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Influence of organic and inorganic nutrients on nutrient accumulation in grafted tomato

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Abstract
An experiment was conducted using inorganic nutrients and organic nutrients *i.e.* vermicompost and with their combinations in grafted tomato through integrated nutrient management practices. Experimental results revealed that the nutrient concentrations were lower at 30 DAT, increased and achieved highest at 60 DAT and decreased thereafter. But, the K concentration was low at 30 DAT and 60 DAT, increased and achieved highest at 100 DAT. Similarly, the Sulphur concentration was higher at 30 DAT and decreased there after till 100 DAT. In the INM packages the 100 % inorganic nitrogen (T_2) maintained high N, P and Mg concentration in leaf at 30 and 60 DAT and N at 100 DAT. But, 50 % inorganic nitrogen + 50 % organic nitrogen (T_4) maintained high K, Ca and S concentration at 30 and 60 DAT. where as, 75 % inorganic nitrogen + 25 % organic nitrogen (T_3) showed high P, K, Ca and S concentrations at 100 DAT. Among three types of grafted tomatoes, Grafted tomato maintained high N, P and S concentrations than others. Where as, non-grafted tomato plants maintained higher K and Ca concentration and self-grafted tomato maintained higher Mg concentrations.

Keywords: integrated nutrient management, grafting, non-grafted tomato, organic and inorganic nitrogen, days after transplanting (DAT)

Introduction

Tomato (*Solanum lycopersicon*) is one of the widely grown vegetable and most important food crops in India. It is rich in minerals, essential amino acids, sugars and dietary fibres, vitamin B and C, iron, lycopene, organic acids and phosphorus (Bagal *et al*., 1989) [4]. It provides 3-4 per cent total sugar, 4-7 per cent total solids, 15-30 mg/100g ascorbic acid, 7.5-10 mg/100ml titratable acidity and 20-50 mg of lycopene per 100 g fruit. It is well responsive to fertilizer application and reported to be heavy feeders of nutrients. Supply of balanced nutrients can increase the yield, fruit quality, fruit size, keeping quality, colour and taste of tomato (Shukla and Naik 1993) [31]. The tomato crop is considered a crop with major fertilization requirements (Badr *et al*., 2010) [3]. Commercial growers often apply higher rates than recommended fertilizers levels compared to open field production. Application of excessive chemical fertilizers may affect soil health and sustainable productivity. It is imperative to search for possible alternate organic manures that can sustain soil health and crop production. Organic manures having humic substances not only improve soil fertility by modifying soil physical and chemical properties (Asik *et al*., 2009) [2], (Heitkamp *et al*., 2011) [15] but also improves the moisture holding capacity of soil, thus resulting in enhanced crop productivity along with better quality of crop produce (Premsekhar *et al*., 2009) [25]. Humus derived from vermicompost is most commonly used for sustainable production (Premsekhar *et al*., 2009) [25] due to its beneficial effects on nutrient uptake and retention, pest control and productivity (Barrios-Masias *et al*., 2011) [6]. Among such preparations, vermicompost has been recognized as having considerable potential for soil amendments (Wei, Y.Y *et al*., 2012) [35]. Humus originated from vermicompost is a finely divided manure peat like material with high porosity, aeration, drainage and water holding capacity and microbial activity and is stabilized by interaction between earthworms and microorganisms in a non-thermophilic process (Edwards *et al*., 1988) [13]. Vermicompost is made up primarily of carbon (C), hydrogen (H) and oxygen (O) and contains nutrients such as NO3, PO4, Ca, K, Mg, S and other micronutrients which exhibit similar effects on plant growth and yield as inorganic fertilizers when applied to soil (Singh, R *et al*., 2008) [32]. Vermicompost also contains a high proportion of humic substances (humic acids, fulvic acids and humin) which provide numerous sites for chemical reaction; microbial components known to enhance plant growth and disease suppression through the activities of bacteria (*Bacillus*), yeast (*Sporobolomyces* and *Cryptococcus*) and fungi *(Trichoderma*), as well as chemical antagonists such as phenols and amino acids (Theunissen *et al*., 2010) [33].

Grafting is an art and technique in which two living parts of different plants or same plant are joined together in a manner that they would unite together and subsequently grow into a composite plant. Grafting technique has been successfully used for controlling several soil-borne diseases and damage caused by root-knot nematodes in tomato production especially under intensive cultivation (Lee *et al*., 2010; Rivard *et al*., 2010a) [19, 28]. The main purpose of employing grafting technology is to control soil borne diseases. However, the impact of grafting includes not only a stronger resistance against pathogens but also a higher tolerance to abiotic stress conditions such as salinity, heavy metal, nutrient stress, thermal stress, water stress, organic pollutants, and alkalinity, and could improve fruit quality. (Crino *et al*., 2007; Lee *et al*., 2010; Rouphael *et al*., 2008b and Proietti *et al*., 2008) [10, 19, 29, 26].

Plant growth and development largely depend on the combination and concentration of mineral nutrients available in the soil. Plants often face significant challenges in obtaining an adequate supply of plant nutrients to meet the demands of basic cellular processes due to their relative immobility. Plants, having vigorous and extensive root systems, can explore large soil volumes and absorb more water and nutrients under nutrient stress conditions and can increase crop yield, nutrient uptake, accumulation and nutrient use efficiency (Merrill *et al*., 2002) [22].

Material Method

The experiment was conducted in Central Horticultural Experiment Station (Aiginia), Bhubaneswar with Grafted Tomato, Non-Grafted Tomato, Self-Grafted Tomato during 2017-18 in a Completely Randomized Design with six treatments and each treatment was replicated thrice. Each ploy bag was filled with 15 kg soil. The experimental soil was acidic in nature, soil texture was sandy loam with low CEC and organic carbon content. Available N, P and K status was medium, low and medium respectively. The available micronutrient status like Fe, Mn, Cu and Zn was adequate. Inorganic and organic nutrients were supplied through fertilizer sources like Urea, SSP, MOP and Vermicompost (organic source). The experiment was laid out in a Completely Randomised Design comprising of six treatments with Grafting interaction. Grafted Tomatoes (Tomato var. Utkal Kumari (BT-10) was grafted on brinjal var. Utkal Anushree), non-grafted and self-grafted tomatoes (BT-10 was grafted on BT-10) were evaluated with six treatments i.e. T_1 (Absolute Control), T_2 (100 % inorganic nitrogen), T_3 (75 % inorganic nitrogen + 25 % organic nitrogen), T_4 (50 % inorganic nitrogen + 50 % organic nitrogen), T_5 (25 % inorganic nitrogen + 75 % organic nitrogen), T_6 (100 % organic nitrogen).

***Source* of Nutrient:** Urea, SSP, MOP & vermicompost.

Method of Fertilizers and lime Application

Full dose of P_2O_5, K_2O and Lime was applied as basal, and half dose of Nitrogen was applied as basal and remaining half dose of Nitrogen was applied as top dressing at 30 days after transplanting. N, P & K applied to all the treatments except Control.

Grafting

Before grafting, scion and rootstock were exposed to sunshine for three days. In Grafted Tomato Utkal Kumari (BT-10) scion were grafted onto the Utkal Anushree (brinjal var.) rootstock using “side grafting” and in Self Grafted Tomato Utkal Kumari (BT-10) scion were grafted onto the Utkal Kumari (BT-10) rootstock using “side grafting”. Non-grafted seedlings were used directly. Grafting was carried out at 2-3 leaf stage (20-25 days) of scion seedlings and 3-4 leaf stage (55-60 days) of root stock. Grafting was carried out in moist chambers. Grafting was made with similar thickness of scion and root stock which was cut at 45^0 and joined by using plastic clips. The grafted seedlings were transferred to humidified chambers with a relative humidity of 85-95 per cent for five days to allow the graft union to heal, then intensity of light was gradually increased with decrease and relative humidity. The grafted plants were transplanted into poly-pot after thirty-five days after sowing.

Collection and Processing of plant samples

For determination of nutrient content, plant samples (leaf) were collected at 30, 60 and 100 days after transplanting (DAT). Five plants from each treatment were selected randomly. The collected leaf samples were washed and allowed for sun drying in the oven at 75 ^{0}C temperature till constant weight was obtained. Then the leaf samples were powdered and used for nutrient analysis.

Analysis of plant samples

- **Nitrogen:** Kjeldahl digestion followed by distillation method as described in AOAC (1960) [1]
- **Phosphorus (P), Potash (K), Calcium (Ca), Magnesium (Mg), and Sulphur (S):** The sample are to be digested in di-acid mixture (HNO_3: $HClO_4$=3:2). The P and S are estimated by spectrophotometrically, the K by flame photo meter, and Ca and Mg by EDTA titration method.
- **Statistical analysis:** The experimental data pertaining to biometric observations, nutrient concentrations were recorded, compiled in appropriate tables and analyzed statistically as per the procedure appropriate to the design and Gomez and Gomez (1976). All the data were statistically analyzed by two-factorial CRD ANOVA.

Results and Discussion

Influence of INM practices of grafted tomato on nutrient concentration in leaf at different days after transplanting (30, 60 and 100 DAT)

The data related to nutrient concentrations in grafted tomato at different growth stages were presented in Fig-1(a & b), 2 (a & b), 3 (a & b), 4 (a & b), 5 (a & b) and 6 (a & b).

Nitrogen concentration

It was observed that at 30 DAT the treatments T_5 is showing highest nitrogen content (2.83) which was at par with treatment combinations T_3, T_4 with nitrogen content of (2.74) and (2.78) respectively. Where as treatments with completely inorganic and organic were showed significant difference in nitrogen content at 30 days after transplanting. At 60 DAT and 100 DAT the treatment with completely inorganic T_2 showed highest nitrogen content (4.30) and (3.91) respectively. where as treatment T3 and T_5 were at par with each other, but where as treatments completely inorganic (T_2) and completely organic (T_6) were showed significant difference with each other at 60 DAT and 100 DAT. While looking to grafting effect grafted tomato was showed highest nitrogen content which showed significant difference with non-grafted tomato and self-grafted tomato at 60 DAT and 100 DAT and non-significant effect at 30 DAT (Fig-1(a & b)).

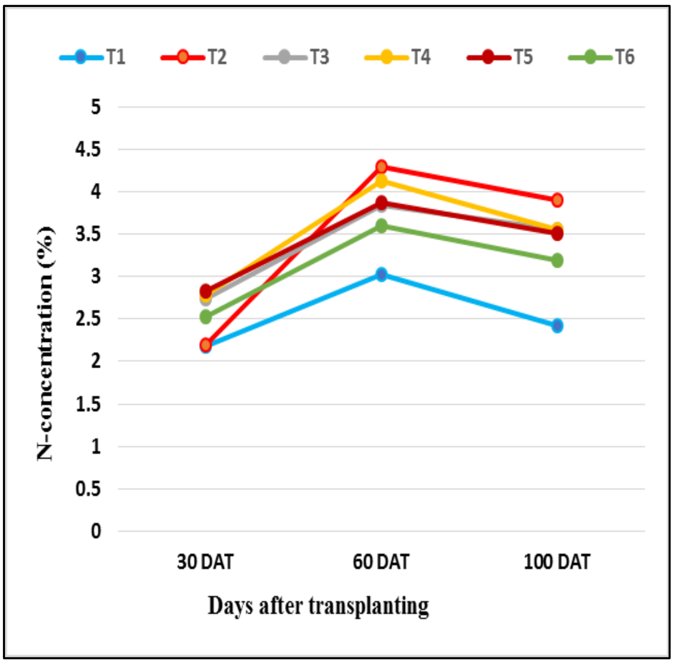

Fig 1(a): Influence of INM Practices on N concentration of tomato leaves

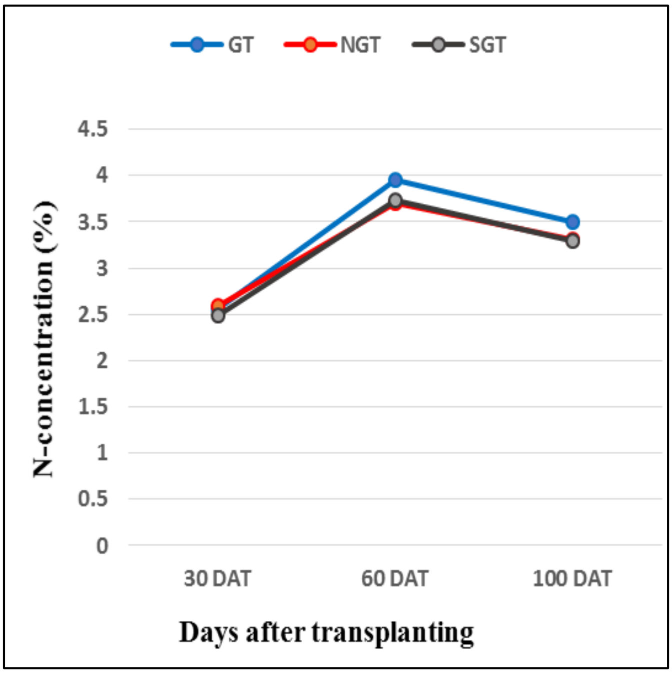

Fig 1(b): Influence of INM on leaf N concentration in different types of grafting

Phosphorus concentration

At 30 DAT the treatments imposed with T_2 and T_4 were showed highest phosphorus content (0.197) and at 60 DAT the treatment T_2 alone showed highest phosphorus content (0.28). where as treatment combinations T_3, T_5 and T_6 were at par at 30 DAT and T_4 and T_6 were at par at 60 DAT. But at 100 DAT treatment T_3 and T_6 were showed highest content of phosphorus (0.27) which was at par with T_2 and T4. At the three growth stages, grafted tomato showed highest content of phosphorus than non-grafted and self-grafted tomato with significant difference (Fig-2 (a & b)).

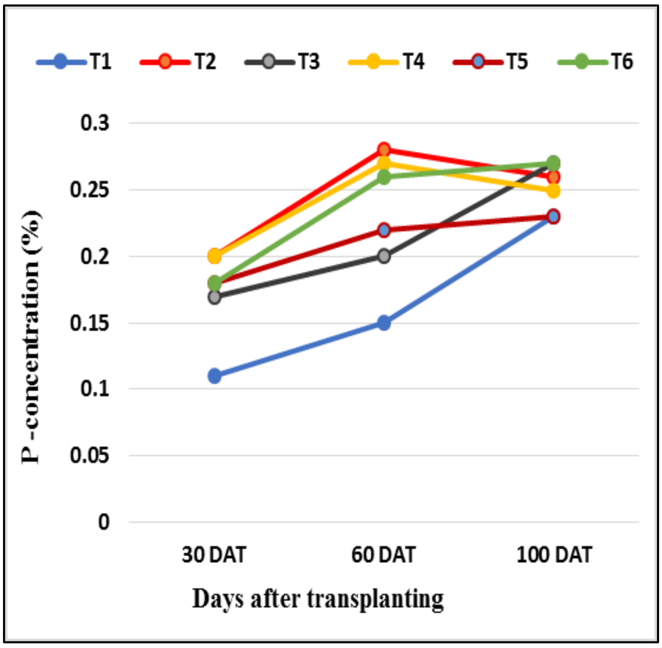

Fig 2(a): Influence of INM practices on P concentration of tomato leaves

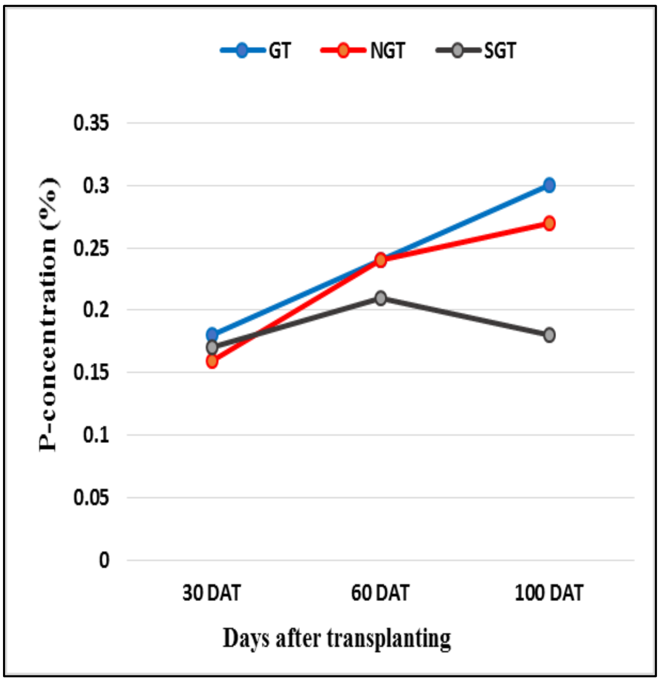

Fig 2(b): Influence of INM on leaf P concentration in different types of grafting

Potassium concentration

It was observed that at 30 DAT and 60 DAT the treatment combination with T_4 was showed highest content of potassium (3.50) and (5.56) respectively. Where as at 100 DAT the treatment T_3 showed highest content of potassium (5.73) which showed significant difference with other treatments at respective growth stages. Unlike Nitrogen and Phosphorus the Potassium concentration at different growth stages in grafted tomato was lower than non-grafted tomato but comparatively higher than self-grafted tomato only at 100 DAT (Fig-3 (a & b)).

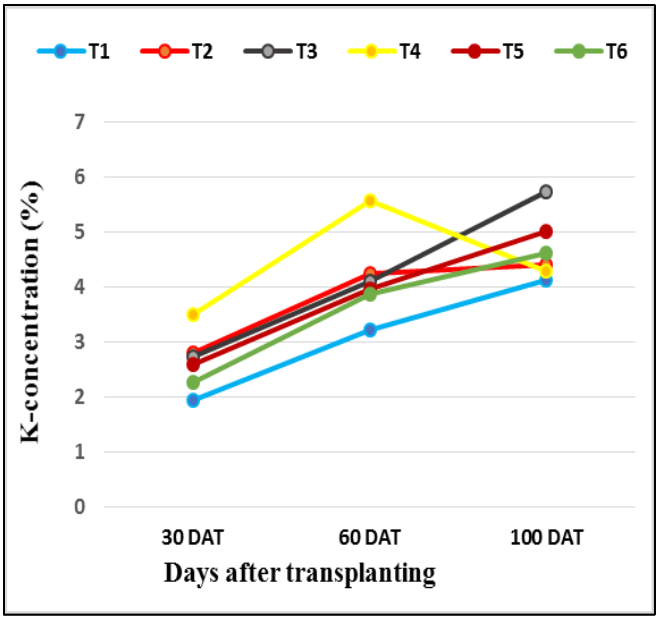

Fig 3(a): Influence of INM practices on K concentration of tomato leaves

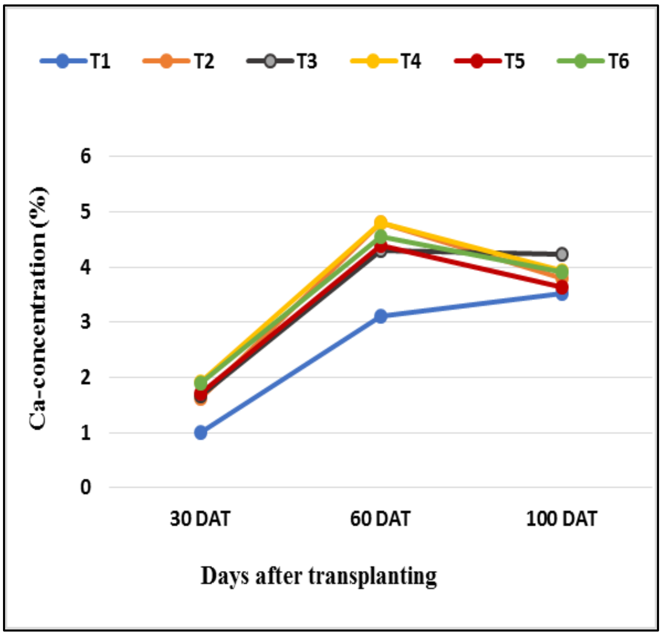

Fig 4(a): Influence of INM practices on Ca concentration of tomato leaves

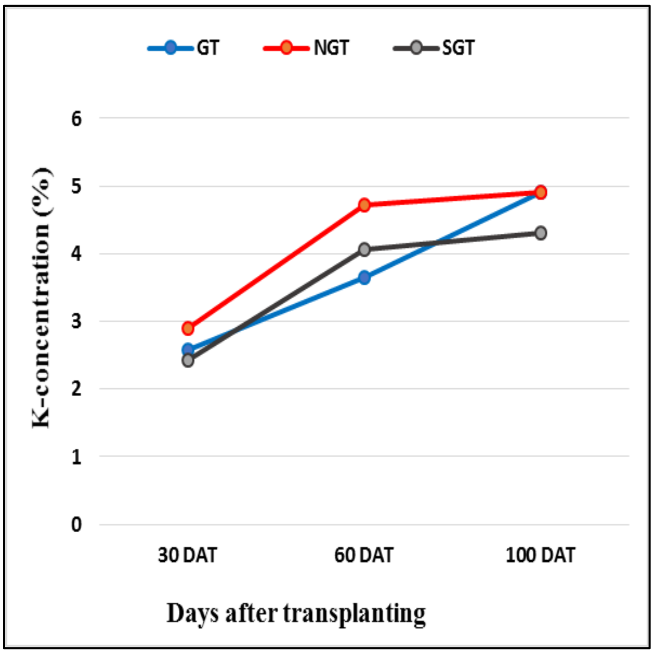

Fig 3(b): Influence of INM on leaf K concentration in different types of grafting

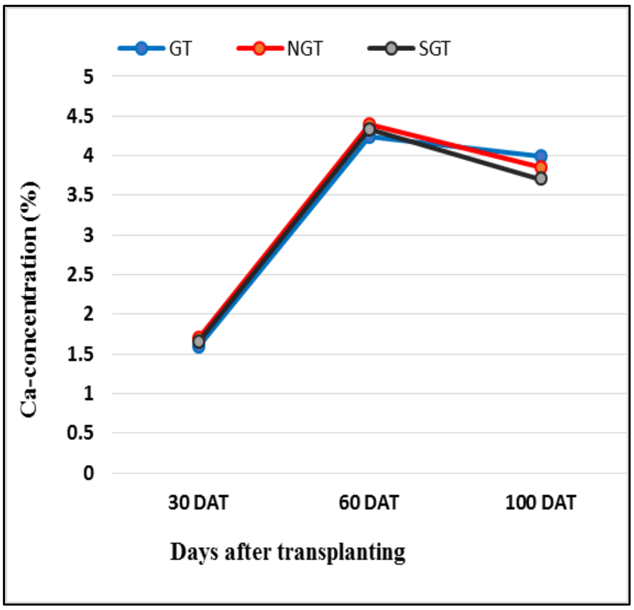

Fig 4(b): Influence of INM on leaf Ca concentration in different types of grafting

Calcium concentration

At 30 DAT it was observed that treatment combinations with T_4 showed highest content of calcium (1.93) which was at par with T_6. where as at 60 DAT the treatments T_2 and T_4 were showed highest calcium content (4.80) which were at par with T_6. The treatment combinations T_3 and T_5 were at par in both growth stages. But, at 100 DAT the treatment T_3 showed highest content of calcium (4.24) which was at par with treatments T_4 and T_6. Grafting effect showed highest content of Calcium in non-grafted tomato at 30 DAT and 60 DAT. But, grafted tomato at 100 DAT (Fig-4 (a & b)).

Magnesium concentration

It was observed that treatment combinations with T_5 showed highest content of magnesium (1.42) which was at par with T_6. where as treatments with T_2 and T_4 were at par at 30 DAT. But, at 60 DAT and 100 DAT the treatment T_2 showed highest magnesium content (3.91), but treatment combinations T_4 and T_6 were at par to each other as well as treatment combinations T_3 and T_5 were at par with each other at 60 DAT and significantly differing at 100 DAT. While looking to grafting effect self-grafted tomato showed highest content of magnesium at three growth stages followed by non-grafted and grafted tomato respectively (Fig-5 (a & b)).

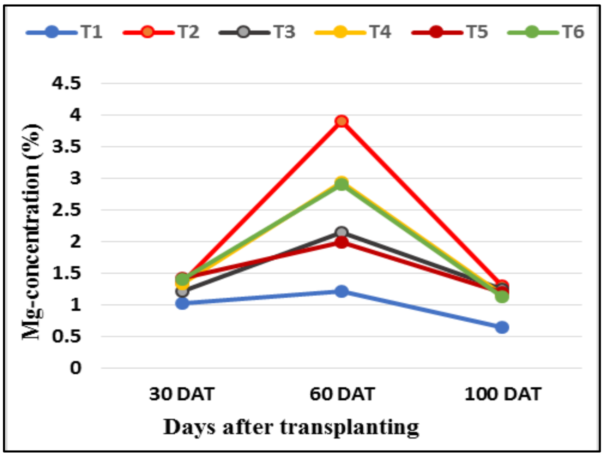

Fig 5(a): Influence of INM practices on Mg concentration of tomato leaves

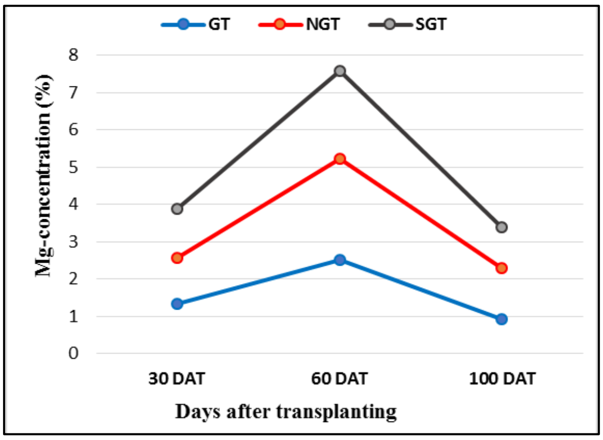

Fig 5(b): Influence of INM on leaf Mg concentration of different types of grafting

Sulphur concentration

At 30 and 60 DAT the treatment combinations with T_4 showed highest content of Sulphur (0.85) and (0.71) respectively. where as all other treatment combinations were showed significance difference with each other at both growth stages. But, the treatment T_3 showed highest content of Sulphur (0.49) which was at par with T_5 at 100 DAT. The Sulphur concentration was higher at 30 DAT and decreased there after till 100 DAT. Grafted tomato showed highest content of Sulphur at all three growth stages and significance difference with non-grafted tomato and self-grafted tomato (Fig-6 (a & b)).

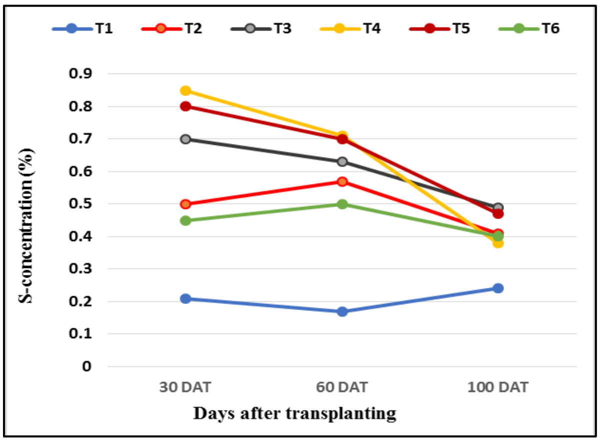

Fig 6(a): Influence of INM practices on S concentration of tomato leaves

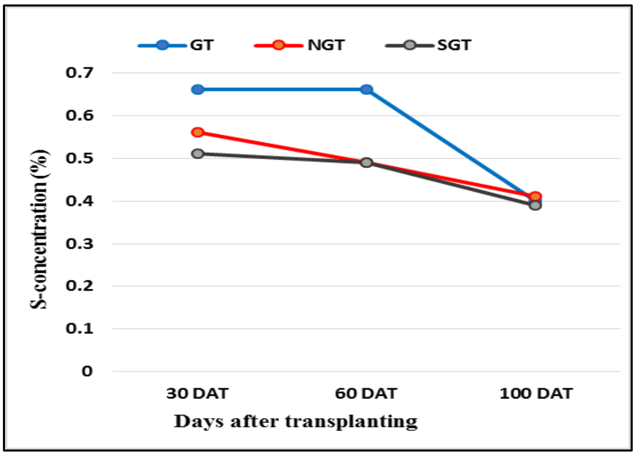

Fig 6(b): Influence of INM on leaf S concentration of different types of grafting

Among three types of grafted tomatoes, Grafted tomato maintained high N, P, Ca and S concentrations than others. Similarly, 100 % inorganic nitrogen (T_2) maintained high N and P concentration in leaf but, T_4 maintained high Ca and K concentration. Where as, non-grafted tomato plants maintained higher K concentration and self-grafted tomato plants maintained highest Mg concentration. At 100 DAT the concentration of K was high which was due to antagonistic effect between potassium and calcium cations. Similar results were stated by Pujos and Morard, 1997 [27]; Kanai *et al.*, (2011) [16]. Plants, having vigorous and extensive root systems, can explore large soil volumes and absorb more water and nutrients under nutrient stress conditions and can increase crop yield and nutrient use efficiency and nutrient accumulation (Merrill *et al.*, 2002) [22]. The quantity of nutrient taken up by plants is largely influenced by root radius, mean root hair density and length of root (Barber, 1995) [15]. The shape and extent of root systems influences the rate and pattern of nutrient uptake from soil. Vose (1990) [34] states that rooting depth; lateral spreading, branching and number of root hairs has major impact on plant nutrition. The configuration of root system is influenced markedly by nutrient supply. Type of nutrient source and root morphology shows a mark on the nutrient concentration of plant at different growth stages.

Irrespective of grafting nutrient concentrations were lower at 30 DAT, increased and achieved highest at 60 DAT and decreased thereafter. Among three types of grafting, Grafted tomato had shown high nutrient concentration compared to non-grafted and self-grafted tomatoes. It was due to root traits of brinjal root-stock which has more root density and number of root hairs and lateral and vertical development of roots which increased the absorption and translocation of nutrients. The results corroborated by earlier findings of Davis *et al.*, 2008b [11]; Lee, 1994 [18]; Ruiz, Romero 1999 [30], Leonardi, Giuffrida 2006 [20]; Martinez-Ballesta *et al.*, 2010 [21]; Colla *et al.*, 2011 [9]; Lee and Oda, 2003 [17]; Desire Djionou (2012) [12].

Conclusion

The nutrient concentrations were lower at 30 DAT, increased and achieved highest at 60 DAT and decreased thereafter. But, the K concentration was low at 30 DAT and 60 DAT, increased and achieved highest at 100 DAT. Similarly, the Sulphur concentration was higher at 30 DAT and decreased there after till 100 DAT. During the initial growth stages the nutrient concentrations were low because of low root growth and volume and achieved highest in middle of growth stages and decreased there after due to the nutrients are utilized for plant growth and yield of the crop. Among three types of grafted tomatoes, Grafted tomato maintained high N, P and S concentrations than others. Where as, non-grafted tomato plants maintained higher K and Ca concentration and self-grafted tomato maintained higher Mg concentrations.

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