended for commercial tomato producer. But, for the farmers adopting organic farming with 15 t ha⁻¹ compost with fermented cattle urine was the best for plastic tunnel tomato production as well as improving the soil fertility.

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