Int.J.Curr.Microbiol.App.Sci (2021) *10*(02): 2813-2820

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 10 Number 02 (2021)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2021.1002.312

Effect of Fertilizers and Fertigation Treatments on Pomato Growth and Yield under Protected Environments

Sunil Kumar[1], Pardeep Kumar[2*], Parveen Sharma[1], Narender Kumar Sankhyan[1] and Anjali[1]

[1]Chaudhary Sarwan Kumar Himachal Pradesh Agriculture University, Palampur, Himachal Pradesh, India
[2]Department of Plant Sciences, School of Life Sciences-Central University of HP, India

**Corresponding author*

Keywords

Pomato growth, Fertigation, Treatments

Article Info

Accepted:
20 January 2021
Available Online:
10 February 2021

A B S T R A C T

Pomato is said to be the amalgamation of potato and tomato, produced by grafting, where potato is used as a rootstock and tomato as a scion. The experiment was conducted under controlled conditions at Vegetable Research Farm, Himachal Pradesh Agricultural University, Palampur to investigate the effect of fertilizers on horticultural traits of pomato plant. The experimental material consisted of fourteen different fertilizer treatments comprising three controls T1 (100% RDF + FYM), T2 (100% RDF Sole Tomato) and T3 (100% RDF (Sole Potato) for which potato cultivar "Kufri Himalini" and tomato cultivar "Palam Tomato Hybrid-1", served as grafting parents. Most of the traits under investigation were found to be significantly affected by different fertilizer treatments. The effect of fertilizer treatments on survival of grafted plants was found to be non-significant. Among different fertilizer treatments for pomato under study, maximum number of shoots per plant and prolonged harvest duration of tomato fruits were recorded at 75% RDF along with fertigation @ 4.56 g m-2. Least days to attain graftable shoots were found at 125% RDF. Minimum days (42.93) to first flowering in pomato plants and maximum plant height were recorded at 125% RDF + 2.28 g m-2 fertigation. Yield attributes for potato and tomato in pomato plant were found at an upper hand in case of treatment T8 (100% RDF + 6.84 g m-2 (F) and T10 (75% RDF + 4.56 g m-2 (F) respectively.

Introduction

Pomato is a recombinant plant which provides an opportunity to polyhouse farmers to get two crops on a single plant, thereby, efficiently exploiting limited land resources. Pomato is a modern technology that can make crops more efficient in maximizing yield per unit area, mainly under semi-controlled environmental conditions. It can contribute for effective utilization of polyhouses and provide two crops in one season. It looks like a genetically engineered product with tomatoes at one end and potatoes at the other.

The crop nutrient requirement of nitrogen, phosphorus, and potassium (as N, P_2O_5, and K_2O, respectively) reflects the optimum levels of these nutrients needed to produce maximum tomato and potato yield (Reiter, 2012). Nasreen and Islam (1990) showed that nitrogen and phosphorus increased yield more effectively than the other nutrients needed. Adequate supply of nutrient can increase the yield and quality of produce (Shukla and Naik, 1993). Over-fertilization decreases the effectiveness of fertilizers and raises the possibility of contamination of groundwater. For example, excess use of nitrogen fertilizer can cause more vegetative growth instead of tuber production and delay maturity (Love *et al.,* 2005; Kumar *et al.,* 2007) and also reduce tuber quality (Zebarth and Rosen, 2007). Deliberate use of fertilizers without soil testing can also contribute to crop loss due to abiotic stress (Nityamanjari, 2018). The traditional nutrient application methods resulted in leaching of fertilizers due to excess irrigation and plants don't get benefit from fertilizers.

Sometimes, it leads to accumulation of nutrients in unavailable form. On the contrary, soil fertigation significantly results in enhancement of yield and quality, so that nutrients are available throughout the growing period to meet the actual nutritional requirement of crops. If adequate nutrients are not supplied then crop exhibits abnormal growth. Hence, there should be a system which will help to provide adequate amount of nutrients to crop. Therefore, soil fertigation can help in fulfilment of water and nutrient requirements of a crop as it is an efficient and agronomically sound method of providing soluble plant nutrients directly to the active plant root zone. Fertigation helps in saving the water and avoid losses of nutrients which generally occur due to conventional method of fertilizer application (Sudhakar, 2017).

Materials and Methods

The experiment was conducted at Vegetable Research Farm, Department of Vegetable Science and Floriculture, CSKHPKV, Palampur (HP) in a modified naturally ventilated quonset polyhouse during 2019-20. Since under the polyhouse conditions only 60 per cent of total crop area is covered, thus for the present study, the cumulative of 60 per cent of recommended doses for potato and tomato were applied. The experimental material consisted of fourteen fertilizer treatments comprising of three controls T_1 (100% RDF + FYM), T_2 (100% RDF (Sole Tomato) and T_3 (100% RDF (Sole Potato) for which potato cultivar "KufriHimalini" and tomato cultivar "Palam Tomato Hybrid-1", served as grafting parents (Table 1). The experimental design consisted of a Randomized Block Design with three replications. Urea, SSP, MOP and well rotten FYM were applied in each bed as per treatment before sowing of seed tubers or transplanting of tomato seedlings. Tomato seedlings of 28-30 days old, were grafted on potato plant (15-20 cm height) using cleft grafting technique. Optimum conditions for healing of grafted plants were maintained by overhead 50% agro UV stabilized shade net and frequent fogging of water in the polyhouse to maintain optimum humidity. After three weeks when the graft was firmly established the fertigation was given twice a week by applying water soluble fertilizer (N:P:K 19:19:19) as per treatments. Recommended package of practices was followed to raise a healthy crop. In each replication, five best plants from each treatment were selected to assess the effect of treatments on various characters. The data recorded during the above described investigation was analyzed statistically and treatment differences were tested for their significance as per the methods given by Gomez and Gomez (1984).

Results and Discussion

Growth attributes of pomato plant

The perusal of data in table 2, revealed that most of the growth attributes were significantly affected by various fertilizer treatments. The data pertaining to survival of grafted plants (%) was found non-significant.

For number of shoots per plant and harvest duration of tomato (in days), plants in treatment T_{10} (75% RDF + 4.56 g m^{-2} Fertigation) was performed the best, whereas, days to attain graftable shoots were found minimum in treatment T_5 (125% RDF). Minimum number of days (42.93) to first flowering was recorded in plants under treatment T_{12} consisted of 125% RDF along with fertigation @ 2.28 g m^{-2}. Maximum plant height on an average was recorded in treatment T_{12} (125% RDF + 2.28 g m^{-2} Fertigation).

When compared to plants in control (grafted and non-grafted), number of shoots per plant were lesser than that of in treatment T_{10} (75% RDF + 4.56 g m^{-2}Fertigation). Days to attain graftable shoots in control T_1 (100% RDF + FYM) were found equivalent with treatment T_5 (75% RDF). Controls T_1 (100% RDF + FYM) and T_2 (100% RDF (sole tomato) was found inferior to treatment T_{12} (125% RDF + 2.28 g m^{-2}Fertigation) with respect to days to first flowering. Both the controls, T_1 (100% RDF + FYM) and T_2 (100% RDF (sole tomato) were found inferior to treatment T_{10} regarding harvest duration of tomato (days). Same was the case with respect to plant height (in cm), as treatment T_{12} (125% RDF + 2.28 g m^{-2}Fertigation) performed better than both the controls.

Yield attributes of potato in pomato plant

An examination of the data presented in table 3, indicated that there was a significant impact of fertilizer treatments on yield attributes of potato in pomato plant.

Among the different fertilizer treatments for grafted pomato plants, maximum number of tubers per plant and tuber yield per plant was obtained in treatment T_8 (100% RDF + 6.84 g m^{-2} (F). Similarly, maximum average tuber weight (103.51 g) was found in treatment T_{13} (125% RDF + 4.56 g m^{-2} (F) for grafted pomato plants under different fertilizer treatments.

On comparison of grafted plants under different treatments with controls T_1 (100% RDF + FYM (pomato) and T_3 (100% RDF (sole potato) it was observed that grafted plants under different treatments were found superior to that of the control T_1 for characters like number of tubers and tuber yield per plant whereas, on the contrary control T_2 (100% RDF) ie. ungrafted sole potato plant was found superior to all the other grafted pomato plants for all the yield attributes except for the character average tuber weight (g) where treatment T_{13} (125% RDF + 4.56 g m^{-2} (F) was found superior to both the controls.

These findings are in line with those reported by Peres (2005) and Negi (2017). Peres *et al.*, (2005) in a study on grafting of tomato mutants onto potato rootstocks: an approach to study leaf-derived signalling on tuberization observed that tomato scions failed to divert the photo-assimilates towards stolons for proper tuber development. Possible reason for reduced tuber yield of pomato plants might be due to the increased transmission of nutrients from the root zone to the aerial parts for the development of tomato fruits.

Yield attributes of tomato in pomato plant

It is apparent from the data presented in the table 4 that different fertilizer treatments

significantly influenced the yield attributes of tomato in pomato plant.

Among the different fertilizer treatments, significantly highest number of marketable fruits and marketable fruit yield per plant were obtained for treatment T_{10}(75% RDF + 4.56 g m^{-2} (Fertigation). Similarly, significantly highest average tomato fruit weight was obtained for treatment T_{12} (125% RDF + 2.28 g m^{-2}Fertigation).

Comparisons between control T_1 (100% RDF + FYM) and grafted plants under different fertilizer treatments revealed that about 30% and 45.6 % decrease in number of marketable fruits and yield per plant was obtained in control T_1 than in treatment T_{10}(75% RDF + 4.56 g m^{-2} (Fertigation). While, in case of control T_2 i.eungrafted sole tomato plant the yield attributes were found superior to all the other fertilizer treatments used in the study. The superiority of yield attributes of sole tomato plant may be due to less diversion of nutrients for development of both tomato and potato on single plant.

Fig.1 Harvesting stage of Potato and Tomato

Table.1 List of nutrient treatments used in experiment

Treatments detail	Dose of fertilizers (per plot-g/plot) (Urea: SSP: MOP)
T_1 : 100% RDF+ FYM-Control (Recommended Dose)	111:244:47 g + FYM (7.5 kg)
T2 : 100% RDF -Control (Tomato-Non grafted)	53:133:17 g/plot
T_3 : 100% RDF -Control (Potato-Non grafted)	59:111:30 g/plot
T_4 : 75% RDF -Pomato	83:183:35 g/plot
T_5 : 125% RDF-Pomato	139:305:58 g/plot
T_6 : 100% RDF + 2.28 gm^{-2} (Fertigation)- Pomato	111:244:47 g/plot
T_7 : 100% RDF + 4.56 gm^{-2} (Fertigation)- Pomato	111:244:47 g/plot
T_8 : 100% RDF + 6.84 gm^{-2} (Fertigation)-Pomato	111:244:47 g/plot
T_9 : 75% RDF + 2.28 gm^{-2} (Fertigation)-Pomato	83:183:35 g/plot
T_{10} : 75% RDF + 4.56 gm^{-2} (Fertigation)-Pomato	83:183:35 g/plot
T_{11} : 75% RDF + 6.84 gm^{-2} (Fertigation)-Pomato	83:183:35 g/plot
T_{12} : 125% RDF + 2.28 gm^{-2} (Fertigation)-Pomato	139:305:58 g/plot
T_{13} : 125% RDF + 4.56 gm^{-2} (Fertigation)-Pomato	139:305:58 g/plot
T_{14} : 125% RDF + 6.84 gm^{-2} (Fertigation)-Pomato	139:305:58 g/plot

Table.2 Effect of fertilizer treatments on Number of shoots per plant, Days to attain graftable shoots, survival of grafted plants (%), Days to first flowering, Harvesting duration of tomato (days) and Plant height (cm)

Treatments	Number of shoots per plant	Days to attain graftable shoots	Survival of grafted plants (%)	Days to first flowering	Harvest duration of tomato (days)	Plant height (cm)
T_1 (100% RDF + FYM) -Control-Recommended Dose	1.92	22.67	74.00	48.47	72.27	200.00
T_2 (100% RDF) - Control -Tomato-Non grafted	-	-	-	43.47	65.67	178.27
T_3 (100% RDF) - Control -Potato-Non grafted	1.71	-	-	-	-	-
T_4 (75% RDF) -Pomato	1.87	24.67	73.33	47.8	69.73	194.00
T_5 (125% RDF) -Pomato	1.74	22.67	71.00	47.27	71.67	205.67
T_6 (100% RDF + 2.28 g m^{-2} (F) -Pomato	1.53	24.33	74.00	45.27	72.07	210.00
T_7 (100% RDF + 4.56 g m^{-2} (F) -Pomato	1.57	24.67	78.33	46.13	74.80	208.47
T_8 (100% RDF + 6.84 g m^{-2} (F) -Pomato	1.73	23.67	78.00	47.47	76.40	217.20
T_9 (75% RDF + 2.28 g m^{-2} (F) -Pomato	1.80	25.67	76.00	46.33	72.27	195.47
T_{10} (75% RDF + 4.56 g m^{-2} (F)- Pomato	2.19	25.00	82.35	44.73	77.07	223.13
T_{11} (75% RDF + 6.84 g m^{-2} (F)- Pomato	1.93	24.00	78.33	43.6	74.27	216.80
T_{12} (125% RDF + 2.28 g m^{-2} (F)- Pomato	1.95	23.00	79.33	42.93	76.00	230.53
T_{13} (125% RDF + 4.56 g m^{-2} (F)- Pomato	1.73	24.00	78.67	43.6	73.73	212.93
T_{14} (125% RDF + 6.84 g m^{-2} (F)- Pomato	1.87	23.67	77.00	44.13	75.20	215.60
CD (P=0.05)	**0.29**	**1.37**	**N/A**	**1.79**	**3.30**	**15.75**

Table.3 Effect of fertilizer treatments on Number of tubers per plant, Tuber yield per plant (g) and Average tuber weight (g)

Treatments	Number of tubers per plant	Tuber yield per plant (g)	Average tuber weight (g)
T_1 (100% RDF + FYM) -Control-Recommended Dose	5.13	462.57	90.17
T_2 (100% RDF) - Control -Tomato-Non grafted	-	-	-
T_3 (100% RDF) - Control -Potato-Non grafted	5.90	588.23	99.70
T_4 (75% RDF) -Pomato	5.20	398.06	76.55
T_5 (125% RDF) -Pomato	4.93	416.83	84.55
T_6 (100% RDF + 2.28 g m^{-2} (F) -Pomato	4.88	463.50	94.98
T_7 (100% RDF + 4.56 g m^{-2} (F) -Pomato	5.67	554.24	97.75
T_8 (100% RDF + 6.84 g m^{-2} (F) -Pomato	5.77	558.82	96.85
T_9 (75% RDF + 2.28 g m^{-2} (F) -Pomato	5.19	471.41	90.83
T_{10} (75% RDF + 4.56 g m^{-2} (F)- Pomato	5.61	549.89	98.02
T_{11} (75% RDF + 6.84 g m^{-2} (F)- Pomato	5.33	493.88	92.66
T_{12} (125% RDF + 2.28 g m^{-2} (F)- Pomato	5.53	533.59	96.49
T_{13} (125% RDF + 4.56 g m^{-2} (F)- Pomato	4.91	508.23	103.51
T_{14} (125% RDF + 6.84 g m^{-2} (F)- Pomato	5.20	517.82	99.59
CD (P=0.05)	**0.65**	**51.88**	**9.33**

Table.4 Effect of fertilizer treatments on Number of marketable fruits per plant, Marketable fruit yield per plant (kg) and Average fruit weight (g)

Treatments	Number of marketable fruits per plant	Marketable fruit yield per plant (kg)	Average fruit weight (g)
T_1 (100% RDF + FYM) -Control-Recommended Dose	16.05	0.87	54.25
T_2 (100% RDF) - Control -Tomato-Non grafted	24.05	1.70	70.68
T_3 (100% RDF) - Control -Potato-Non grafted	-	-	-
T_4 (75% RDF) -Pomato	14.21	0.65	46.13
T_5 (125% RDF) -Pomato	15.77	0.81	51.12
T_6 (100% RDF + 2.28 g m^{-2} (Fertigation) -Pomato	17.27	1.05	61.00
T_7 (100% RDF + 4.56 g m^{-2} (Fertigation) -Pomato	19.13	1.13	59.47
T_8 (100% RDF + 6.84 g m^{-2} (Fertigation) -Pomato	21.14	1.43	67.51
T_9 (75% RDF + 2.28 g m^{-2} (Fertigation) -Pomato	18.24	1.09	60.20
T_{10} (75% RDF + 4.56 g m^{-2} (Fertigation)- Pomato	23.20	1.60	68.14
T_{11} (75% RDF + 6.84 g m^{-2} (Fertigation)- Pomato	20.27	1.31	65.00
T_{12} (125% RDF + 2.28 g m^{-2} (Fertigation)- Pomato	22.84	1.59	69.46
T_{13} (125% RDF + 4.56 g m^{-2} (Fertigation)- Pomato	20.9	1.42	67.81
T_{14} (125% RDF + 6.84 g m^{-2} (Fertigation)- Pomato	17.65	1.21	68.78
CD (P=0.05)	**2.16**	**0.17**	**9.37**

In conclusion among the different experimental fertilizer treatments for pomato, tuber sown at 75% RDF along with fertigation @ 4.56 g m^{-2} (T_7) resulted in maximum number of shoots per plant (2.19) and longer harvest duration of tomato fruits. Whereas, effect of fertilizer treatments on survival of grafted plants (%) were found non-significant. Minimum days to attain graftable shoots (22.67) were recorded in pomato plants at 125% RDF (T_5). Minimum days to first flowering (42.93 days) and maximum plant height of pomato plants were recorded at 125% RDF with fertigation @ 2.28 g m^{-2} (T_{12}).For the yield attributes of potato and tomato in pomato plant, maximum number of tubers per plant (5.77) and tuber yield per plant (558.82 g) were recorded at 100% RDF along with fertigation @ 6.84 g m^{-2}, whereas maximum tuber average weight (103.51 g) was found in treatment T_{13} (125% RDF + 4.56 g m^{-2} (F). At 75% RDF with fertigation @4.56 g m^{-2} twice in a week resulted in highest number of marketable fruits and marketable fruit yield per plant in pomato plants. While, average tomato fruit weight was recorded maximum in treatment T_{12} (125% RDF + 2.28 g m^{-2} Fertigation). The decreased yield in pomato plant as compared to control i.e ungrafted sole potato and tomato plant was obtained due to diversion of the nutrients from the root zone to the foliage for development of both potato tubers and tomato fruits simultaneously on a single plant. Hence, grafting of tomato-potato along with fertigation technique can prove to be a promising technique in order to obtain higher yields of potato and tomato fruits from a single plant.

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How to cite this article:

Sunil Kumar, Pardeep Kumar, Parveen Sharma, Narender Kumar Sankhyan and Anjali. 2021. Effect of Fertilizers and Fertigation Treatments on Pomato Growth and Yield under Protected Environments. *Int.J.Curr.Microbiol.App.Sci.* 10(02): 2813-2820.
doi: https://doi.org/10.20546/ijcmas.2021.1002.312