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Effect of Transplanting Dates and Bio-fertilizers Application on Plant Growth and Fruit Quality Parameters of Tomato

Suresh Chand[1], Narender Kumar[1] and Sanjay Kumar[1]

ABSTRACT: *The research work was conducted at the research farm and laboratory of Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during 2008-09. The experiment was laid out in randomized block design replicated thrice with three different dates of transplanting and ten different combinations ofbio-fertilizer-inorganic fertilizer. From the various parameters recorded, nutrients uptake by plant, total soluble solids and titratable acidity of fruits were maximum with 1st January date of transplanting (D_2) and Azotobactor +100% of rec. N + rec. P_2O_5 and $K_2O(B_7)$ biofertilizer-inorganic fertilizer combination i.e. D_2B_7. While, plant height and number of primary branches per plant were highest with 1st December date of transplanting (D_1) and Azotobactor+100% of rec. N + rec. P_2O_5 and $K_2O(B_7)$ biofertilizer-inorganic fertilizer combination i.e. D_1B_7. Moreover, ascorbic acid content in fruits was maximum with 1st December date of transplanting (D_1) and Azospirillum+ 50% of rec. N + rec. P_2O_5 and $K_2O(B_2)$ biofertilizer-inorganic fertilizer combination i.e. D_1B_2, maximum pericarp thickness of fruits was obtained with 1st January date of transplanting (D_2) and Azotobactor +75% of rec. N + rec. P_2O_5 and $K_2O(B_6)$ biofertilizer-inorganic fertilizer combination i.e. D_2B_6 and minimum days taken to 50% flowering was obtained with 1st february date of transplanting (D_3) and Azotobactor +100% of rec. N + rec. P_2O_5 and K_2O (B_7) biofertilizer-inorganic fertilizer combination i.e. D_3B_7. So, keeping in view to the experimental results it was concluded that to get good crop establishment, growth and fruit quality the 1st January (D_2) transplanting date and Azotobactor + 100% of rec. N + rec. P_2O_5 and K_2O (B_7) biofertilizer-inorganic fertilizer combination i.e. D_2B_7 was more suitable.*

Keywords: *Randomized block design, bio-fertilizer, inorganic fertilizer, ascorbic acid, TSS, titratable acidity, pericarp thickness, acre.*

INTRODUCTION

Tomato *(Lycopersicon esculentum Mill.)* is one of the most important and widely grown vegetable crops in the world.Tomato fruits are good source of Vitamin A, Vitamin C, minerals and organic acids. It plays an important role in processing industry *i.e.* a number of productslike ketchup, paste, sauce,soup and juices are prepared from tomato fruits on small scale as well as on commercial scale. Its importance in transport and processing industry depends on some specific fruit quality parameters *i.e.* total soluble solids content, acidity, ascorbic acid content and fruit pericarp thickness. Better establishment and vigorous growth of plant also plays an important role to increase yield and quality of tomato fruits.

Among the various cultural practices,the date of transplanting of seedling is an important factor that influences plant growth, yield and quality of tomato fruits. The crop is sensitive to low and high temperature. The low temperature at the time of transplanting results in poor stand of the crop, whereas, high temperature above 35°C affects fruit set and other important quality characteristics.Now, it has become very essential to find out the optimum date of transplanting, so that the plant is exposed to most conducive atmosphere during their growth period.

Tomato requires ample supply of plant nutrients for satisfactory plant growth, fruit yield and quality (Rafi *et al*. 2002). Application of chemical fertilizers plays a major role for obtaining maximum yield per unit area. However, at present chemical fertilizers are in short supply and expensive too. Their regular, excessive and unbalanced use may lead to a healthy

[1] Department of Vegetable Science, CCS Haryana Agricultural University, Hissar-125004, Haryana, India
* *E-mail : manjeetrao170@gmail.com*

and classical hazard. To minimize excessive use of chemical fertilizers the current trends to explore the possibility of supplementing chemical fertilizers with organic ones particularly bio-fertilizers which are free from problems of pollution and other hazards are gaining popularity. Bio-fertilizers are eco-friendly biological input containing microorganisms, which are capable of mobilizing nutrient elements from non-usable form to usable form through the biological process. They fix appreciable amount of atmospheric nitrogen in the soil, enhance plant growth by production of organic acid and growth substances and make available the complex phosphorus to the plants, which may cause reduction in consumption of inorganic fertilizers.

Hence, they lower down the cost of inorganic fertilizer. Keeping in view the above facts, the present study was carried out with the objective to find out the suitable date of transplanting and optimum level of N, P_2O_5 and K_2O fertilizer with and without bio-fertilizers application to get good crop establishment, growth and quality fruit production.

MATERIAL AND METHODS

The experiment was carried out at Vegetable Research Farm, Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during the spring-summer season of 2008-09. Hisar is situated at the latitude of 29°.10′N, longitude of 75°.46′E and at a mean altitude of 215.2 meters above sea level. This place is characterized by hot and dry summer (April to June) followed by a hot and humid monsoon period and cold winters during December-January.

Soil analysis revealed that the soil of the experimental field was sandy loam in texture, non-saline (pH = 8.18), medium in organic carbon content (0.44%), low in available nitrogen (140 kg/ha), high in available phosphorus (21.0 kg/ha) and rich in potassium content (486.0 kg/ha).

The experiment was laid out according to Randomized Block Design and replicated thrice in a plot size of 3m × 2.70 m = 8.1 m^2 for each replication. A spacing of 60 cm × 45 cm was maintained between line-to-line and plant-to-plant. The treatment includesthree different dates of transplanting *i.e.* 1st December (D_1), 1st January (D_2) and 1st February (D_3) and ten different combination of fertilizer doses.

Table 1
Different combination of fertilizer doses

B_1	Recommended dose of N, P_2O_5, and K_2O through chemical fertilizers (40:25:20kg/acre)
B_2	*Azospirillum*+ 50% of rec. N+ rec. P_2O_5 and K_2O
B_3	*Azospirillum* + 75% of rec. N+ rec. P_2O_5 and K_2O
B_4	*Azospirillum* + 100% of rec. N+ rec. P_2O_5 and K_2O
B_5	*Azotobactor*+50% of rec. N+ rec. P_2O_5 and K_2O
B_6	*Azotobactor*+75% of rec. N+ rec. P_2O_5 and K_2O
B_7	*Azotobactor*+100% of rec. N+ rec. P_2O_5 and K_2O
B_8	*PSB*+50% of rec. P_2O_5+ rec. N and K_2O
B_9	*PSB*+75% of rec. P_2O_5+ rec. N and K_2O
B_{10}	*PSB*+ 100%rec. P_2O_5+ rec. N and K_2O

Rec.-Recommended dose of

Genetically pure seed of tomato cv. Hisar Arun was obtained from the Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar. Seeds were sown during 2008-2009 in the well-prepared nursery beds in such a way that on each desired transplanting date, the seedlings become ready for transplanting. After the sowing seeds nursery beds were irrigated daily with the help of water cane. The nursery beds were covered with polythene sheet during night to protect the seedlings against frost and prevailing low temperature. All the cultural practices were carried as per package of practices for vegetable crops during the growth period of the crop.

Four to five leaf stage old seedlings were dipped in solution prepared by mixing 100 g bio-fertilizer in three litres of water as per treatment. Roots of the seedlings were dipped and kept in the bio-fertilizer slurry for 10-15 minutes before transplanting. Required quantity of the each chemical fertilizer was added in the allocated plot and mixed well after preparing the ridges. Tomato seedlings were transplanted on three dates as per schedule of the treatment. Experimental field was irrigated immediately after transplanting following ridge furrow method of irrigation.

Five plants were randomly selected in each treatment for recording various plant growth parameters in each replication. Mean values of different characters were used for statistical analysis. Various observations recorded were plant height (cm), number of primary branches per plant, minimum days to 50% flowering, nutrient uptake (N, P and K) by plant (g/plant) and fruit quality parameters *i.e.* pericarp thickness (mm), total soluble solids (%), ascorbic acid content (mg/100 g fruit weight), titratable acidity (%).

Table 2
Effect of transplanting dates and fertilizer combinations on growth and fruit quality parameters of tomato

	Treatment								*Uptake of nutrients (g/plant)*		
	Transplanting dates	*Plant height (cm)*	*Primary branches per plant*	*Days to 50% flowering*	*Pericarp thickness (mm)*	*TSS (%)*	*Ascorbic acid content (mg/100 g pulp)*	*Titratable acidity (%)*	*N content*	*P_2O_5 content*	*K_2O content*
D_1	1st December	70.87	8.52	56.43	2.29	5.0	26.81	0.74	0.85	0.14	0.31
D_2	1st January	68.96	7.20	33.03	3.03	5.2	21.51	0.79	0.91	0.16	0.34
D_3	1st February	51.89	5.37	29.36	2.74	5.1	20.38	0.76	0.56	0.13	0.28
	C.D. (P = 0.05)	2.81	1.42	1.84	0.52	0.1	0.28	0.01	0.05	NS	0.04
Fertilizer combinations											
B_1	Control (Rec. NPK)	56.60	5.70	43.88	2.58	4.6	18.79	0.70	0.70	0.11	0.32
B_2	*Azospirillum* + 50% of rec. N+ rec. P_2O_5 and K_2O	57.59	5.80	39.50	2.79	4.9	27.68	0.74	0.88	0.15	0.34
B_3	*Azospirillum* + 75% rec. of N+ rec. P_2O_5 and K_2O	58.13	6.96	39.86	2.85	5.2	26.45	0.78	1.12	0.16	0.37
B_4	*Azospirillum* + 100% rec. N+ rec. P_2O_5 and K_2O	62.58	7.92	38.33	3.27	5.3	24.39	0.80	1.15	0.16	0.38
B_5	*Azotobactor* +50% of rec. N+ rec. P_2O_5 and K_2O	63.05	6.12	41.33	2.47	4.4	22.79	0.76	0.92	0.13	0.36
B_6	*Azotobactor* +75% of rec. N+ rec. P_2O_5 and K_2O	64.78	7.81	37.00	3.28	4.9	22.77	0.78	1.18	0.17	0.39
B_7	*Azotobactor* + 100% of rec. N+ rec. P_2O_5 and K_2O	65.70	8.07	36.30	2.77	5.6	21.77	0.81	1.28	0.19	0.42
B_8	*PSB* + 50% of rec. P_2O_5+ rec. N and K_2O	58.81	6.14	39.22	2.76	5.2	23.50	0.77	0.84	0.14	0.34
B_9	*PSB* + 75% of rec. P_2O_5+ rec. N and K_2O	59.29	6.88	40.44	2.73	5.0	20.49	0.75	0.80	0.12	0.32
B_{1O}	*PSB* + 100% rec. P_2O_5+ rec. N and K_2O	61.19	6.40	42.44	2.48	5.1	19.38	0.73	0.94	0.15	0.35
	C.D. (P = 0.05)	3.30	0.99	3.37	0.46	NS	0.52	0.02	0.05	0.02	0.03

Rec.- Recommended dose of

The primary branches per plant are the total number of fruiting branches emerging from the main stem was counted at 90 days after transplanting. Time taken from transplanting dates for 50 per cent of plants to flower in a treatment was recorded as days to 50 per cent flowering. Nitrogen uptake in plant samples was determined by colorimetric (Nessler regent) method (Linder, 1994). Phosphorous in plant samples was determined by Vonado molybdo-phoshoric yellow color method (Keoning and Jonason, 1992). Potassium in the acid digest of plant can be determined by using flame photometer.

Pericarp (epicarp + mesocarp) thickness was measured in mm with Vernier caliper by dissecting equatorial of the fruits. Total soluble solids was determined with the help of Erma Hand Refract metre and expressed as percent TSS. Ascorbic acid content in tomato fruits was determined by using 2, 6-dichlorophenol indophenols titration method (A.O.A.C., 1975) and expressed in mg per 100 g of fruit weight. Acidity content of extracted juice was determined by titrating the fruit juice against N/10 NaOH using phenolphthalein as an indicator (A.O.A.C., 1975).

The analysis of variance was performed following the standard method suggested by Rao (2007). The significance of treatment differences was tested at 5% levels of probability.

RESULTS

Data presented in Table 2 indicates that plant height, number of primary branches per plant, days to 50% flowering, nutrient uptake by plant and fruit quality parameters *i.e.* pericarp thickness, ascorbic acid content and titratable acidity were significantly influenced by both dates of transplanting and biofertilizer-inorganic fertilizer doses. However, total soluble solids in fruits were significantly influenced by dates of transplanting but were found to be non-significant with biofertilizer-inorganic fertilizer doses.

It is revealed from the data recorded for various observations that nutrients uptake by plant, total soluble solids and titratable acidity of fruits were maximum with 1st January date of transplanting (D_2) and *Azotobactor* + 100% of rec. N + rec. P_2O_5 and K_2O (B_7) biofertilizer-inorganic fertilizer combination *i.e.* D_2B_7. While, plant height and number of primary branches per plant were highest with 1st December date of transplanting (D_1) and *Azotobactor* + 100% of rec. N + rec. P_2O_5 and K_2O(B_7) biofertilizer-inorganic fertilizer combination *i.e.* D_1B_7. Moreover, ascorbic acid content in fruits was maximum with 1st December date of transplanting (D_1) and *Azospirillum* + 50% of rec. N + rec. P_2O_5 and K_2O(B_2) biofertilizer-inorganic fertilizer combination *i.e.* D_1B_2, maximum pericarp thickness of fruits was obtained with1st January date of transplanting (D_2) and *Azotobactor* + 75% of rec. N + rec. P_2O_5 and K_2O(B_6) biofertilizer-inorganic fertilizer combination *i.e.* D_2B_6 and minimum days taken to 50% flowering was obtained with 1st february date of transplanting (D_3) and *Azotobactor* + 100% of rec. N + rec. P_2O_5 and K_2O(B_7) biofertilizer-inorganic fertilizer combination *i.e.* D_3B_7.

DISCUSSION

In view of the literature information available, the results presented in the previous tables is discussed here as under. In the present investigation among the various transplanting dates maximum plant height and highest number of primary branches per plant was recorded when the transplanting was done on 1st December (D_1) or 1st January (D_2) with *Azotobactor* + 100% of rec. N + rec. P_2O_5 and K_2O(B_7) biofertilizer-inorganic fertilizer combination. Plant height and number of branches per plant decreased as the seedlings transplanting was delayed. A remarkable increase in all the growth characters at the early transplanting date might be due to longer growing period available for plant growth at favourable temperature, which helped in quick and vigorous growth. Sharma *et al*. (1992) found maximum plant height from early dates of transplanting than the later dates of transplanting in tomato. The results of the present study are also in conformity with the findings of Singh *et al*. (2005) in tomato. In respect of biofertilizer-inorganic fertilizer treatment combinations the increase in plant growth related attributes might be due to the fact that the bio-fertilizers secrete growth promoting substances in the inoculated plants which was able to absorb nutrients at faster rate. It might have resulted in accumulation of more dry matter due to increased growth promoting hormones produced by microbes near root zone. Similar observations were recorded by Gajbhiya *et al*. (2003) who reported that bio-fertilizer when applied with chemical fertilizers was found to enhance the plant height and number of primary branches.

There was a marked influence of day and night temperatures on the initiation of flowers and days taken to 50% flowering, which are the major components for the enhanced number of fruits. There was a gradual decrease in days taken to 50% flowering with the advancement in date of transplanting. IstFebruary (D_3) transplanting took minimum number of days to 50% flowering. The probable reason could be assigned because of gradual increase in temperature coupled with short growth period resulted in early flowering in plant. These results are in agreement with the findings of Samnotra *et al*. (1998) who opined that maximum number of days to 50% flowering was taken when the seedlings were transplanted on 30th January as compared with 14th February transplanting. Similar results were confirmed by Dhandpani *et al*. (1982) in tomato.

Bio-fertilizer treatments influenced the number of days to 50 % flowering significantly. Minimum number of days taken to 50% flowering were recorded with B_7 (*Azotobactor* + RDF) which was followed by B_6 (*Azotobactor*+75% of recommended N + recommended P_2O_5 and K_2O). The earliness in flowering could be ascribed due to the faster enhancement of vegetative growth, which stored sufficient reserved food for differentiation of buds in to flower buds. The delayed flowering in plant was recorded when no bio-fertilizers was applied. Ocampo *et al*. (1978) observed that the flowering in tomato plant was earliest and most intense in tomato

seedling inoculated with *Azotobactor* and receiving N and P_2O_5 fertilizers 10 weeks after transplanting. Similar findings have been reported by Bhadoria *et al.* (2007) in tomato.

Quality of the tomato fruit is determined by pericarp thickness which determines fruit firmness, TSS helps in the recovery of processed product, acidity is considered ideal for processing and high ascorbic acid helps in better retention of red colour and flavour of the product. Pericarp thickness, TSS and acidity were found best when the seedlings were transplanted on Ist January (D_2). It might be because of better temperature prevailing during flowering and fruit development. Similar observations are recorded by Shukla *et al.* (1990) in tomato. Maximum ascorbic acid content was recorded with IstDecember (D_1) transplanting. It decreased as the transplanting was delayed. It indicated that crop matured at cool temperature had higher ascorbic acid content. Quality attributes were markedly influence by use of bio-fertilizer and inorganic fertilizer. Pericarp thicknesses of fruits increased with all the bio-fertilizer treatments as compared to control. Maximum Pericarp thickness was obtained in B_6 (*Azotobactor* + 75% of recommended N+ recommended P_2O_5 and K_2O kg/acre). These finding are in confirmatory with the reports of Chaurasia *et al.* (2001) in tomato, they found that soil application of *Azotobactor* @ 15 kg/ha coupled with inorganic fertilizers increased the pericarp thickness in tomato. Total soluble solid of fruits was increased by all the treatments as compared with control. These finding are in confirmatory with the results of Kumarswamy *et al.*, (1990) who reported that *Azotobactor* treated plants produced high TSS (8.46%) of fruit in tomato. Similar observations were reported byPremesekher and Rajashree (2009).

Improvement in fruit quality might be due to increase in efficiency of microbial inoculants to fix atmospheric nitrogen and secret growth promoting substance, which might have accelerated the physiological process.

Acidity in fruits were maximum with the application of *Azotobactor* + 75% of recommended N + recommended P_2O_5 and K_2O kg/acre(B_6). It might be due to improvement in soil physical and chemical properties due to increased activity of enzyme namely acetose and hormone etc with the application of bio-fertilizer might have enhanced acidic content of fruits.Ascorbic acid content (vitamin C) of tomato fruit was significantly increased by the application of bio-fertilizer plus inorganic fertilizer. Tomato seedling treated with *Azospirillum* significantly increased the ascorbic acid content of fruit as compared with untreated. The most probable reason for increased synthesis of ascorbic acid content by bio-fertilizer might be due to increase in the activity of ascorbic acid oxidase enzyme causing marked improvement in Vitamin-C. Kumarswamy *et al.* (1990) suggested that *Azospirillum* treated plants produced maximum ascorbic acid content (32.91mg/100gm) in tomato. Similar observations were recorded by Kumaran *et al.* (1998) in tomato.

CONCLUSION

The present study indicated that under the agro-climatic conditions of Hisar, for getting good crop establishment and growth, quality fruit production in case of tomato variety Hisar Arun, the 1st January date of sowing (D_2) and Azotobactor + 100% of rec. N + rec. P_2O_5 and K_2O (B_7) biofertilizer-inorganic fertilizer combination *i.e.* $D_2B_7$was more suitable.

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