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Effect of different chemicals in reducing fruit cracking and improving yield and quality in Pomegranate cv. Pearl

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Abstract

Pomegranate is a drought tolerant fruit crop and is well adopted to temperate to tropical climate. Fruit cracking is a major disorder in pomegranate which causes significant monetary losses. In the present study, effect of anti-biotic (T1: Streptomycin @ 1 g/L), bio-stimulant (T_2: Isabion @ 1 ml/L) and fungicide Nativo (T_3: Tebuconazole + Trifloxystrobin @ 1 g/L) alone or in combination of the three i.e., Streptomycin + Isabion (T_4), Streptomycin + Nativo (T_5), Isabion + Nativo (T_6) and taking untreated plants as control (T_7) were applied to minimize fruit cracking disorder in Pomegranate fruit cv. Pearl. Application of treatments started two months after fruit setting in May and repeated twice during June and July every year. Spray of these chemicals influenced productivity and fruit quality parameters of Pomegranate cv. Pearl. From mean of two years data, maximum yield per plant (51.5 kg), number of fruits per plant (243), fruit weight (252 g), number of arils per fruit (504), fruit size (55 cm^2), total soluble solids (14.5 ºBrix), juice percentage (40.6%) as well as minimum number of cracked fruit (13.8), fruit cracking percentage (5.7%) and fruit acidity (0.32%) were recorded when pomegranate plants were sprayed with Streptomycin plus Nativo (each @ 1 g/L) at monthly interval from May to July. Hence, combined application of Streptomycin and Nativo could be recommended for reducing fruit cracking and improving yield and fruit quality of Pomegranate cv. Pearl in the semi-arid climate of South Punjab, Pakistan.

Keywords: Isabion, Nativo, Productivity, Pomegranate (*Punica granatum*), Streptomycin, Splitting

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Introduction

Pomegranate (*Punica granatum* L.) is classified in the family Punicaceae. It is one of the most delicious and nutritious fruits (Gunnaiah et al., 2021). Interest in pomegranate cultivation has increased (Liu et al., 2021) after recent reports of its high antioxidant content in fruit and juice, making it super fruit (Sau et al., 2021; Tozzi et al., 2021). Although pomegranate is extensively cultivated in many Mediterranean countries, but bulk of pomegranate cultivation occurs under arid and semi-arid areas of Iran facing water scarcity (Ghanbarpour et al., 2018). Pomegranate bush is moderately drought tolerant, however, under semi-arid conditions 10-35% fruit are hit by fruit cracking (Khattab et al., 2012). The cracked fruit are further attacked by many fungi or influenced by environmental, physiological and genetic factors (Galindo et al., 2014; Thomidis, 2014). World major producer and exporter of pomegranate is Iran where quality production is from arid and semi-arid climates (Sheikh & Manjula, 2012).

Pakistan produced 36.84 thousand tons pomegranate fruit over an area of 7.270 thousand hectares during 2017-18. Balochistan contributes a major share in production with 26.450 thousand tons from an area of 5.813 thousand hectares. Punjab contributes 8.339 thousand tons in production from an area of 1.259 thousand hectares, while KPK shares 2.051 thousand tons in production from an area of 0.198 thousand hectares. Area and production of pomegranate is decreasing from previous years due to some problems, categorically one of them is fruit cracking.

Fruit cracking is an alarming issue in a number of fruits and the extent of loss fluctuates under the influence of many factors. Fruit cracking is considered mainly a physiological disorder of pomegranate, which not only lowers quality of fruit but also returns substantial monetary losses to fruit growers in South Punjab (Pakistan). Cracked fruit are prone to chemical injury, infection by fungi, rapid moisture loss, shriveling and low quality. Many biotic, genetic, physiological, environmental and cultural factors are involved to cause fruit cracking (Butani et al., 2019). Cracked fruits under sunburn increase about 30-60% more fruit unmarketable (Melgarejo et al., 2004; Bakeer, 2016). Soil depleted in macro and micronutrients (boron, magnesium, potassium, zinc and calcium etc.) along with laggard field management contribute in fruit cracking (Khalil & Aly, 2013). Nutrient deficiencies are found because of leaching, exhaustive cropping and deficient organic matter in soils (Hasani et al., 2012).

Fruit cracking is controlled by different methods in Pomegranate viz application of water through drip system (Prasad et al., 2003); use of growth regulators and mineral nutrients such as Paclobutrazol (El-Khawaga, 2007), N-(2-Chloro-4-pyridyl)-N′-phenylurea (Sharma & Belsare, 2009), 2,4-D (Kumar et al., 2017), GA_3 (Singh et al., 2003; Yilmaz & Ozguven, 2009), NAA (Sharma & Singh, 2007) and nutrients (Digrase et al., 2016) like boron from borax (Ahmed, 2009), boric acid (Sheikh & Manjula, 2012; Bashir et al., 2019; Tadayon, 2021), boron with controlled systematic watering (Khalil & Aly, 2013), calcium from calcium sulfate (Lal et al., 2011), potassium from potassium nitrate and magnesium from magnesium sulfate (Bashir et al., 2019), Zinc and manganese (Hasani et al., 2012), salicylic acid + all nutrients (Ahmed et al., 2014); spray of humic acid + calcium-boron+kaolin (Ghanbarpour et al., 2018); application of bio-stimulants like cytozyme (Abubakar, et al., 2013); bagging with prgmen bags (Abou El-Wafa, 2014).

Streptomycin is an aminoglycoside antibiotic which is being used in Horticulture for bacterial disease control, particularly against fire blight in pome fruit orchards (McManus et al., 2002). Isabion is an amino acid, nutrient-based bio-stimulant, a natural biological activator which activates plant potency, regulates plant metabolizing, increases plant vigor, maximizes crop performance in terms of growth, vigor, yield and quality. It is complementary to crop nutrition and crop protection not only improving nutrient uptake and nutrient efficiency but crop defense mechanisms as well. It promotes root growth, bud development, flowering, pollination, and fruit setting resultantly improves the quantity and quality of ultimate production (Botta, 2013; Vasconcelos & Chaves, 2019). Nativo (Tebuconazole+Trifloxystrobin) is a broad-spectrum systemic triazole fungicide that is being used to treat plant pathogenic fungi. It eliminates fungi by inhibiting their ability to spread spores which slow plant growth. It provides not only disease control but also improves quality and yield of crops through protective and curative action (Ann & Mercer, 2017). Kumar (2011) revealed that spray of antibiotic (Streptocycline @ 500 ppm) + fungicide (Copper oxychloride @ 2000 ppm were effective in reducing disease incidence of bacterial blight to 25.5% when compared with control (78.5%) and increasing yield to 9.3 tons/ha compared to untreated check (2.95 tons/ha). However, information regarding the role of bio-stimulant such as Isabion, Streptomycin (anti-biotic) and Nativo (fungicide) in controlling fruit cracking of pomegranate under semi-arid conditions of South Punjab (Pakistan) is limited. Therefore, the current investigations were initiated to assess the effective role of Streptomycin, Isabion and Nativo in minimizing fruit splitting and improving productivity and quality of pomegranate fruit.

Materials and Methods

The experiment was conducted during 2018-19 and repeated during 2019-20 on 12-year-old, healthy, vigorous plants of pomegranate at experimental farm of Horticultural Research Station, Bahawalpur (Altitude 105m, Longitude 71.64°E, Latitude 29.38°N), South Punjab (Pakistan) under prevailing semi-arid and subtropical climate. The experiment was envisaged to assess the effect of antibiotic (Streptomycin), bio-stimulant (Isabion) and fungicide (Nativo) on fruit cracking as well as yield and fruit quality of pomegranate. Seven treatments were applied to 21 plants of pomegranate cv. Pearl, uniform in size, shape, vigor, planted in a square system keeping plant to plant and row to row distance of 15 feet. The experiment was laid out in randomized complete block design with seven treatments and three replications. Twenty-one plants having uniform age (10 year), size, shape and vigor, spaced in a square system (plant to plant = 15 feet and row to row = 15 feet). All plants were provided with the same inputs and field operations except treatments which were replicated thrice in randomized complete block design and applied at monthly intervals from May to July in both years. Treatments which were applied were as: T_1: Spray of Streptomycin (1 g/L), T_2: Spray of Isabion (1 ml/L), T_3: Spray of Nativo (1g/L), T_4: Spray of Streptomycin (1g/L) + Isabion (1 ml/L), T_5: Spray of Streptomycin (1 g/L) + Nativo (1 g/L), T_6: Spray of Isabion (1 ml/L) + Nativo (1 g/L) and T_7: Control.

Foliar spray of these substances was carried out two months after fruit setting (May), repeated after 30 days (June) and 60 days (July). The mixture of these chemicals was prepared by dissolving in water and sprayed with hand sprayer till run off during morning when day is shiny and mild hot to enhance effectiveness of the drugs.

Data were recorded on various productivity and quality parameters viz yield per plant (kg) which has been assessed by taking overall plant yield, number of cracked fruits per plant, number of fruits per plant, fruit cracking (%) which was estimated by counting cracked and total number of fruits by applying the following formula:

$$\text{Fruit cracking } (\%) = \frac{\text{Number of cracked fruits}}{\text{Total number of fruits}} \times 100$$

Average fruit weight (g) which was recorded by weighing 10 fruits on digital balance (SF-400A, China) and by taking their average. The other fruit quality parameters i.e., number of arils per fruit (counted and averaged from 10 fruits, fruit size (determined by taking length and width of fruit with Vernier's Caliper and multiplying the both for product as fruit size (cm^2), total soluble solids (ºBrix) was noted by Refractometer (BX-1 Atago, Japan), juice percentage was determined by taking juice weight and total weight of fruit by using following formula:

$$\text{Juice } (\%) = \frac{\text{Juice weight (g)}}{\text{Fruit weight (g)}} \times 100$$

Fruit acidity was determined from juice contents with the help of Pocket Brix-Acidity Meter (Atago, Japan).

Statistical analysis

Data were analyzed by using software Statistix 8.1 for analysis of variance (ANOVA) and differences among treatment means were compared by Duncan Multiple Range test at $p \leq 0.05$.

Results and Discussion

Foliar application of different chemicals influenced the productivity, quality parameters and minimized cracking incidence in pomegranate cv. Pearl. All chemicals i.e., Streptomycin @ 1 g/L, Isabion @ 1 ml/L and Nativo @1 g/L alone or in combination, improved the fruit yield and quality compared to untreated plants. However, a combination of chemicals was more effective as apparent from data of each year and average of two years.

Yield per plant

Mean of two years data indicated that the highest yield (51.5 kg/plant) of pomegranate was found for plants treated with combined application of Streptomycin (1g/L) with Nativo (1g/L) at monthly interval from May-July as compared to control (30.8 kg/plant) (Table 1). Combined application of Streptomycin @ 1g/L) with Isabion @ 1 ml/L (T_4) or Nativo @ 1 g/L (T_3) or Isabion @ 1 ml/L with Nativo @ 1 g/L (T_6) behaved statistically alike imparting yield 45.6, 44.0 and 43.1 kg per plant, respectively. Application of Streptomycin @ 1g/L alone (T_1) or Isabion @1 ml/L (T_2) shared statistically the same effect on yield by giving 38.0 and 36.4 kg per plant respectively (Table 1). Enhanced yield in response to spray of applied chemicals with about 23-67% increase over control might be the result of protective and curative action of Streptomycin and Nativo against diseases (McManus et al., 2002; Kumar, 2011; Thomidis, 2014; Ann & Mercer, 2017) as well as plant potency activation by Isabion (Botta, 2013; Vasconcelos & Chaves, 2019). Improved yield was noted in 2nd year (2020) as compared to 1st year (2019). Improvement in yield may be either attributed to a smaller number of cracked fruit (12.3 fruits) and minimum cracking percentage (4.9%) or a greater number of fruits per plant (250 fruits) with better individual fruit weight (255 g) during 2020 as compared with 1st year for respective parameters under T_5 during 2019. Similar trend of improvement in the case of fruit size and number of arils per fruit was noted for 2nd year as compared to previous year. All these parameters are contributory characteristics which imparted their potential to yield after improvement in themselves under the influence of applied chemicals.

Table 1 Effect of Streptomycin, Isabion and Nativo on yield per plant (kg) of Pomegranate during 2019 and 2020

Treatments	Yield per plant (kg)		
	2019 (Mean ± SD)	2020 (Mean ± SD)	Average (2 years) (Mean ± SD)
T_1 = Streptomycin @ 1 g/L)	$37.0^b \pm 0.69$	$38.9^c \pm 2.06$	$38.0^c \pm 1.37$
T_2 = Isabion @ 1 ml/L	$35.6^c \pm 1.26$	$37.1^c \pm 2.79$	$36.4^c \pm 2.03$
T_3 = Nativo @ 1 g/L	$40.3^b \pm 0.66$	$47.6^b \pm 1.49$	$44.0^b \pm 1.08$
T_4 = Streptomycin @ 1 g/L + Isabion @ 1 ml/L	$39.8^b \pm 0.45$	$51.4^{ab} \pm 3.04$	$45.6^b \pm 1.75$
T_5 = Streptomycin @ 1 g/L) + Nativo @ 1 g/L	$47.6^a \pm 3.64$	$55.3^a \pm 4.64$	$51.5^a \pm 4.14$
T_6 = Isabion @ 1 ml/L) + Nativo @ 1 g/L	$40.8^b \pm 0.86$	$45.4^b \pm 0.59$	$43.1^b \pm 0.73$
T_7 = Control (un-treated)	$29.7^d \pm 3.67$	$31.9^d \pm 4.92$	$30.8^d \pm 4.29$

Comparison of means by DMR test at $p \leq 0.05$; Means sharing similar letter (s) in a column are statistically non-significant; Values after ± sign indicate standard deviation.

Number of cracked fruits per plant

From mean of two-year data the minimum number of cracked fruits (13.8) was recorded from plants sprayed with treatment T_5 (Streptomycin + Nativo each @ 1g/L), followed by T_3 (Nativo @1g/L) with 16.7 fruits (Table 2). T_3 further shared statistical similarity with T_4 (Streptomycin @1g/L + Isabion @1ml/L) with 19.8 cracked fruits per plant. Similarly, effect of T_6 (Isabion @1ml/L with Nativo @1g/L) with 24.4 fruits and T_1 (Streptomycin @1g/L) with 28.7 fruits was at par, and that of T_1 and T_2 (Isabion @1ml/L) with 31.8 fruits was also statistically same. Maximum number of cracked fruit (40.7 fruits) was recorded in plants treated as control (T_7) (Table 2). Delay in picking of ripe fruit for a longer period or attack of disease may add to fruit cracking in pomegranate (Hoda & Hoda, 2013). Reduction in cracked fruit by Isabion (amino acid) can be explained as being a bio-stimulant, it is a biological activator which might activate plant potency and regulate plant metabolism against fruit cracking (Abubakar et al., 2013). Water-soaked lesions, followed by small cracks and fruit splitting due to bacterial blight as well as fungal infection (Petersen et al., 2010) which was being controlled by antibiotic (Streptomycin/ Streptocycline) and fungicide (Copper oxychloride) as reported previously (Kumar, 2011; Lokesh et al., 2014; Naz et al., 2018). Hence, reduction in cracked fruit might be due to the protective role of Nativo fungicide and Streptomycin antibiotic (McManus et al., 2002; Ann & Mercer, 2017). Similarly, the least percentage of fruit rots was reported by pre-storage application of tebuconazole or thiophanate methyl in pomegranate cv. Wonderful (Thomidis, 2014).

Table 2 Effect of Streptomycin, Isabion and Nativo on number of cracked fruits per plant during 2019 and 2020

Treatments	Number of cracked fruits per plant		
	2019 (Mean ± SD)	2020 (Mean ± SD)	Average (2 years) (Mean ± SD)
T_1 = Streptomycin @ 1 g/L)	$28.3^{c} \pm 0.80$	$29.0^{b} \pm 2.08$	$28.7^{bc} \pm 1.44$
T_2 = Isabion @ 1 ml/L	$36.3^{b} \pm 4.07$	$27.3^{b} \pm 1.39$	$31.8^{b} \pm 2.73$
T_3 = Nativo @ 1 g/L	$18.7^{e} \pm 3.11$	$14.7^{d} \pm 3.76$	$16.7^{de} \pm 3.43$
T_4 = Streptomycin @ 1 g/L + Isabion @ 1 ml/L	$21.3^{d} \pm 2.05$	$18.3^{c} \pm 2.29$	$19.8^{d} \pm 2.17$
T_5 = Streptomycin @ 1 g/L) + Nativo @ 1 g/L	$15.3^{f} \pm 4.50$	$12.3^{d} \pm 4.74$	$13.8^{e} \pm 4.62$
T_6 = Isabion @ 1 ml/L) + Nativo @ 1 g/L	$22.7^{d} \pm 1.48$	$26.0^{b} \pm 0.86$	$24.4^{c} \pm 0.31$
T_7 = Control (un-treated)	$41.7^{a} \pm 6.27$	$39.7^{a} \pm 6.45$	$40.7^{a} \pm 6.36$

Comparison of means by DMR test at $p \leq 0.05$; Means sharing similar letter (s) in a column are statistically non-significant; Values after ± sign indicate standard deviation.

Number of fruits per plant

Two years pooled data of number of fruits per plant showed that all the applied substances increased the number of fruit per plant and the maximum one (243) was recorded from plants treated with T_5 (Streptomycin + Nativo each at 1 g/L) followed by T_4 (Streptomycin @ 1 g/L + Isabion @ 1 ml/L) with 234 fruits, T_6 (Isabion @ 1 ml/L + Nativo @ 1 g/L) with 233 fruit, T_1 (Streptomycin @ 1 g/L) with 231 fruit and T_3 (Nativo @ 1 g/L) with 230 fruit per plant respectively (Table 3). The latter four treatments were statistically at par. T_2 (Isabion @ 1 ml/L) had 226 fruit per plant and it shared statistical similarity with T_3 and T_1. The lowest number of fruits per plant (197) was recorded in un-sprayed plants (T_7) (Table 3). About 15% (T_2) to 23% (T_5) increase in number of fruits per plant as compared to control plants could be definite role of Isabion bio-stimulant which regulated plant metabolism and promoted flowering, pollination, fruit setting and number of fruits per plant as well for ultimate production (Abubakar et al., 2013; Botta, 2013). More number of fruits in response to spray of antibiotic, fungicide and bio-stimulant can be related to escape of healthy fruits from disease attack in terms of fruit retention on tree till harvest through curative, protective and invigorating action of these chemicals on plant physiology (McManus et al., 2002; Thomidis, 2014; Ann & Mercer, 2017; Vasconcelos & Chaves, 2019).

Table 3 Effect of Streptomycin, Isabion and Nativo on number of fruits per plant during 2019 and 2020

Treatments	Number of fruits per plant		
	2019 (Mean ± SD)	2020 (Mean ± SD)	Average (2 years) (Mean ± SD)
T_1 = Streptomycin @ 1 g/L)	$226^{b} \pm 1.75$	$235^{b} \pm 0.64$	$231^{bc} \pm 1.20$
T_2 = Isabion @ 1 ml/L	$224^{b} \pm 0.93$	$228^{c} \pm 2.22$	$226^{c} \pm 0.64$
T_3 = Nativo @ 1 g/L	$222^{b} \pm 0.12$	$238^{b} \pm 1.87$	$230^{bc} \pm 0.99$
T_4 = Streptomycin @ 1 g/L + Isabion @ 1 ml/L	$225^{b} \pm 1.34$	$242^{b} \pm 3.50$	$234^{b} \pm 2.42$
T_5 = Streptomycin @ 1 g/L) + Nativo @ 1 g/L	$236^{a} \pm 5.83$	$250^{a} \pm 6.77$	$243^{a} \pm 6.30$
T_6 = Isabion @ 1 ml/L) + Nativo @ 1 g/L	$229^{ab} \pm 2.97$	$237^{b} \pm 1.46$	$233^{b} \pm 2.22$
T_7 = Control (un-treated)	$190^{c} \pm 12.95$	$204^{d} \pm 12.01$	$197^{d} \pm 12.48$

Comparison of means by DMR test at $p \leq 0.05$; Means sharing similar letter (s) in a column are statistically non-significant; Values after ± sign indicate standard deviation.

Fruit cracking percentage

Mean of two-year data indicated the minimum fruit cracking (5.7%) significantly from the plants sprayed by T_5 (Streptomycin + Nativo each at 1 g/L), followed by T_3 (Nativo @ 1 g/L) with 7.9% and T_4 (Streptomycin @ 1 g/L + Isabion @ 1 ml/L) with 8.7% cracked fruit (Table 4). The latter two treatments were statistically similar and T_4 further exhibited similarity to T_6 (Isabion @ 1 ml/L + Nativo @ 1 g/L) with 10.5% fruit cracking and T_6 remained same in effect to that of T_1 (Streptomycin @ 1 g/L) with 12.4% fruit cracking and T_1 remained alike in effect with T_2 (Isabion @ 1 ml/L) that had 14.1% fruit cracking. Plants under control expressed the highest fruit cracking (20.8%) (Table 4). A significant reduction in fruit cracking percentage was observed by all treatments compared to un-sprayed plants. The decreased fruit cracking may be due to the smaller number of cracked fruit and a greater number of healthy fruits under the influence of applied substances individually or in combination with each other. All supporting arguments under the parameters 'number of cracked fruits' and 'number of fruits per plant' can be endorsed for the parameter of fruit cracking percentage. Effect of bactericides and fungicides against bacterial and fungal diseases as well as in reduction of fruit splitting disorder is well documented (McManus et al., 2002; Kumar, 2011; Lokesh et al., 2014; Naz et al., 2018; Ann & Mercer, 2017). Further boosting in reduction of fruit cracking could be attributed to crop improvement by Isabion (bio-stimulant) as application of bio-stimulants like Cytozyme reduced fruit cracking (Abubakar et al., 2013).

Table 4 Effect of Streptomycin, Isabion and Nativo on fruit cracking percentage during 2019 and 2020

Treatments	Fruit cracking percentage		
	2019 (Mean ± SD)	2020 (Mean ± SD)	Average (2 years) (Mean ± SD)
T_1 = Streptomycin @ 1 g/L)	$12.5^{c} \pm 0.15$	$12.3^{b} \pm 0.66$	$12.4^{bc} \pm 0.40$
T_2 = Isabion @ 1 ml/L	$16.2^{b} \pm 1.66$	$12.0^{b} \pm 0.54$	$14.1^{b} \pm 1.10$
T_3 = Nativo @ 1 g/L	$8.4^{de} \pm 1.53$	$7.3^{c} \pm 1.38$	$7.9^{c} \pm 1.46$
T_4 = Streptomycin @ 1 g/L + Isabion @ 1 ml/L	$9.5^{d} \pm 1.08$	$7.8^{c} \pm 1.18$	$8.7^{de} \pm 1.13$
T_5 = Streptomycin @ 1 g/L) + Nativo @ 1 g/L	$6.5^{e} \pm 2.30$	$4.9^{d} \pm 2.36$	$5.7^{f} \pm 2.33$
T_6 = Isabion @ 1 ml/L) + Nativo @ 1 g/L	$9.9^{d} \pm 0.92$	$11.0^{b} \pm 0.13$	$10.5^{cd} \pm 0.39$
T_7 = Control (un-treated)	$22.0^{a} \pm 4.02$	$19.5^{a} \pm 3.60$	$20.8^{a} \pm 3.81$

Comparison of means by DMR test at $p \leq 0.05$; Means sharing similar letter (s) in a column are statistically non-significant; Values after ± sign indicate standard deviation.

Fruit weight

Data averaged over two years exhibited the heaviest fruit weight (252g) in fruits from plants treated with T_5 (Streptomycin + Nativo each @ 1g/L) significantly. T_3 (Nativo @ 1 g/L) ranked 2nd with 243 g fruit weight, followed by T_4 (Streptomycin @ 1 g/L + Isabion @ 1 ml/L) with 241 g, T_1 (Streptomycin @ 1 g/L) with 235 g and T_2 (Isabion @1ml/L) with 231g (Table 5). All the four treatments remained statistically similar. The lightest fruit weight (210 g) in fruits from plants treated as control (T_7). The trend was almost the same regarding fruit weight during 2 years (2019 & 2020) as apparent from Table 5. It is reported earlier by a number of researchers that chemicals which are effective in reducing fruit cracking, also effective in improving fruit weight (Khayyat et al., 2012; Hoda & Hoda, 2013; Ghanbarpour et al., 2018).

Table 5 Effect of Streptomycin, Isabion and Nativo on single fruit weight (g) during 2019 and 2020

Treatments	Single fruit weight (g)		
	2019 (Mean ± SD)	2020 (Mean ± SD)	Average (2 years) (Mean ± SD)
T_1 = Streptomycin @ 1 g/L)	$229^{bc} \pm 0.17$	$240^{b} \pm 0.23$	$235^{b} \pm 0.20$
T_2 = Isabion @ 1 ml/L	$224^{c} \pm 1.87$	$237^{b} \pm 0.99$	$231^{b} \pm 1.43$
T_3 = Nativo @ 1 g/L	$238^{b} \pm 3.85$	$248^{b} \pm 3.50$	$243^{b} \pm 3.67$
T_4 = Streptomycin @ 1 g/L + Isabion @ 1 ml/L	$230^{b} \pm 3.03$	$246^{b} \pm 2.68$	$241^{b} \pm 2.86$
T_5 = Streptomycin @ 1 g/L) + Nativo @ 1 g/L	$248^{a} \pm 7.93$	$255^{a} \pm 6.36$	$252^{a} \pm 7.14$
T_6 = Isabion @ 1 ml/L) + Nativo @ 1 g/L	$220^{c} \pm 3.50$	$235^{b} \pm 1.81$	$228^{c} \pm 2.65$
T_7 = Control (un-treated)	$205^{d} \pm 9.62$	$215^{c} \pm 9.97$	$210^{d} \pm 9.80$

Comparison of means by DMR test at $p \leq 0.05$; Means sharing similar letter (s) in a column are statistically non-significant; Values after ± sign indicate standard deviation.

Fruit size

Maximum fruit size (55cm^2) was obtained by fruits from plants sprayed with T_5 (Streptomycin + Nativo each @ 1g/L), proceeded by T_4 (Streptomycin @ 1 g/L + Isabion @ 1 ml/L) with 50 cm^2 fruit size. Both treatments were statistically alike. T_4 further shared similarity with T_3 (Nativo @ 1 g/L) with 47 cm^2 and T_1 (Streptomycin @ 1 g/L) with 45cm^2 fruit size respectively (Table 6). T_1 was also at par with T_2 (Isabion @ 1 ml/L) that showed 43 cm^2 fruit size and with T_6 (Isabion @1ml/L + Nativo @ 1 g/ L) that had 44cm^2 fruit size. T_4 further shared similarity with T_3 ((Nativo @1g/L) with 47cm^2 and T_1 (Streptomycin @1g/L) with 45cm^2 fruit size respectively. T_1 was also at par with T_2 ((Isabion @1ml/L) that showed 43cm^2 fruit size and with T_6 (Isabion @ 1 ml/L + Nativo @ 1 g/L) that had 44cm^2 fruit size. T_3 further shared similarity with T_1 (45 cm^2). Similarly, the effect of $T_{1,}$ T_6 (44 cm^2) and T_2 (43 cm^2) was the same on the parameter and T_2 remained at par with T_7 (36cm^2) taken as control. Previously, it was reported that substances playing a role in reduction of fruit cracking definitely improved fruit size (Khattab et al., 2012; Khalil and Aly, 2013; Ghanbarpour et al. 2018). Kishor et al., (2017) recorded maximum fruit weight and fruit length with foliar spray of 15 ppm 2, 4-D and maximum fruit diameter with 75 ppm NAA as compared to control because bio regulators and chemicals significantly improved the physical parameters of the pomegranate fruits as endogenous hormones and their balance play a modulating role in the mobilization of nutrients to the developing organs by influencing the longevity of fruit bud. The dependence of abscission relative to the endogenous content of auxins has been proven by exogenous application of bio regulators, as the transportation of auxins by the plant lasts for a long time without ethylene appearing to affect it.

Table 6 Effect of Streptomycin, Isabion and Nativo on fruit size (cm^2) during 2019 and 2020

Treatments	Fruit size (cm^2)		
	2019 (Mean ± SD)	2020 (Mean ± SD)	Average (2 years) (Mean ± SD)
T_1 = Streptomycin @ 1 g/L)	$43^{bc} \pm 0.58$	$46^{b} \pm 0.29$	$45^{bc} \pm 0.44$
T_2 = Isabion @ 1 ml/L	$41^{c} \pm 1.40$	$45^{b} \pm 0.70$	$43^{c} \pm 1.05$
T_3 = Nativo @ 1 g/L	$45^{bc} \pm 0.23$	$48^{bc} \pm 0.52$	$47^{bc} \pm 0.38$
T_4 = Streptomycin @ 1 g/L + Isabion @ 1 ml/L	$49^{ab} \pm 1.87$	$51^{ab} \pm 1.75$	$50^{ab} \pm 1.81$
T_5 = Streptomycin @ 1 g/L) + Nativo @ 1 g/L	$53^{a} \pm 3.50$	$57^{a} \pm 4.20$	$55^{a} \pm 3.85$
T_6 = Isabion @ 1 ml/L) + Nativo @ 1 g/L	$46^{bc} \pm 0.64$	$42^{cd} \pm 1.92$	$44^{c} \pm 0.64$
T_7 = Control (un-treated)	$34^{d} \pm 4.25$	$38^{d} \pm 3.56$	$36^{d} \pm 3.91$

Comparison of means by DMR test at $p \leq 0.05$; Means sharing similar letter (s) in a column are statistically non-significant; Values after ± sign indicate standard deviation.

Number of arils per fruit

Two years pooled data of number of arils per fruit showed that all the applied substances increased the number of arils per fruit and the maximum arils (504) were obtained from plants treated with T_5 (Streptomycin + Nativo each at 1g/L) (Table 7). T_3 (Nativo @1g/L) ranked 2nd with 464 arils per fruit followed by T_4 (Streptomycin @1g/L + Isabion @1ml/L) with 459 arils, both were statistically similar and further shared similarity with T_6 (Isabion @1ml/L + Nativo @1g/L) with 451 arils and T_1 (Streptomycin @1g/L) with 442 arils per fruit. The latter (T_1) also remained at par with T_2 (Isabion @1ml/L) that had 438 arils per fruit as well as at par with T_6 (451 arils) respectively. The minimum number of arils per fruit (406) was noted in un-sprayed plants (T_7) (Table 7). About 8% (T_2) to 24% (T_5) increase in number of arils per fruit in comparison with control plants indicated the pivotal impact of Isabion bio-stimulant on plant metabolism which might regulated and boosted flowering, pollination, fruit setting and arils formation in fruits per plant as well as fruit weight, size and juice contents ultimately led to high productivity (Abubakar et al., 2013; Botta, 2013). More number of arils per fruit in response to spray of antibiotic, fungicide and bio-stimulant might be due to control of diseases in healthy plants from attack of fungal and bacterial diseases which might helped fruit retention on tree till harvest through protective, curative and boosting action on plant physiology by the chemicals applied in the experiment (McManus et al., 2002; Thomidis, 2014; Ann & Mercer, 2017; Vasconcelos & Chaves, 2019).

Table 7 Effect of Streptomycin, Isabion and Nativo on number of arils per fruit during 2019 and 2020

Treatments	Number of arils per fruit		
	2019 (Mean ± SD)	2020 (Mean ± SD)	Average (2 years) (Mean ± SD)
T_1 = Streptomycin @ 1 g/L)	$436^{bc} \pm 3.62$	$448^{bc} \pm 4.55$	$442^{bc} \pm 4.08$
T_2 = Isabion @ 1 ml/L	$434^{c} \pm 4.43$	$442^{c} \pm 7.00$	$438^{c} \pm 5.72$
T_3 = Nativo @ 1 g/L	$456^{b} \pm 4.55$	$472^{b} \pm 5.25$	$464^{b} \pm 4.90$
T_4 = Streptomycin @ 1 g/L + Isabion @ 1 ml/L	$452^{b} \pm 2.92$	$466^{b} \pm 2.80$	$459^{b} \pm 2.86$
T_5 = Streptomycin @ 1 g/L) + Nativo @ 1 g/L	$496^{a} \pm 20.88$	$512^{a} \pm 21.58$	$504^{a} \pm 21.23$
T_6 = Isabion @ 1 ml/L) + Nativo @ 1 g/L	$444^{bc} \pm 0.35$	$458^{bc} \pm 0.47$	$451^{bc} \pm 0.41$
T_7 = Control (un-treated)	$396^{d} \pm 19.95$	$416^{d} \pm 17.61$	$406^{d} \pm 18.78$

Comparison of means by DMR test at $p \leq 0.05$; Means sharing similar letter (s) in a column are statistically non-significant; Values after ± sign indicate standard deviation.

Total soluble solids

Average of two years data showed that spray of Streptomycin @ 1g/L + Nativo @ 1g/L (T_5) produced maximum total soluble solids (14.5°Brix), spray of Nativo @ 1g/L (T_3) ranked 2nd with 14.0 °Brix (Table 8). Both were statistically similar. The latter further shared similarity with T_6 (13.6 °Brix) and T_4 (13.5 °Brix). T_4 was similar to T_2 (13.1 °Brix) and T_2 was similar to T_1 (12.7 °Brix). Minimum TSS (12.2 °Brix) was noted in fruits from un-sprayed plants and it had statistically the same effect as was noted in T_1. Application of chemicals (Bioregulators, bio-stimulants, nutrients etc.) and protective pesticides (antibiotics, fungicides etc.) not only reduce fruit cracking but also improve fruit total soluble solids due to stimulatory properties as well as curative action against biotic and abiotic stresses (Sharma & Belsare, 2009; Digrase et al., 2016, Ghanbarpour et al. 2018). Abu El-Wafa (2014) recorded the lowest fruit cracking (1%) in pomegranate fruits bagged with prgmen bags and the same fruit also had the maximum TSS (16 °Brix). So, reduction in fruit cracking in response to a treatment application may also improve fruit TSS by the same treatment.

Table 8 Effect of Streptomycin, Isabion and Nativo on total soluble solids (°Brix) during 2019 and 2020

Treatments	Total soluble solids (°Brix)		
	2019 (Mean ± SD)	2020 (Mean ± SD)	Average (2 years) (Mean ± SD)
T_1 = Streptomycin @ 1 g/L)	$12.5^{d} \pm 0.27$	$12.8^{de} \pm 0.29$	$12.7^{de} \pm 0.28$
T_2 = Isabion @ 1 ml/L	$12.9^{cd} \pm 0.11$	$13.2^{cd} \pm 0.12$	$13.1^{cd} \pm 0.12$
T_3 = Nativo @ 1 g/L	$13.8^{ab} \pm 0.26$	$14.1^{ab} \pm 0.24$	$14.0^{ab} \pm 0.25$
T_4 = Streptomycin @ 1 g/L + Isabion @ 1 ml/L	$13.3^{bc} \pm 0.05$	$13.6^{bc} \pm 0.04$	$13.5^{bc} \pm 0.05$
T_5 = Streptomycin @ 1 g/L) + Nativo @ 1 g/L	$14.3^{a} \pm 0.46$	$14.7^{a} \pm 0.49$	$14.5^{a} \pm 0.48$
T_6 = Isabion @ 1 ml/L) + Nativo @ 1 g/L	$13.5^{bc} \pm 0.13$	$13.7^{bc} \pm 0.08$	$13.6^{bc} \pm 0.11$
T_7 = Control (un-treated)	$11.9^{e} \pm 0.52$	$12.4^{e} \pm 0.45$	$12.2^{e} \pm 0.48$

Comparison of means by DMR test at $p \leq 0.05$; Means sharing similar letter (s) in a column are statistically non-significant; Values after ± sign indicate standard deviation.

Juice percentage

The highest juice percentage (40.6%) was noted in juice of fruits from plants sprayed with T_5, T_3 ranked 2nd with juice percentage (38.2%) that remained at par with T_4 (37.8%), T_6 (37.3%) and T_2 (36.7%) that showed further similarity with T_1 (34.7%) (Table 9). The lowest juice percentage (30.8%) was noted in fruits from plants under control. Ghanbarpour et al. (2018) noticed the minimum fruit cracking (1.63%) by foliar application of 5 ml per liter humic aid and obtained the maximum juice content (45.92%) by the same treatment because organic supplements e.g., humic acid and Isabion as applied in our study; are being used to regulate hormone levels, nutritional uptake and stress tolerance ultimately improved fruit productivity and quality parameters like juice percentage (Khattab et al., 2012). Yilmaz and Ozguven (2009) reduced fruit cracking in pomegranate (1.9%) by applying 100mg per liter GA^3 and by the same time increased juice percentage (42.9%) under the same bioregulator.

Table 9 Effect of Streptomycin, Isabion and Nativo on juice percentage during 2019 and 2020

Treatments	Juice percentage		
	2019 (Mean ± SD)	2020 (Mean ± SD)	Average (2 years) (Mean ± SD)
T_1 = Streptomycin @ 1 g/L)	$33.6^{d} \pm 0.75$	$35.7^{c} \pm 0.82$	$34.7^{c} \pm 0.79$
T_2 = Isabion @ 1 ml/L	$35.6^{c} \pm 0.06$	$37.8^{b} \pm 0.03$	$36.7^{bc} \pm 0.05$
T_3 = Nativo @ 1 g/L	$37.6^{ab} \pm 0.88$	$38.8^{b} \pm 0.44$	$38.2^{b} \pm 0.66$
T_4 = Streptomycin @ 1 g/L + Isabion @ 1 ml/L	$36.5^{bc} \pm 0.43$	$39.1^{b} \pm 0.57$	$37.8^{b} \pm 0.50$
T_5 = Streptomycin @ 1 g/L) + Nativo @ 1 g/L	$38.9^{a} \pm 1.41$	$42.3^{a} \pm 1.87$	$40.6^{a} \pm 1.64$
T_6 = Isabion @ 1 ml/L) + Nativo @ 1 g/L	$37.1^{ab} \pm 0.68$	$37.5^{b} \pm 0.09$	$37.3^{b} \pm 0.29$
T_7 = Control (un-treated)	$28.8^{e} \pm 2.71$	$32.8^{d} \pm 2.00$	$30.8^{d} \pm 2.36$

Comparison of means by DMR test at $p \leq 0.05$; Means sharing similar letter (s) in a column are statistically non-significant; Values after ± sign indicate standard deviation.

Fruit acidity

The lowest fruit acidity (0.32%) was recorded from fruits sprayed with T_5, followed by T_3 (0.33%) that was statistically similar to T_1 (0.34%), T_4 (0.34%) & T_6 (0.35%) and T_6 (0.35%) was further alike to T_2 (0.37%). The highest fruit acidity (0.38%) was in fruits from untreated plants and it was the same in effect with that of T_2 (Table 10). The results corroborate the fact that factors reducing fruit cracking may decrease fruit acidity as Abu El-Wafa (2014) noted the highest fruit cracking (10%) of pomegranate fruit in response to bagging with plastic bags and the same fruit also possessed the highest fruit acidity (1.62-1.65%). While fruit with minimum cracking (1%) in response to bags covering, also had the lower fruit acidity (1.25-1.27%).

Table 10 Effect of Streptomycin, Isabion and Nativo on acidity percentage during 2019 and 2020

Treatments	Acidity percentage		
	2019 (Mean ± SD)	2020 (Mean ± SD)	Average (2 years) (Mean ± SD)
T_1 = Streptomycin @ 1 g/L)	$0.36^{b} \pm 0.006$	$0.32^{ef} \pm 0.002$	$0.34^{c} \pm 0.005$
T_2 = Isabion @ 1 ml/L	$0.38^{a} \pm 0.008$	$0.36^{ab} \pm 0.006$	$0.37^{ab} \pm 0.007$
T_3 = Nativo @ 1 g/L	$0.34^{bc} \pm 0.004$	$0.33^{de} \pm 0.003$	$0.33^{cd} \pm 0.003$
T_4 = Streptomycin @ 1 g/L + Isabion @ 1 ml/L	$0.35^{bc} \pm 0.005$	$0.34^{bc} \pm 0.004$	$0.34^{c} \pm 0.004$
T_5 = Streptomycin @ 1 g/L) + Nativo @ 1 g/L	$0.33^{c} \pm 0.010$	$0.31^{f} \pm 0.010$	$0.32^{d} \pm 0.010$
T_6 = Isabion @ 1 ml/L) + Nativo @ 1 g/L	$0.36^{b} \pm 0.006$	$0.34^{cd} \pm 0.004$	$0.35^{b} \pm 0.005$
T_7 = Control (un-treated)	$0.39^{a} \pm 0.010$	$0.37^{a} \pm 0.009$	$0.38^{a} \pm 0.010$

Comparison of means by DMR test at $p \leq 0.05$; Means sharing similar letter (s) in a column are statistically non-significant; Values after ± sign indicate standard deviation.

Conclusion

Combined application of Streptomycin (bactericide) and Nativo (fungicide) each @ 1g/L at monthly intervals from May-July significantly decreased the fruit cracking incidence and improved the fruit quality parameters in Pomegranate cv. Pearl. Hence, it is advisable to apply a combination of Streptomycin with Nativo (each at 1g/L) at monthly intervals from May-July to minimize fruit cracking and improve fruit quality in Pomegranate.

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