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Influence of integrated nutrient management on bio-chemical and quality parameters of pomegranate (*Punica granatum* L.) cv. Bhagwa

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Abstract
A study was carried out at farmer's field, Bagepalli taluk, Chikkaballapur district to determine the influence of integrated nutrient management on bio-chemical and quality parameters of pomegranate (*Punica granatum* L.) cv. Bhagwa. The experimental plot was laid out in a randomized complete block design with three replications and twelve treatments. The bio-chemical and quality parameters such as total soluble solids, titratable acidity, sugar to acid ratio, ascorbic acid, anthocyanin and phenol content, sugars content, fruit and aril colour, physiological loss in weight, fruit shelf life and organoleptic evaluation were recorded during course of the investigation. The study results indicated that, the higher values for total soluble solids (15.98 °B), fruit anthocyanin content (49.15 mg/100ml), total sugar (13.92%) reducing sugar (12.69%), fruit (*a**) (48.60) and aril colour (*a**) (15.86) were recorded in a plants treated with 100 per cent RDF + vermicompost (5kg/plant) + neem cake (1kg/plant) + trichokawach (100g/plant) + darakshak (4ml/litre) foliar application + VAM (50g/plant) + *Penicillium pinophilum* (20g/plant) + seaweed extract (20g/plant) + chitosan (2g/litre) + salicylic acid (300ppm) + phosphoric acid (3ml/litre) + micronutrients through soil and foliar application + growth regulators (foliar application) (T_{12}). Whereas, lower acidity (0.41%), higher TSS to acid ratio (38.90), minimum physiological loss in fruit weight (25.29%), maximum fruit shelf life (33.33 days) and highest organoleptic score (overall acceptability) were reported in T_8 {(75% RDF + vermicompost (5kg/plant) + neem cake (1kg/plant) + trichokawach (100g/ plant) + darakshak (4ml/litre) foliar application + VAM (50g/plant) + *Penicillium pinophilum* (20g/ plant)+ seaweed extract (20g/plant) + chitosan (2g/litre) + salicylic acid (300ppm) + phosphoric acid (3ml/litre) + micronutrients (soil and foliar application) + growth regulators (foliar application)}.

Keywords: Bio-stimulants, bio-fertilizers, pomegranate, bio-chemical and quality parameters

Introduction
Pomegranate (*Punica granatum* L.) is one of the commercial fruit crop capable of growing in all agro-climatic conditions. It belongs to a distinct family Lythraceae and having a chromosomal number 2n=16 (Rana *et al.*, 2010) [20]. The fruits have wider consumer preference for its attractive, juicy, sweet-acidic, cool-refreshing arils and also for its different value added products such as juice, jam, jelly, syrup, anar-rub, anardana and wine. It is a rich source of carbohydrates (14.50%), proteins (1.60%), fats (0.10%), vitamin C and minerals (0.70%) comprising calcium (10 mg/100g), magnesium (12 mg/100g), phosphorus (70 mg/100g) and iron (0.3 mg/100g) hence, this fruit is referred as 'Elixir of life'. Since ancient times, the pomegranate has been regarded as a "Healing food" with numerous beneficial effects on several ailments (Vidal *et al.*, 2003) [23]. Each and every part of pomegranate plant posses pharmaceutical and therapeutic properties hence it is cited as "Power house of health or Super fruit" (Sharma and Maity, 2010) [21]. The high content of antioxidant, anthocyanin, phenols and phyto-chemicals in pomegranate helps to exhibit the anti-bacterial, anti-aging, anti-tumor, anti-diabetic, anti-cancer and anti-inflammatory properties. The fruit and peel extract has tremendous medicinal potential and used in traditional cures of many diseases such as atherosclerosis, hemorrhage, bronchitis, throat inflammation, leprosy, jaundice, diarrhea, diabetes, blood pressure, obesity, cancer, oral and cardiovascular problems (Stover and Mercure, 2007) [22].

In any production system, the primary goal is to achieve maximum fruit yield per unit area without affecting the fruit quality. Apart from fruit weight, the most important quality attributes contributing to the marketability of fresh pomegranate produce either for domestic or

export purpose; includes fruit appearance, rind colour, texture, flavor, nutritive bio-chemical content and microbiological safety. Therefore, considering the importance of fruit nutritional, pharmaceutical and medicinal value of pomegranate, an investigation was carried out to study the influence of integrated nutrient management on bio-chemical and quality parameters of pomegranate cv. Bhagwa.

Material and Methods

Experimental design and treatments

The experimental design adopted for the experiment was Randomized Complete Block Design (RCBD) consisting of 12 treatments with three replications. Healthy uniform pomegranate plants were selected and treated with different source of organic and inorganic fertilizers in single or in combinations. The details of treatments and fertilizers used in the experiment are mentioned as follows. T_1: 100% RDF through soil application, T_2:75% RDF + Trichokawach (100g/plant) + Darakshak (4ml/litre/plant) Foliar application + VAM (50g/plant) + *Penicillium pinophilum* (20g/plant) + Seaweed extract (20g/plant) + micronutrients (Soil and Foliar application), T_3: T_2 + Growth regulators, T_4: 75% RDF + Chitosan (20g/plant) Soil application + Chitosan (2g/litre/plant) Foliar application + micronutrients (Soil and Foliar application), T_5: 75% RDF + Salicylic acid (10g/plant) Soil application + Salicylic acid (300ppm/plant) Foliar application + micronutrients (Soil and Foliar application), T_6: 75% RDF + Phosphoric acid (20ml/plant) Soil application + Phosphoric acid (3ml/litre/plant) Foliar application + micronutrients (Soil and Foliar application), $T_{7,}$ 9 and 11: (75%, 50% and 100% RDF + Trichokawach (50g/plant) + Darakshak (4ml/litre/plant) Foliar application + VAM (50g/plant) + *Penicillium pinophilum* (20g/plant) + Seaweed extract (20g/plant) + Chitosan (20g/plant) + Salicylic acid (10g/plant) + Phosphoric acid (20ml/plant) + micronutrients through Soil application), $T_{8,\ 10\ and\ 12}$: (75%, 50% and 100% RDF + Trichokawach (50g/plant) + Darakshak (4ml/litre/plant) Foliar application + VAM (50g/plant) + *Penicillium pinophilum* (20g/plant) + Seaweed extract (20g/plant) + Chitosan (2g/litre/plant) + Salicylic acid (300ppm/plant) + Phosphoric acid (3ml/litre/plant) + micronutrients through Soil and Foliar application). Except treatment T_1 rest were applied with Vermicompost (5kg/plant) + Neem cake (1kg/plant) and growth regulators foliar spray (except T_1 and T_2) in common.

Fertilizers application

The recommended dose of fertilizers 625:250:250 ($N:P_2O_5:K_2O$ grams/plant) were applied as per the norms of National Research Centre, Pomegranate, Solapur (Anon., 2016) [2]. Urea was applied as four splits; single super phosphate (SSP) and muriate of potash (MOP) were applied as 3 splits doses during growing season (Lalithya *et al.*, 2017) [13]. The fertilizers such as vermicompost (5 kg/plant), neem cake (1 kg/plant), trichokawach (100 g/plant), VAM (Glomus spp) (50 g/plant), *Pencilium phinophilum* (20 g/plant) and seaweed extract (20 g/plant) were applied once through soil application during bahar treatment. The soil application of micronutrients, chitosan (20 g/plant), salicylic acid (10 g/plant) and phosphoric acid (20 ml/plant) were applied twice through split application during bahar treatment and 3 months after the first application.

The foliar application of darakshak (4 ml/litre), micronutrients, chitosan (2 g/litre), salicylic acid (300 ppm) and phosphoric acid (3 ml/litre) were applied twice at pre-flowering stage and at fruit colour green to pink conversion stage. The growth regulators such as lihocin (500 ppm) was applied 20 days after leaf shedding, NAA (50 ppm) was applied 30 days after bahar treatment and gibberellic acid (50 ppm) was applied 120 days after bahar treatment.

Bio-chemical and quality parameters

Five fruits were selected from each replication for recording observations in each treatment. All the bio-chemical and quality parameters were recorded after the fruits harvest from the tagged plants. The bio-chemical and quality parameters such as total soluble solids, titratable acidity, sugar to acid ratio, ascorbic acid, anthocyanin and phenol content, sugars content, fruit and aril colour, physiological loss in fruit weight and shelf life of pomegranate in response to integrated nutrient management were recorded using the following methods.

Total soluble solids content of pomegranate juice was recorded by using ERMA Hand Refractometer (0-32 °Brix) and it was expressed in °Brix. The titratable acidity was determined by titration method. Ascorbic acid content was estimated by 2, 6-Dichlorophenol indophenols (DCPIP) method and it was expressed in mg/100g. Total sugar and reducing sugar content of sample were determined by using titration method. Non-reducing sugar was calculated by deducting the quantity of reducing sugar from total sugar and multiplied by a constant factor 0.95 and the results were expressed as percent of non-reducing sugar. Anthocyanin content of fruit arils were estimated by VIS spectrophotometer and fruit phenol content was determined by using Folin - Ciocalteau's method.

Results

Total soluble solids, Titratable acidity (%) and TSS to acid ratio

The INM treatments significantly influenced the total soluble solids content, titratable acidity and TSS to acid ratio in pomegranate aril during both the years which is depicted in Table 1. The interpretation of data revealed that, the maximum TSS was recorded in T_{12} (15.97 and 15.98 and 15.98 °B) in which T_8 (15.90, 15.97, 15.94 °B) and T_{11} (15.83, 15.91 and 15.87 °B) showed on par values with T_{12} and minimum TSS was observed in T_9 (13.65, 13.37 and 13.51 °B) during both the consecutive years. Whereas, T_8 exhibited minimum fruit acidity (0.42, 0.40 and 0.41%) during first and second year of the study whereas T_{12} (0.43, 0.41 and 0.42%) and T_{11} (0.45, 0.44 and 0.45%) were at par with the superior treatment and maximum per cent of fruit acidity was recorded in T_9 (0.57, 0.59 and 0.58%). Meanwhile, the highest TSS to acid ratio was recorded in T_8 (37.86, 39.93 and 38.90) although T_{12} (37.14, 38.98 and 38.06) showed statistical similarity and lowest TSS to acid ratio was reported in T_9 (23.95, 22.66 and 23.31) during first and second year of the study.

Ascorbic acid content (mg/100g)

The data depicted in Table 2 revealed that, a non significant difference was observed for ascorbic acid content among the INM treatments during both the experimental years. The compiled values of two years data cited that, the maximum ascorbic acid content was recorded in T_{11} (14.16 mg/100g)

and minimum content (12.95 mg/100g) was noticed in T_6.

Fruit anthocyanin (mg/100ml) and phenol content (mg GAE/100g) content

A significant difference was observed among the treatments with respect to anthocyanin and phenol content of fruit during both the years of the investigation (Table 2). The T_{12} showed significant effect on enhancing the accumulation of anthocyanin content (49.66, 48.63 and 49.15 mg/100ml) which was at par with T_8 (47.96, 50.33 and 49.15 mg/100ml) and T_{11} (46.43, 48.09 and 47.26 mg/100ml) and lesser anthocyanin content was observed in T_1 (30.32, 32.32 and 31.32 mg/100ml). While, the maximum phenol content was expressed in T_5 (163.85 mg GAE/100g) which was on par with T_4 (161.68 mg GAE/100g) and T_{11} (154.62 mg GAE/100g) and minimum phenol content was observed in T_1 (125.83 mg GAE/100g).

Table 1: Effect of integrated nutrient management on total soluble solids content (°Brix), titratable acidity (%) and TSS to acid ratio of pomegranate fruit

Treatments	Total soluble solids (°Brix)			Titratable acidity (%)			TSS to acid ratio		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1	14.84	14.06	14.45	0.52	0.50	0.51	28.54	28.12	28.33
T_2	14.74	14.81	14.78	0.49	0.48	0.49	30.08	30.85	30.47
T_3	15.18	15.07	15.12	0.47	0.47	0.47	32.30	32.06	32.18
T_4	14.60	15.06	14.83	0.48	0.47	0.48	30.42	32.04	31.23
T_5	14.85	14.86	14.86	0.49	0.47	0.48	30.31	31.62	30.97
T_6	14.46	14.40	14.43	0.52	0.51	0.52	27.81	28.24	28.03
T_7	15.52	15.69	15.61	0.47	0.46	0.47	33.02	34.11	33.57
T_8	15.90	15.97	15.94	0.42	0.40	0.41	37.86	39.93	38.90
T_9	13.65	13.37	13.51	0.57	0.59	0.58	23.95	22.66	23.31
T_{10}	15.02	14.32	14.67	0.55	0.56	0.56	27.31	25.57	26.44
T_{11}	15.83	15.91	15.87	0.45	0.44	0.45	35.18	36.16	35.67
T_{12}	15.97	15.98	15.98	0.43	0.41	0.42	37.14	38.98	38.06
S. Em ±	0.26	0.31	0.35	0.01	0.02	0.01	0.83	0.95	0.92
C. D @5%	0.76	0.90	1.03	0.04	0.05	0.04	2.43	2.78	2.69

Total sugar, reducing sugar and non-reducing sugar (%) content

The result depicted that, all the treatments significantly affected the sugars per cent during two years of the experiment (Table 3). The data of pooled mean of two years study suggested that, the higher per cent of total sugar content was reported in T_{12} (13.92%) which was statistically similar with T_8 (13.83%), T_{11} (13.65%) and T_7 (13.33%) and T_9 recorded the minimum total sugar content (11.63%). Meanwhile, T_{12} enhanced the per cent of reducing sugar content (12.69%) which was at par with T_8 (12.53%), T_{11} (12.31%) and T_7 (11.97%) and minimum reducing sugar content was reported in T_9 (10.07%). Whereas, the lowest per cent of non-reducing sugar content (1.13, 1.20 and 1.17%) was recorded in T_{12} although T_8 (1.22, 1.25 and 1.24%) were found to be on par with T_{12} and highest per cent of non-reducing sugar content was noticed in T_1 (1.51, 1.58 and 1.55%).

Fruit and aril colour (*L, *a** and *b**)**

The analysis of pooled data of two years study indicated that, the minimum value for lightness was reported in T_4 (36.45) and maximum value for lightness was expressed in T_1 (43.51). Meanwhile, the T_{12} exhibited higher value for redness (48.60) and minimum value for redness was recorded in T_1 (39.30). While, the minimum value for yellowness was noticed in T_4 (23.76) although T_8 (24.36) showed statistical similarity and maximum value for yellowness was observed in T_1 (31.72). In case of aril colour, the minimum value for lightness was reported in T_4 (18.51) and maximum value for lightness was noticed in T_1 (25.50). Whereas, the T_{12} exhibited the maximum value for redness (15.86) while it was found to be similar with T_{11} (15.43) and T_8 (15.42) and minimum value for redness was recorded in T_1 (8.47). Meanwhile, the minimum value for yellowness was expressed in T_5 (1.66) and maximum value for yellowness was observed in T_1 (2.17) (Table 4 and 5).

Physiological loss in fruit weight (PLW) (%)

After 20 days of fruit storage, the loss in fruit weight was observed minimum in T_{12} (25.14%) in which T_8 (25.48%) showed statistical similarity and maximum fruit weight loss was noticed in T_1 (33.20%) during first year of the study. In second year of the experiment, the lowest percentage of loss in fruit weight was recorded in T_8 (25.11%) which was on par with T_{12} (25.51%) and highest percentage of fruit weight loss was expressed in T_1 (34.10%). The compiled data of two years study cited that, the lesser per cent of fruit weight loss was recorded in T_8 (25.29%) which was found to be similar with T_{12} (25.33%) and higher per cent of fruit weight loss was recorded in T_1 (33.65%) (Table 6).

Table 2: Effect of integrated nutrient management on enhancing the phyto-chemicals content of pomegranate fruit

Treatments	Ascorbic acid (mg/100g)			Anthocyanin content (mg/100ml)			Phenol content (mg GAE/100g)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1	13.28	13.35	13.32	30.32	32.32	31.32	123.12	128.53	125.83
T_2	13.41	13.54	13.47	35.43	36.43	35.93	135.88	140.20	138.04
T_3	13.61	13.75	13.68	40.89	41.22	41.06	142.61	145.97	144.29
T_4	13.88	13.98	13.93	44.73	45.53	45.13	155.92	167.45	161.68
T_5	13.85	13.95	13.90	44.52	45.81	45.16	162.51	165.20	163.85

T_6	12.90	12.99	12.95	35.26	35.93	35.60	135.28	142.54	138.91
T_7	13.99	14.05	14.02	42.15	44.15	43.15	148.99	155.37	152.18
T_8	14.10	14.15	14.13	47.96	50.33	49.15	143.05	146.74	144.90
T_9	13.34	13.29	13.31	34.68	35.35	35.02	139.07	143.38	141.23
T_{10}	13.52	13.47	13.50	38.85	39.52	39.19	145.83	152.73	149.29
T_{11}	14.13	14.19	14.16	46.43	48.09	47.26	152.01	157.23	154.62
T_{12}	14.07	14.10	14.09	49.66	48.63	49.15	145.50	150.63	148.07
S. Em ±	NS	NS	NS	1.24	0.91	1.03	3.43	3.42	3.26
C. D @5%	NS	NS	NS	3.63	2.67	3.02	10.07	10.05	9.57

Table 3: Effect of integrated nutrient management on sugars content (%) of pomegranate arils

Treatments	Total sugar (%)			Reducing sugar (%)			Non-reducing sugar (%)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1	11.80	11.87	11.84	10.21	10.20	10.21	1.51	1.58	1.55
T_2	12.51	12.53	12.52	11.03	11.09	11.06	1.40	1.37	1.39
T_3	12.83	12.96	12.90	11.39	11.58	11.49	1.37	1.31	1.34
T_4	12.94	12.90	12.92	11.53	11.56	11.55	1.34	1.27	1.31
T_5	12.52	12.56	12.54	11.07	11.07	11.07	1.38	1.41	1.40
T_6	12.10	12.03	12.07	10.59	10.57	10.58	1.43	1.39	1.41
T_7	13.20	13.46	13.33	11.87	12.07	11.97	1.27	1.32	1.30
T_8	13.67	13.98	13.83	12.39	12.66	12.53	1.22	1.25	1.24
T_9	11.61	11.64	11.63	10.08	10.05	10.07	1.45	1.51	1.48
T_{10}	12.05	12.19	12.12	10.58	10.67	10.63	1.40	1.44	1.42
T_{11}	13.51	13.79	13.65	12.15	12.46	12.31	1.30	1.27	1.29
T_{12}	13.95	13.88	13.92	12.76	12.62	12.69	1.13	1.20	1.17
S. Em ±	0.30	0.35	0.33	0.32	0.34	0.37	0.04	0.03	0.04
C. D @5%	0.88	1.00	0.96	0.94	0.98	1.05	0.12	0.09	0.12

Table 4: Effect of integrated nutrient management on fruit colour of pomegranate

Treatments	Fruit colour								
	L*			a*			b*		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1	43.06	43.95	43.51	39.63	38.97	39.30	31.45	31.98	31.72
T_2	39.86	40.18	40.02	42.85	42.18	42.52	28.06	27.63	27.85
T_3	38.72	35.62	37.17	45.09	44.43	44.76	26.72	28.16	27.44
T_4	35.72	37.17	36.45	45.10	44.85	44.98	22.98	24.54	23.76
T_5	38.87	39.65	39.26	42.08	43.61	42.85	27.28	26.31	26.80
T_6	39.02	40.12	39.57	42.68	41.85	42.27	28.28	28.92	28.60
T_7	36.33	38.87	37.60	45.91	45.13	45.52	27.70	27.03	27.37
T_8	38.10	38.87	38.49	47.78	47.92	47.85	25.60	23.12	24.36
T_9	39.48	39.74	39.62	42.71	42.12	42.42	28.17	28.64	28.41
T_{10}	38.70	38.47	38.59	44.97	43.97	44.47	27.60	27.19	27.39
T_{11}	36.97	36.39	36.68	48.80	47.90	48.35	26.88	26.26	26.57
T_{12}	37.98	38.95	38.47	48.93	48.27	48.60	26.21	26.84	26.53
S. Em ±	0.70	0.94	0.68	1.00	1.04	0.98	0.71	0.70	0.68
C. D @5%	2.05	2.80	2.01	2.97	3.10	2.90	2.09	2.05	1.98

Table 5: Effect of integrated nutrient management on aril colour of pomegranate

Treatments	Aril colour								
	L*			a*			b*		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1	25.08	25.91	25.50	8.16	8.77	8.47	2.19	2.15	2.17
T_2	22.64	21.97	22.31	10.72	10.65	10.69	1.93	1.97	1.95
T_3	17.75	19.48	18.62	12.70	12.94	12.82	1.90	1.92	1.91
T_4	19.48	17.54	18.51	14.58	14.97	14.77	1.85	1.86	1.86
T_5	20.08	21.84	20.96	11.83	12.38	12.11	1.64	1.69	1.66
T_6	23.22	22.54	22.88	10.50	10.49	10.50	2.09	2.02	2.06
T_7	18.82	19.73	19.28	14.56	14.98	14.77	1.78	1.82	1.80
T_8	21.50	19.32	20.41	15.08	15.76	15.42	1.91	1.96	1.94
T_9	22.23	23.56	22.90	11.52	11.05	11.28	2.05	2.08	2.07
T_{10}	21.83	20.24	21.04	12.65	11.93	12.29	1.96	1.92	1.94
T_{11}	19.82	21.39	20.61	15.31	15.55	15.43	1.97	1.98	1.98
T_{12}	21.56	19.64	20.60	15.77	15.94	15.86	1.83	1.85	1.84
S. Em ±	0.64	0.56	0.55	0.40	0.32	0.32	0.04	0.04	0.04
C. D @5%	1.87	1.65	1.62	1.17	0.94	0.95	0.12	0.12	0.12

Fruit shelf life (Days)

The maximum fruit shelf life (33.00, 33.66 and 33.33 days) was recorded in T_8 which was found to be at par with T_{12} (32.33, 32.00 and 32.17 days) and T_4 (30.33, 30.66 and 30.49 days) and minimum shelf life was noticed in T_1 (21.33, 20.66 and 21.00 days) (Table 7).

Organoleptic score (9 point hedonic scale)

Score on organoleptic evaluation of pomegranate as influenced by different INM treatments with respect to fruit and aril colour, aril taste, flavour, texture and overall acceptability are presented in Table 8 and the score indicated that colour, taste, flavour, texture and overall acceptability were affected by the treatments. In both the years the highest score for overall acceptability was noticed in T_8 and T_{12} (8.75 and 8.70) followed by T_{12} and T_8 (8.80 and 8.75) respectively.

Discussion

The integrated nutrient management treatments significantly enhanced the total soluble solids content, titratable acidity, sugar to acid ratio, ascorbic acid, anthocyanin and phenol content, sugars content, fruit and aril colour, physiological loss in weight and shelf life of pomegranate cv. Bhagwa during both the years of the study which is depicted in Table 1 to 8.

The variation with respect to total soluble solids content, titratable acidity and TSS to acid ratio might be due to the combined application of bio-fertilizers, bio-stimulants, organic manures along with inorganic fertilizers as RDF and micronutrients resulted in the synthesis of higher carbohydrates, organic acids and their rapid translocation from leaves to the fruits has led to the accumulation of more sugars and other soluble solids content in the fruits. Beerappa *et al.* (2019) [4] in pomegranate has reported that, the increased in the level of total soluble solids and sugars content in the fruit will helps to lower the fruit acidity. Thereby, increase in total soluble solids content and reduction in acidity in T_8 has resulted in obtaining the maximum TSS to acid ratio as compared to other treatments. These results are in conformity with the findings of Aziz *et al.* (2017) [3], Meena *et al.* (2018) [15], Yadav *et al.* (2018) [24], Harhash *et al.* (2019) [7] and Ibtesam *et al.* (2019) [10] in pomegranate.

Whereas, the probable increase in the anthocyanin and phenol content of the fruit might be due to the combined application of nutrients especially potassium will enhances the fruit anthocyanin content which is having a positive correlation with the anthocyanin accumulation in the fruit and also plays a crucial role in anthocyanin synthesis through increasing the translocation of sugars to the developing fruits, as well as act as a co-factor and stimulator of enzymes which are involved in the synthesis of anthocyanin and phenol compound. The foliar application of chitosan, salicylic acid and darakshak will increases the expression of genes involved in the biosynthesis of flavonoid compounds such as flavanol synthase and anthocyanidin synthase that improves the anthocyanin and phenol contents in the fruits. These results are in conformity with the findings of Mirdehghana and Vatanparast (2013) [16], Khodaei *et al.* (2015) [12], Ibtesam *et al.* (2019) [0], Harhash *et al.* (2019) [7] and Moradinezhad *et al.* (2020) [17] in pomegranate.

Table 6: Effect of integrated nutrient management treatments on per cent physiological loss in fruit weight of pomegranate

Treatments	Physiological loss in fruit weight (%)														
	4 days			8 days			12 days			16 days			20 days		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1	7.01	7.12	7.06	12.24	12.38	12.31	18.26	18.08	18.17	26.67	26.58	26.63	33.20	34.10	33.65
T_2	6.12	6.19	6.15	9.53	9.63	9.58	15.77	15.89	15.84	22.43	22.59	22.51	28.39	29.52	28.95
T_3	5.37	5.42	5.39	9.47	9.54	9.51	14.90	15.07	14.98	21.46	21.56	21.51	28.29	28.40	28.35
T_4	4.52	4.63	4.58	6.98	7.08	7.03	10.75	10.86	10.80	18.91	19.13	19.02	25.79	25.92	25.86
T_5	5.76	5.83	5.79	9.82	9.93	9.88	14.88	14.97	14.92	21.27	21.44	21.35	28.25	28.38	28.32
T_6	6.15	6.27	6.21	10.34	10.46	10.40	17.16	16.61	16.89	24.23	23.71	23.97	29.42	29.90	29.66
T_7	5.37	5.43	5.40	8.34	8.45	8.39	12.89	12.96	12.93	20.95	21.33	21.14	27.63	27.77	27.70
T_8	4.17	4.28	4.23	6.54	6.64	6.59	10.24	10.35	10.30	18.78	18.92	18.85	25.48	25.11	25.29
T_9	5.70	5.81	5.76	9.27	9.34	9.31	14.26	14.34	14.30	21.82	21.95	21.89	28.90	28.75	28.82
T_{10}	5.44	5.53	5.49	8.81	8.92	8.86	13.48	13.57	13.53	21.62	21.73	21.68	28.83	28.43	28.63
T_{11}	5.36	5.40	5.38	8.15	8.01	8.08	12.23	12.02	12.12	20.88	21.20	21.04	26.21	26.36	26.29
T_{12}	4.22	4.32	4.27	6.77	6.87	6.82	10.44	10.53	10.49	18.87	18.99	18.93	25.14	25.51	25.33
S. Em ±	0.40	0.37	0.38	0.52	0.47	0.49	0.65	0.55	0.59	0.70	0.76	0.72	1.03	1.04	0.97
C. D @5%	1.17	1.10	1.13	1.54	1.36	1.45	1.92	1.62	1.74	2.04	2.23	2.10	3.01	3.04	2.85

Table 7: Effect of integrated nutrient management treatments on extending the shelf life (days) of pomegranate fruits

Treatments	Shelf life (Days)		
	2019-20	2020-21	Pooled
T_1	21.33	20.66	21.00
T_2	25.00	25.33	25.17
T_3	25.66	25.00	25.33
T_4	30.33	30.66	30.49
T_5	25.33	25.66	25.50
T_6	23.00	23.33	23.17
T_7	28.66	29.00	28.83
T_8	33.00	33.66	33.33
T_9	24.66	24.00	24.33
T_{10}	25.33	25.00	25.17
T_{11}	30.00	30.00	30.00

T_{12}	32.33	32.00	32.17
S. Em ±	1.35	1.40	1.14
C. D @5%	3.96	4.11	3.33

Table 8: Effect of integrated nutrient management treatments on organoleptic score of pomegranate fruit during two years of the study

Treatments	Organoleptic score											
	Colour and appearance				Aril							
	Fruit		Aril		Taste		Flavor		Texture		Overall acceptability	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	6.40	6.30	6.75	6.60	7.20	7.10	7.30	7.20	7.30	7.40	6.90	6.80
T_2	7.20	7.40	7.40	7.50	7.40	7.40	7.80	7.50	7.75	7.50	7.20	7.40
T_3	7.80	7.60	8.20	8.40	7.80	7.60	8.10	8.40	8.20	8.40	8.10	8.30
T_4	7.50	7.70	8.10	8.00	7.50	7.70	7.75	7.40	7.90	7.70	7.80	7.60
T_5	7.80	7.40	7.90	7.70	7.25	7.10	7.50	7.40	8.10	8.30	7.50	7.70
T_6	7.30	7.80	7.25	7.50	6.90	6.70	7.20	7.10	7.25	7.40	7.10	7.20
T_7	8.00	8.20	8.20	8.30	8.10	8.30	8.20	8.40	8.25	8.40	8.30	8.40
T_8	8.75	8.50	8.80	8.70	8.60	8.60	8.40	8.40	8.75	8.60	8.75	8.75
T_9	6.70	6.50	6.90	6.70	6.50	6.40	6.75	6.40	7.10	7.30	6.30	6.40
T_{10}	7.10	7.20	7.40	7.60	7.00	7.20	7.10	7.30	7.25	7.20	7.10	7.30
T_{11}	8.20	8.40	8.50	8.50	8.30	8.40	8.30	8.30	8.50	8.30	8.50	8.60
T_{12}	8.60	8.70	8.70	8.80	8.50	8.70	8.40	8.50	8.60	8.60	8.70	8.80

Meanwhile, the combined application of nutrients has exerted regulatory role for enhancing the quality of fruits. The carbohydrate reserves accumulated in the leaves and stems were drawn up rapidly and heavily by the developing fruits, thus resulted in increment of sugars content as compared to other treatments. The similar results were also reported by Hazarika and Ansari (2008) [8] in banana and Osman and Abd El-Rhman (2010) [19] in fig. Chidananda *et al.* (2020) [6] reported that, the potassium and boron helps in translocation of sugars from leaves to the developing fruits and because of higher assimilating power of leaves over a long period resulted in increasing the availability of sugars in the fruits. The supporting results have also been reported by Aziz *et al.* (2017) [3], Meena *et al.* (2018) [15], Yadav *et al.* (2018) [24], Beerappa *et al.* (2019) [4], Harhash *et al.* (2019) [7] and Ibtesam *et al.* (2019) [10] in pomegranate. While, the possible reason for the attractive fruit and aril colour might be due to the foliar application of chitosan, salicylic acid, darakshak and potash fertilizers has increased the accumulation of anthocyanin content in fruit peel as well as in fruit arils which ultimately imparts attractive red colour to the fruits and arils respectively. The current results are in accordance with the study of Mirdehghana and Vatanparast (2013) [16], Khodaei *et al.* (2015) [12], Boshadi *et al.* (2018) [5], Harhash *et al.* (2019) [7], Ibtesam *et al.* (2019) [10], Khemnar *et al.* (2019) [11] and Moradinezhad *et al.* (2020) [17] in pomegranate.

The minimum fruit weight loss in T_8 might be due to the application of bio-stimulants *viz.*, chitosan, darakshak and salicylic acid will helps to reduce the respiration rate and also minimizes the loss in fruit weight by acting as a coating material on the fruit surface (Manjunatha *et al.*, 2010) [14] as well as it enhances the membrane integrity of fruits, so that the fruit rind could retain more water against the force of evaporation. Nithin *et al.* (2020) [18] observed that, the foliar application of chitosan and salicylic acid has a significant role in improving the fruit quality by enhancing the stability of cell wall of the rind tissue and enhanced its resistance to the pectic enzymes produced by fungal pathogens (fungal disease resistance) (Hernandez-Munoz *et al.*, 2006) [9], thereby reduced the postharvest diseases, weight loss and increased the shelf life of the fruits. These results are in accordance with findings of Anawal *et al.* (2016) [1] and Beerappa *et al.* (2019) [4] in pomegranate. Whereas, the reason for obtaining highest score in T_8 and T_{12} might be due to the combined application of nutrients helped in maintaining the overall quality, taste, texture and giving best visual colour appearance of fruits and arils respectively. Similar results were also obtained by Meena *et al.* (2018) [15] and Khemnar *et al.* (2019) [11] in pomegranate.

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