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Study on effect of NPK and micro nutrient for plant growth fruit yield and quality of pomegranate (*Punica granatum* L.) cv. (Bhagwa)

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Abstract
The present experiment was carried out during July 2017 to December 2017 in Central Research Field of Department of Horticulture, SHUATS, Allahabad. The experiment was conducted in Randomized Block Design (RBD), with twelve treatments, replicated thrice. the treatments were T_0 Control (RDF), T_1 (50 % NPK + 0.4 % $FeSO_4$ + 0.2 Boric acid + 0.3 % $ZnSO_4$), T_2 (50 % NPK + 0.50 % $FeSO_4$ + 0.50 % Boric acid + 0.50 % $ZnSO_4$), T_3 (50 % NPK + 0.75 % $FeSO_4$ + 0.75 %Boric acid + 0.75 % $ZnSO_4$), T_4 (75 % NPK + 1 % $FeSO_4$ + 1 % Boric acid + 1 % $ZnSO_4$), T_5 (75 % NPK + 1.25 % $FeSO_4$ + 1.25 % Boric acid + 1.25 % $ZnSO_4$), T_6 (75 % NPK + 1.5 % $FeSO_4$ + 1.5 % Boric acid + 1.5 % $ZnSO_4$), T_7 (100 % NPK + 1.75 % $FeSO_4$ + 1.75 % Boric acid + 1.75 % $ZnSO_4$), T_8 (100 % NPK + 2 % $FeSO_4$ + 2 % Boric acid + 2 % $ZnSO_4$), T_9 (100 % NPK + 2.25 % $FeSO_4$ + 2.25 % Boric acid + 2.25 % $ZnSO_4$), T_{10} (75 % NPK + 2.5 % $FeSO_4$ + 2.5 % Boric acid + 2.5 % $ZnSO_4$) and T_{11} (100 % NPK + 2.75 % $FeSO_4$ + 2.75 % Boric acid + 2.75 % $ZnSO_4$). Based on the present investigation it is concluded that the treatment T_8 recorded maximum plant height, plant spread at 180 days respectively, maximum Number of Branches, Number of Fruits/Plant, Fruit yield/Plant, Fruit yield (q)/ha, Average fruit weight, Specific gravity (g/cm^3) and Number of flowers, minimum days to flowering and Days taken to first fruit. In terms of Total Soluble Solid (^{o}Brix), minimum Acidity and maximum Ascorbic acid mg/100g was recorded in treatment T_9, whereas minimum was recorded in treatment T_0 in all the parameters. In terms of cost benefit ratio the maximum Cost Benefit ratio 1:3.40 was found in treatment T_8 whereas the minimum cost benefit ratio was found with treatment T_0.

Keywords: Pomegranate, micronutrients, NPK

Introduction
Pomegranate (*Punica granatum* L.) Belongs to the family Punicaceae, subclass Rosidae and order Myrtales, is the only known genus of the family. It is a genus of large shrubs or small trees with 2 species. One is *Punica protopunica* which is wild type found in Socotra Island of the Arabian Peninsula, and is considered as an ancestral species (Shilikina, 1973) [10] and the other is *Punica granatum* cultivated in tropical and subtropical parts of the world. *Punica granatum* has been classified into two sub species chlorocarpa and porphyrocarpa, each having two varieties. These sub-species have been established on the basis of the colour of the ovary, a stable feature, which is retained even when they are reproduced by seeds. Sub-species chlorocarpa is mainly found in the transcaucasus, whereas, the second sub-species porphyrocarpa is mainly central Asian in distribution.

It has 2n=2x=16 and 18 chromosomes (Smith, 1979) [9]. The number of chromosomes in Dholka, Ganesh, Kandhari, Muscat white and Patiala varieties was found to be 2n=16, while the varieties double flowered had 2n=18 (Nath and Randhawa, 1959) [6]. The chromosome number in Vellodu and Kashmiri varieties was found to be 2n=18 with 1 or 2 quadrivalent associations at meiosis (Raman *et al*., 1963) [8]. Floral biology of Pomegranate has revealed that both self and cross pollination take place. The pollen from male flowers gives higher fruit set than those from the hermaphrodite ones (Game, 1987) [2].

Commercially it is propagated by stem cutting, air layering and recently by in vitro raised plants. In major Pomegranate growing areas of the deccan plateau of India, air layered plants are used for establishing orchards. Air layering during rainy season and November to December results in better success. Multiplication of Pomegranate by hardwood cutting is a common practice in major parts of the world. Cuttings can be propagated round the year using pruned wood under polyhouses. Optimum age of shoots for the hardwood cuttings ranges from 6-18 months (ICAR-NRCP).

In the present study, poor tree growth was noticed when one or more sources of nutrients were missing. This may be due to the reason that absence of even single source caused misbalancing in the nutrient uptake by the plants, hindering proper plant growth. Thus, the optimized standards of fertilizer application are of great importance to get good growth.

Materials and Methods

The Experimental was conducted in Randomized Block Design (RBD) with 12 treatments and 3 replications in the Central Research field of Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad during the year 2017 - 2018. Total number of treatments were nine *viz.* T_0 Control (RDF), T_1 (50 % NPK + 0.4 % $FeSO_4$ + 0.2 Boric acid + 0.3 % $ZnSO_4$), T_2 (50 % NPK + 0.50 % $FeSO_4$ + 0.50 % Boric acid + 0.50 % $ZnSO_4$), T_3 (50 % NPK + 0.75 % $FeSO_4$ + 0.75 %Boric acid + 0.75 % $ZnSO_4$), T_4 (75 % NPK + 1 % $FeSO_4$ + 1 % Boric acid + 1 % $ZnSO_4$), T_5 (75 % NPK + 1.25 % $FeSO_4$ + 1.25 % Boric acid + 1.25 % $ZnSO_4$), T_6 (75 % NPK + 1.5 % $FeSO_4$ + 1.5 % Boric acid + 1.5 % $ZnSO_4$), T_7 (100 % NPK + 1.75 % $FeSO_4$ + 1.75 % Boric acid + 1.75 % $ZnSO_4$), T_8 (100 % NPK + 2 % $FeSO_4$ + 2 % Boric acid + 2 % $ZnSO_4$), T_9 (100 % NPK + 2.25 % $FeSO_4$ + 2.25 % Boric acid + 2.25 % $ZnSO_4$), T_{10} (75 % NPK + 2.5 % $FeSO_4$ + 2.5 % Boric acid + 2.5 % $ZnSO_4$) and T_{11} (100 % NPK + 2.75 % $FeSO_4$ + 2.75 % Boric acid + 2.75 % $ZnSO_4$).

Plant Material

The present studies were conducted on four years old pomegranate trees of cultivar Bhagwa. Thirty trees with uniform vigour and size, planted at a spacing of 5m x 5m were selected for the study. All plants were given uniform cultural practices during the period of investigation.

Climatic condition in the experimental site

The area of Allahabad district comes under subtropical belt in the south east of Utter Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46 ºC- 48 ºC and seldom falls as low as 4 ºC- 5 ºC. The relative humidity ranges between 20 to 94 %. The average rainfall in this area is around 1013.4 mm annually. However, occasional precipitation is also not uncommon during winter months.

Results and Discussion

The present investigation was conducted on four years old pomegranate trees of cultivar Bhagwa. Thirty-six trees with uniform vigour and size, planted at a spacing of 5m x 5m were tagged for the recording observations. The findings of the experiment are summarized in following heads.

(A.) Growth Parameters

In terms of plant height treatment T_8 (100 % NPK + 2 % $FeSO_4$ + 2 % Boric acid + 2 % $ZnSO_4$) recorded maximum (211.742, 215.260, 218.233, 220.892, 224.423 and 227.040 cm) plant height at 30, 60, 90, 120, 150 and 180 days respectively after application of NPK and micronutrients followed by T_7 (100 % NPK + 1.75 % $FeSO_4$ + 1.75 % Boric acid + 1.75 % $ZnSO_4$) where as minimum Plant height (cm) (159.673, 162.290, 165.190, 167.190, 169.550 and 171.713 cm) was recorded in treatment T_0 (Control) at different days interval.

Similar trends was noticed in plant spreads where treatment T_8 (100 % NPK + 2 % $FeSO_4$ + 2 % Boric acid + 2 % $ZnSO_4$) recorded maximum (181.623, 182.637, 183.667, 185.473, 187.620 and 190.303 cm) plant spread at 30, 60, 90, 120, 150 and 180 days respectively after application of NPK and micronutrients followed by T_9 (100 % NPK + 2.25 % $FeSO_4$ + 2.25 % Boric acid + 2.25 % $ZnSO_4$), where as minimum Plant spread (cm) (137.070, 137.643, 138.370 140.310, 142.19 and 144.440 cm) was recorded in treatment T_0 (Control) at different days interval.

Number of branches was recorded maximum (9.820) in treatment T_8 (100 % NPK + 2 % $FeSO_4$ + 2 % Boric acid + 2 % $ZnSO_4$) followed by T_7 (100 % NPK + 1.75 % $FeSO_4$ + 1.75 % Boric acid + 1.75 % $ZnSO_4$), where as minimum Number of Branches (7.367) was recorded in treatment T_0 (Control) after 180 days.

(B) Flowering and fruiting characters

Days for flowering recorded minimum (126.953 days) in treatment T_8 (100 % NPK + 2 % $FeSO_4$ + 2 % Boric acid + 2 % $ZnSO_4$) followed by T_7 (100 % NPK + 1.75 % $FeSO_4$ + 1.75 % Boric acid + 1.75 % $ZnSO_4$), where as maximum Days to flowering (158.900 days) was recorded in treatment T_0 (Control).

Number of flowers per plant recorded maximum (131.860) in treatment T_8 (100 % NPK + 2 % $FeSO_4$ + 2 % Boric acid + 2 % $ZnSO_4$) followed by T_7 (100 % NPK + 1.75 % $FeSO_4$ + 1.75 % Boric acid + 1.75 % $ZnSO_4$), where as minimum (54.480) Number of flowers/plant was recorded in treatment T_0 (Control).

Days taken to first fruit the minimum (131.860) Days was recorded in treatment T_8 (100 % NPK + 2 % $FeSO_4$ + 2 % Boric acid + 2 % $ZnSO_4$) after application of NPK and micronutrients followed by T_7 (100 % NPK + 1.75 % $FeSO_4$ + 1.75 % Boric acid + 1.75 % $ZnSO_4$), where as maximum Days taken to first fruit (195.073 days) was recorded in treatment T_0 (Control).

In terms of Number of fruits per plant the maximum (36.630) Number of Fruits/Plant was recorded in treatment T_8 (100 % NPK + 2 % $FeSO_4$ + 2 % Boric acid + 2 % $ZnSO_4$), followed by T_7 (100 % NPK + 1.75 % $FeSO_4$ + 1.75 % Boric acid + 1.75 % $ZnSO_4$), where as minimum Number of Fruits/Plant (13.870) was recorded in treatment T_0 (Control). Similar findings were also reported by Kashyap *et al.* (2012) [4], Mir *et al.* (2012) [5] and Obaid *et al.* (2013.) [7].

In terms of fruit yield/plant and Fruit yield/ha (q) the maximum (4.787 kg) Fruit yield/Plant and (19.147 q) Fruit yield/ha was recorded in treatment T_8 (100 % NPK + 2 % $FeSO_4$ + 2 % Boric acid + 2 % $ZnSO_4$), followed by T_7 (100 % NPK + 1.75 % $FeSO_4$ + 1.75 % Boric acid + 1.75 % $ZnSO_4$) in both parameters, where as minimum Fruit yield/Plant (kg) (1.343 kg) and Fruit yield/ha (q) (5.373) was recorded in treatment T_0 (Control). Similar findings were also reported by Kashyap *et al.* (2012) [4], Mir *et al.* (2012) [5] and Obaid *et al.* (2013) [7].

In terms of Average fruit weight (g) the maximum (187.680 g) Average fruit weight was recorded in treatment T_8 (100 % NPK + 2 % $FeSO_4$ + 2 % Boric acid + 2 % $ZnSO_4$) after application of NPK and micronutrients followed by T_7 (100 % NPK + 1.75 % $FeSO_4$ + 1.75 % Boric acid + 1.75 % $ZnSO_4$), where as minimum Average fruit weight (104.050 g) was recorded in treatment T_0 (Control). Similar findings were also reported by Kashyap *et al.* (2012) [4], Mir *et al.* (2012) [5] and Obaid *et al.* (2013) [7].

(C) Quality Parameters

In terms of Specific gravity the maximum Specific gravity (g/cm^3) (1.020) was recorded in treatment T_8 (100 % NPK + 2 % $FeSO_4$ + 2 % Boric acid + 2 % $ZnSO_4$) followed by T_7 (100 % NPK + 1.75 % $FeSO_4$ + 1.75 % Boric acid + 1.75 % $ZnSO_4$), where as minimum Specific gravity (g/cm^3) (0.893) was recorded in treatment T_2 (50 % NPK + 0.50 % $FeSO_4$ + 0.50 % Boric acid + 0.50 % $ZnSO_4$). Similar findings were also reported by Kashyap *et al.* (2012) [4], Mir *et al*. (2012) [5] and Obaid *et al.* (2013) [7].

Total soluble solids was recorded maximum (14.913 ºBrix) in treatment T_9 (100 % NPK + 2.25 % $FeSO_4$ + 2.25 % Boric acid + 2.25 % $ZnSO_4$) after application of NPK and micronutrients followed by T_{10} (75 % NPK + 2.5 % $FeSO_4$ + 2.5 % Boric acid + 2.5 % $ZnSO_4$), where as minimum Total Soluble Solid (ºBrix) (10.200) was recorded in treatment T_0 (Control). Similar findings were also reported by Kashyap *et al.* (2012) [4], Mir *et al*. (2012) [5] and Obaid *et al.* (2013) [7].

Acidity was recorded minimum (0.350 %) in treatment T_9 (100 % NPK + 2.25 % $FeSO_4$ + 2.25 % Boric acid + 2.25 % $ZnSO_4$) followed by T_{10} (75 % NPK + 2.5 % $FeSO_4$ + 2.5 % Boric acid + 2.5 % $ZnSO_4$), where as maximum Acidity (0.503 %) was recorded in treatment T_0 (Control). Similar findings were also reported by Kashyap *et al.* (2012) [4], Mir *et al*. (2012) [5] and Obaid *et al.* (2013) [7].

Ascorbic acid mg/100 g was recorded maximum (10.593 mg) in treatment T_9 (100 % NPK + 2.25 % $FeSO_4$ + 2.25 % Boric acid + 2.25 % $ZnSO_4$) followed by T_{11} (100 % NPK + 2.75 % $FeSO_4$ + 2.75 % Boric acid + 2.75 % $ZnSO_4$), where as minimum value of Ascorbic acid (mg/100 g) (8.323) was recorded in treatment T_0 (Control). Similar findings were also reported by Kashyap *et al.* (2012) [4], Mir *et al*. (2012) [5] and Obaid *et al.* (2013) [7].

In terms of Economics the maximum gross return Net Return and Cost Benefit ratio was found in treatment T_8 (100 % NPK + 2 % $FeSO_4$ + 2 % Boric acid + 2 % $ZnSO_4$) followed by treatment T_3 (50 % NPK + 0.75 % $FeSO_4$ + 0.75 % Boric acid + 0.75 % $ZnSO_4$) whereas the minimum return and cost benefit ratio was found with treatment T_0 (Control).

Table 1: Effect of NPK and micro nutrient on Plant height (cm) and Plant spread (cm) of pomegranate (P*unica granatum*) cv. (Bhagwa)

Treatment Symbol	Plant height (cm)						Plant Spread (cm)					
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	180 DAS	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	180 DAS
T_0	159.673	162.290	165.190	167.190	169.550	171.713	137.070	137.643	138.370	140.310	142.193	144.440
T_1	174.590	177.577	179.467	182.227	185.453	188.260	161.830	162.477	163.037	164.233	165.887	167.290
T_2	191.117	193.957	196.213	198.820	202.147	204.817	166.627	167.490	168.107	169.853	171.960	173.803
T_3	194.150	195.990	198.533	202.283	204.820	207.347	168.260	168.843	169.837	172.020	173.663	175.350
T_4	202.563	204.813	207.347	210.667	213.223	215.013	169.737	170.383	171.303	173.333	175.473	177.513
T_5	203.737	205.767	208.257	211.153	214.413	216.327	171.157	172.070	173.010	174.667	177.000	179.043
T_6	207.320	209.717	212.393	215.103	217.393	219.347	173.417	174.100	174.987	177.573	180.000	182.000
T_7	209.447	212.850	215.063	218.093	220.487	223.120	174.833	175.560	176.330	178.633	181.237	183.223
T_8	211.743	215.260	218.233	220.897	224.423	227.040	181.623	182.637	183.667	185.473	187.620	190.303
T_9	205.367	207.720	209.703	212.623	215.180	217.300	177.340	177.913	178.417	180.167	182.803	184.493
T_{10}	202.657	205.123	207.730	210.993	213.267	215.273	174.357	174.907	175.597	177.570	179.590	181.623
T_{11}	202.117	204.897	207.077	209.950	211.390	212.820	172.750	173.417	174.020	176.277	178.393	180.633
F-test	S	S	S	S	S	S	S	S	S	S	S	S
SE(d)	5.341	5.337	5.336	5.221	5.324	5.373	7.116	7.135	7.112	6.904	7.006	6.976
C.D.	11.148	11.140	11.138	10.897	11.113	11.214	14.852	14.892	14.844	14.410	14.624	14.560

Table 2: Effect of NPK and micro nutrient on number of branches, days to first flower, number of flowers/plant, days taken to first fruit, Number of fruits/plant and Fruit Yield/Plant (kg) of pomegranate (P*unica granatum*) cv. (Bhagwa)

Treatment Symbol	Number of Branches	Days to first flower	Number of Flower/plant	Days taken to first fruit	Number of fruits per plant	Fruit yield/plant (kg)
T_0	7.367	158.900	54.480	195.073	13.870	1.343
T_1	7.973	152.773	87.107	184.073	22.300	2.677
T_2	8.280	151.687	94.337	181.303	24.217	3.237
T_3	7.873	148.480	98.047	178.307	27.967	3.580
T_4	8.173	147.567	101.153	176.700	29.347	3.657
T_5	8.493	145.793	103.113	174.143	30.823	3.720
T_6	8.737	142.387	106.847	173.120	33.120	3.750
T_7	9.333	136.340	109.847	167.787	34.067	3.957
T_8	9.820	126.953	131.860	161.000	36.630	4.787
T_9	7.857	146.293	100.827	174.073	32.777	3.353
T_{10}	8.550	143.513	103.577	172.137	29.820	3.197
T_{11}	8.013	140.447	109.113	175.787	24.687	2.643
F-test	NS	NS	S	NS	S	S
SE(d)	1.653	11.339	8.204	13.529	4.228	0.730
C.D.	N/A	N/A	17.123	N/A	8.824	1.524

Table 3: Effect of NPK and micro nutrient on Fruit yield/ha (q), Average fruit weight (g), Specific Gravity (g/cm^3), TSS (^{o}Brix), Ascorbic Acid (mg/100 g) and Cost benefit ratio of pomegranate (P*unica granatum*) cv. (Bhagwa)

Treatment Symbol	Fruit yield/ha (q)	Average fruit weight (g)	Specific Gravity (g/cm^3)	TSS (^{o}Brix)	Acidity (%)	Ascorbic Acid (mg/100 g)	Cost benefit ratio
T_0	5.373	104.050	0.900	10.200	0.503	8.323	1:1.06
T_1	10.707	135.297	0.917	12.170	0.443	8.537	1:2.17
T_2	12.947	140.140	0.893	12.327	0.450	9.257	1:2.60
T_3	14.320	143.193	0.950	13.070	0.423	9.587	1:2.85
T_4	14.627	144.100	0.907	12.467	0.450	9.563	1:2.78
T_5	14.880	147.843	0.967	12.387	0.457	8.877	1:2.80
T_6	15.000	174.353	0.937	13.187	0.430	9.817	1:2.80
T_7	15.707	176.017	0.983	13.053	0.400	9.673	1:2.80
T_8	19.147	187.680	1.020	13.313	0.460	9.733	1:3.40
T_9	13.413	157.567	0.900	14.913	0.350	10.593	1:2.74
T_{10}	12.787	153.927	0.917	14.797	0.390	9.510	1:2.31
T_{11}	10.573	145.353	0.930	14.740	0.403	9.867	1:1.83
F-test	S	S	NS	NS	NS	NS	
SE(d)	2.920	11.003	0.052	0.930	0.041	0.735	
C.D.	6.094	22.966	N/A	1.941	N/A	N/A	

Conclusion

Based on the present investigation it is concluded that the treatment T_8 (100 % NPK + 2 % $FeSO_4$ + 2 % Boric acid + 2 % $ZnSO_4$) recorded maximum plant height, plant spread at 180 days respectively, maximum Number of Branches, Number of Fruits/Plant, Fruit yield/Plant, Fruit yield (q)/ha, Average fruit weight, Specific gravity (g/cm^3) and Number of flowers, minimum days to flowering and Days taken to first fruit, In terms of Total Soluble Solid (^{o}Brix), minimum Acidity and maximum Ascorbic acid mg/100g was recorded in treatment T_9 (100 % NPK + 2.25 % $FeSO_4$ + 2.25 % Boric acid + 2.25 % $ZnSO_4$), whereas minimum was recorded in treatment T_0 (Control) In all the parameters. In terms of cost benefit ratio the maximum Cost Benefit ratio 1:3.40 was found in treatment T_8 (100 % NPK + 2 % $FeSO_4$ + 2 % Boric acid + 2 % $ZnSO_4$) whereas the minimum cost benefit ratio was found with treatment T_0 (Control).

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