Effect of NAA and $ZnSO_4$ on Cracking and Chemical properties of Litchi Fruits

ABSTRACT:

An experiment was carried out in the Garden, Department of Fruit Science, C.S. Azad University of Agriculture and Technology, Kanpur (U.P.) during two subsequent years *i.e.,* 2022 and 2023 to assess the effect of NAA and ZnSo4 on cracking and chemical quality parameters of litchi fruits. The study consisted of 16 treatments including four levels of NAA (0, 25, 50 and 75 ppm), zinc sulphate (0, 0.2, 0.4 and 0.6%), and their combinations which were applied in Factorial-CRD. The foliar application of treatments was done on January 28 and March 16 of both years *i.e.,* in 2022 and 2023, before flowering and fruit setting at pea stage on 63-year-old pants of cv. Rose Scented. The results of the experiment showed that plants treated withthe combination of NAA @ 50ppm and zinc sulphate @0.4% resulted in the significantly lowest number of crackedfruit (1.23 and 1.19) and fruit cracking percent (6.31 and 6.15%) with significant improvement in chemical quality parameters of fruit *i.e.,*juice content (63.63 and 64.22%), TSS (18.09 and 18.38^{0}Brix), total sugars (15.96 and 16.30%), titratable acidity (1.32 and 1.28%), TSS: acid ratio (13.67 and 14.31), sugar: acid ratio (12.04 and 12.66), ascorbic acid (41.22 and 41.64 mg/100g pulp) and organoleptic taste (83.36 and 82.82) during both years of investigations in the plains of northern India.

Keywords: Litchi, NAA,Zinc sulphate,Fruit cracking,and Chemical quality.

1.0 INTRODUCTION

Litchi (*Litchi chinensis* Sonn.) is animportant subtropical evergreen fruit crop belonging to the family Sapindaceae. It is a nut type of fruit that is grown commercially to a limited extent in Bihar, Uttarakhand, Assam, West Bengal, Orissa, Tripura, Himachal Pradesh, and in sub-mountainous districts of Uttar Pradesh**(Gautam *et al.* 2021).**The edible part of litchi is juicy aril which is sour and quite sweet when dried.

Litchi is a delicious and luscious fruit that has a pretty red colour, sweet aroma, and good flavour. The flavour of new fruit mash is musky and when dried, it has a harsh taste and is extremely sweet. It is handled into juice, wine, pickles, jam, jam, frozen yogurt and yogurt *etc.*(Nand et al. 2023).

Over the years, plant growth regulators (PGRs) and micronutrients have reliably supported the litchi growers by giving an excellent financial returnon litchi production by impacting plant growth, fruiting behavior, and quality of fruits. The micronutrients and PGRs emphatically influence the yield and quality of litchi fruit, enhancedflowering, fruit set, and retention. The best concentrations of micronutrients encourage plant growth, boost yield, reduce cracking,and enhance fruit quality. For specific and fast micronutrient requirements, foliar applications are very necessary. Fruit cracking and splitting during the fruiting season when extremely dry and harsh winds blow. The cracked fruit rots quickly and has no selling value. The problem of cracking is considered the main obstacle to the expansion of the litchi growing area.Zinc assumes a critical part in plant metabolic activities, going about as a metal activator for enzymes and impacting RNA and ribosome content. Fruit quality changes as a result of Auxin's significant effects on respiration, photosynthesis, and osmotic pressure. Keeping these in view, an experiment was planted to assess the effect of NAA and ZnSo4 on the cracking and chemical quality of litchi fruits in the plains of north India. ?

2.0 MATERIALSAND METHODS

The litchi trees in the Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur were well-maintained and approximately 63 years old. Sixteen litchi cv. Rose Scented plants were chosen for the study in 2022 and 2023.During the entire duration of the investigation, the whole orchard was kept under clean cultivation, and uniform practices were applied to all plants. A Factorial Completely Randomized Design with three replications and sixteen treatments was used, includingfour levels each of NAA (0, 25, 50 and 75 ppm) and zinc sulphate (0, 0.2, 0.4 and 0.6%) and their combinations were sprayed twice *i.e.*, before flowering (28 January) and at pea stage (16 March) during both the years. Three branches in uniform growth and vigour were selected on each tree for documentation of various parameters.

Data was collected regarding the cracking and chemical-quality parameters. The quantity of cracked fruits was tallied post-harvest during the fruit cleaning process and documented accordingly. Total soluble solids (TSS) were measured with the help of an Erma hand refractometer with the extracted juice and measured. The total sugars, ascorbic acid, and titratable acidity contents were determined by the techniques recommended in AOAC (1980). The organoleptic rating was recorded using a panel of five judges based on various quality attributes and marks were allotted out of 100 points scale for the sweetness, sourness, size, and appearance of fruits, while the sugar: acid ratio was calculated by dividing the sugar values by the titratable acidity values across both years of the study.

3.0 RESULTS AND DISCUSSION

3.1 Fruit cracking: Foliar use of NAA at different concentrations had an impact on fruit cracking and its 50ppm concentration greatly the reduced minimum number of fruit cracking (1.51 and 1.48) and fruit cracking percent (7.82 and 7.55%) were recorded which were harvested from the plants which were treated with NAA @ 50ppm closely followed by 1.78 and 1.76 number and 9.08 and 8.80% from NAA @75ppm,whereas, the maximum number of fruit cracking (2.94 and 2.97) and fruit cracking percent (9.08 and 8.80%) was recorded which were produced from the plants kept under control without any application.The application of auxin might have increased the osmotic pressure of the cell sap, which will induce water uptake and reduce the cracking percentage in fruits. The finding is by the reports of Kumar et al., (2023) Kaur (2017); Chauhan et al., (2019) in litchi.

Further observation of the data presented in Fig. 1 and 2 shows that the minimum fruit cracking (1.98 and 1.94) and fruit cracking percent (10.35 and 10.76%) were noted in fruits that were harvested from the plants treated withzinc sulphate @ 0.6%, closely followed by 2.00 and 2.00 number of cracked fruits and 11.23 and 11.43%of from zinc sulphate @ 0.4% treated plants. The maximum fruit cracking number (2.41 and 2.41) and fruit cracking percent (13.76 and 13.79%) were recorded under control. It has been demonstrated in the past that a zinc deficiency results in interveinal chlorosis of older leaves, which distorts the shape and appearance of fruits as well as leaves and encourages fruit cracking in Litchi. However, in the current investigation, zinc application reduced the physiological disorder, which ultimately led to fruit cracking in Litchi fruits. The finding is by the reports of Saraswat et al., (2006) and Kumar et al., (2023) Kaur (2017); Chauhan et al. (2019), and Gupta et al., (2022)in litchi.

When the interaction effect among various concentrations of NAA and zinc sulfate were compared (Fig. 1 and Fig. 2), the minimum number (1.23 and 1.19) and percent (6.31 and 6.15%) were recorded in fruits which were harvested from the plants treated with the combination of NAA @50ppm + zinc sulphate@ 0.4% closely followed by 1.51 and 1.47 and 7.56 and 7.18% fruit cracking from treatment N_2Z_3, whereas, the plants kept under control produced fruits having maximum number 3.42 and 3.39and21.78 and 22.23% ofcracked fruits during both the years of experimentation. The cellulose, hemicellulose and pectin, which produce cell enlargement by decreasing the wall pH, so that wall loosening and growth occur, auxin has been found to cause cell wall plasticization. This physiological effect of auxin may therefore reduce the cracking of fruit these findings of present experimentation greatly support the observation of Sahay et al., (2018), Saraswat et al., (2006) and Chauhan et al., (2019), and Kumar et al., (2023) in litchi.

3.2 Juice Content: The juice content of fruits was significantly influenced by NAA and zinc sulphate application compared to the control. Fruits derived from plants treated with 0.6% zinc sulphate exhibited a higher juice content of 58.47% and 59.14%, compared to fruits from plants treated with 0.4% zinc sulphate, which had juice contents of 58.46% and 59.04%. In contrast, fruits from control plants without any treatment had the lowest juice content of 56.77% and 57.40%. An adequate amount of zinc improves the auxin content and it also acts as a catalyst in the oxidation process which might increase the juice content in fruits. These findings are in close accordance with the results of Lal et al., (2016) in Kinnow andSaleem et al., (2008) in orange.

The plants treated with NAA @ 50ppm yielded fruits with the highest juice content (62.14 and 63.00%), closely trailed by fruits treated with NAA at 75ppm, which had juice contents of 58.56% and 59.53%. On the other hand, fruits from plants that were untreated and kept under control had the lowest juice content (54.07 and 54.62%).

Combined foliaruse of Zinc and NAA significantly improved juice content in litchi fruits. The maximum juice content(63.63 and 64.22 %) was recorded in fruits that were produced from the plants treated with the combination of N_2Z_2 (50ppm of NAA + 0.4% of zinc sulphate) followed by 62.57 and 63.64 % under N_2Z_3. The minimum juice content of 53.22 and 53.81 % werefound which were in fruits that were produced from the plants kept under control (N_0Z_0). The synthesis of catalytic activity of enzymes and coenzymes due to an adequate amount of zinc and auxin content and it alsoits effect as a catalyst in the oxidation process might have increasedjuice content. These findings are in close accordance with the results of Lal et al.,(2016) in Kinnow, Saleem et al., (2008) who also found increased juice content in orange.

3.3 Total soluble solids and total sugars: Application of 0.4% zinc sulphate on plants resulted in fruits with the highest total soluble solids content (17.30 and 17.69 0Brix) and total sugar content (15.13 and 15.55%), as shown in Table 1. closely followed by 17.24 and 17.38 ^{0}Brix of total soluble solids and total sugars (15.08 and 15.22 %) with 0.6 % of zinc sulphate application, while control plants produced fruits having lowest total soluble solids (16.93 and 16.84 ^{0}Brix)and total sugars (14.74 and 14.65%) content. This increase in TSS and total sugars content in fruit treated with zinc sulphate might be because zinc is credited with a definite role in the hydrolysis of complex polysaccharides into simple sugars, synthesis of metabolites, and rapid translocation of photosynthetic products and minerals from other parts of the plant to developing fruits. The results are by the finding of, Saraswat et al., (2006), Gupta et al., (2022),Kumar et al., (2023) in litchi, Kumar et al., (2018), Anushi et al.,(2021), Khanet al., (2022) in mango, Tiwari et al., (2017) in aonla;Babu and Tripathi (2022) in guava, Kumar and Tripathi (2009) in strawberry.

Foliar feeding with NAA significantly increases total soluble solids and total sugarscontent in fruits. Plants treated with 50ppm of NAA produced fruits having maximum total soluble solids (17.66 and 17.95 ^{0}Brix) and total sugars (15.53 and 16.30 %) followed by (17.15 and 17.02 ^{0}Brix) of TSS and total sugars (14.99 and 14.88 %) from NAA@75ppm treated plants, whereas, the minimum total soluble solids contents (16.69 and 16.88 ^{0}Brix) and total sugars (14.46 and 14.65 %)was documented in the fruits produced from the plants kept under control. This improvement in TSS and total sugars contents with the use of NAA growth regulator might have caused the diversion of more metabolites towards developing fruits as a result of increasing amylase activity and thus, thereis a fast conversion of starch into simple sugar thereby enhancing total soluble solid content. The results are by the findings of Kumar et al., (2023) in Phalsa, Tiwari et al., (2017), Kumar et al., (2017) in Aonla, Babu and Tripathi (2022), Rawat et al., (2010) in Guava, Kumar et al., (2023) in Litchi; Anushi et al., (2021), Lal et al., (2016) in Kinnow;Khan et al., (2022) in Mango.

When the interaction effect between the foliar spray of zinc sulphate and NAA is discussed, it is recorded that the maximum total soluble solids (15.96 and 16.30 ^{0}Brix) and total sugars (15.96 and 16.30%) content(Table 1), were documented in fruits which were produced from the plant treated with the combination of N_2Z_2 (50ppm of NAA + 0.4 % of zinc sulphaste) closely followed by 15.46 and 16.21 ^{0}Brix of total soluble solids (15.96 and 16.30 ^{0}Brix) and total sugars(15.46 and 16.21 %) under N_2Z_3 treatment. The minimum amount oftotal soluble solids 14.12 and 4.17 ^{0}Brix and total sugars (14.12 and 4.17 %) were found in fruits that were produced from the plants kept under control (N_0Z_0) without any treatment.This increase in the total soluble solids of fruits may be because plant bio-regulators and micronutrients play an important role in photosynthesis which ultimately leads to the accumulation of carbohydrates with a greater conversion of starch into sugar which ultimately results in an increase in the TSS and total sugars content of litchi fruits in the presence NAA and zinc. The adequate amount of zinc also improves the auxin content and it also acts as a catalyst in the oxidation process. The results are in close conformity with the finding of Rawat et al., (2010), Babu and Tripathi (2022) in guava, Saraswat et al., (2006), Katiyar et al., (2008), Kumar et al., (2023), Gupta et al., (2022) in litchi, Kumar et al., (2017), Tiwari et al., (2017) in Aonla, Anushi et al., (2021), Khan et al., (2022) in mango, Kumar and Tripathi (2009) in strawberry, and Lal et al., (2016) in Kinnow.

3.4 Titratable acidity: Foliaruse of plant bio-regulators and micronutrients significantly reducedthe titratable acidity percent in fruits(Table 2). The minimum titratable acidity (1.35 and 1.34%) was found in fruits that were produced from the plants treated with zincsulphate @ 0.6% closelyfollowed by (1.35 and 1.34%) from zinc sulphate @ 0.6% treated plants, whereas, the higher amount of titratable acidity (1.38 and 1.37%) was recorded in fruits which were produced from the plants kept under control without any treatment. The role of zinc in decreasing the titratable acidity of fruits might be either due to the conversion of sugar and their derivatives by relation involving reverse glycolytic pathway or growth which may be held responsible for reducing titratable acidity.Results obtained during the present experimental period are also in line with the findings of Tiwari et al., (2017); Singh et al., (2001); Kumar et al., (2023) in Aonla, Awasthi and Lal (2009) in Guava, Yadav et al., (2010), Babu and Tripathi (2022) in Guava, Kumar et al., (2023) in Litchi; Anushi et al., (2021), Pandey et al.,(2011), Khan et al., (2022) in Mango.

The plants treated with NAA @ 50ppm resulted in the production of fruit having 1.328 and 1.297% of titratable acidity in fruits closely followed by 1.350 and 1.333% in fruits which were producedfromNAA @ 75ppm treated plants, whereas, the maximum amount oftitratable acidity (1.421 and 1.430%) was foundin fruits which were produced from the plants kept under control without any treatment. The reduction in acidity content in fruits with NAA treatment might be due to the increased TSS and total sugarcontent in fruits. Results obtained during the present experimental period are also in line with the findings of Tiwari et al., (2017); Singh et al., (2001); Kumar et al., (2017) in Aonla, Lal et al., (2016) in Kinnow, Kumar et al., (2023) in phalsa, Kumar et al., (2023) in litchi, Babu and Tripathi (2022) in Guava and Pandey et al.,(2011), Anushi et al., (2021), Khan et al., (2022) in Mango.

Combined foliar use of zinc sulphate and NAA significantly reducedtitratable acidity content in litchi fruits(Table 2). The minimum titratable acidity (1.323 and 1.280%) was documented in fruits that were produced from the plants treated with the combination of N_2Z_2 (50ppm of NAA + 0.4 % of zinc sulphate) followed by 1.325 and 1.284% in fruits which were producedunder N_2Z_3combination. The maximum titratable acidity content (1.474 and 1.172%) was observed in fruits that were produced from the plants kept under control (N_0Z_0). Titratable acidity content in fruits was found less with the foliar use of NAA and zinc sulphate, which might be due to an increase in the translocation of photosynthates (carbohydrates) and more metabolic conversion of acids to sugars by the reverse reaction of the glycolytic pathway which is utilized in various physiological activities. Another reason for the reduction in titratable acidity percent might be the early ripening of fruits which was induced by the plant bio-regulators and micronutrient spray due to which degradation of acids might have occurred. Results obtained during the present experimental duration are also in line with the findings of Tiwari et al., (2017), Singh et al., (2001), Kumar et al., (2017) in Aonla, Kumar et al., (2023) in Litchi, Babu and Tripathi (2022) in guava and Anushi et al., (2021), Pandey et al., (2011), Khan et al., (2022) in Mango.

3.5 TSS: acid and sugar: acid ratio: The TSS: acid and sugar: acid ratiowere significantly influenced by sole as well as combined use of NAA and zinc sulphate (Table 2).The fruits derived from plants treated with zinc sulphate @ 0.6% exhibited the highest TSS: acid ratio (12.77 and 13.23) and sugar: acid ratio (1.35 and 1.34%). Conversely, the fruits from plants without any treatment showed the lowest TSS: acid ratio (12.28 and 12.24) and sugar: acid ratio (1.38 and 1.38%)..Zinc was crucial for photosynthesis in plants, which in turn caused the build-up of carbohydrates and was responsible for the rise in fruit's TSS and sugars. TSS acid and sugar: acid ratiois ultimately raised by the fast metabolic conversion of starch and pectin into soluble substances and the speedy transfer of sugars from leaves to growing fruits finally increasing TSS: acid and sugar: acid ratio. These findings are in close accordance with the results ofLal et al., (2015) in Kinnow Mandarin, Bal et al., (1984),Kumar et al., (2023), Tripathi et al., (2009) in ber and Trivedi et al., (2012) in Guava.

Further observation of the data presented in Table 2, shows that theplants treated with NAA @ 50ppm produced fruits having maximum TSS: acid ratio (13.30 and 13.83) and sugar: acid ratio(1.33 and 1.30%), whereas, the minimum TSS: acid ratio (11.76 and 11.82) and sugar: acid ratio(1.42 and 1.43%) were recorded in fruits which wereharvested from the plants which were kept under control without any application.The application of NAA significantly improved fruit quality, leading to an increase in TSS and sugar content, possibly due to the conversion of other polysaccharides and retained starch into soluble sugar forms.. Fruit's increasein total soluble solids and total sugar content with reduced titratable acidity might be the result of an increase in the TSS acid ratio. These findings are in close accordance with the results ofLal et al., (2015) in Kinnow Mandarin, Tripathi et al., (2009), Bal et al., (1984) in ber, and Kumar and Tripathi (2009) in strawberry. The interaction effect among the foliar spray of zinc sulphateand NAA have non-significant effect on TSS: acid and sugar: acid ratio during both years of experimentation.

3.6 Ascorbic acid: Perusal of Table 3, clearly shows that the presence of zinc sulphate had a significant impact on the ascorbic acid levels in fruits. Fruits from plants treated with 0.6% zinc sulphate exhibited the highest ascorbic acid content at 37.05 and 38.51 mg/100g pulp, followed closely by fruits from plants treated with 0.4% zinc sulphate at 36.96 and 38.29

mg/100g pulp. In contrast, fruits from control plants, without any application of zinc sulphate, had the lowest levels of ascorbic acid at 35.51 and 36.84 mg/100g pulp.The increased ascorbic acid content in fruit juicemight be due to an increase in the synthesis of catalytic activity of enzymes and coenzymes with the zinc application. An adequate amount of zinc also improves the auxin content which also acts as a catalyst in the oxidation process. These findings are in close accordance with the results of Kumar et al., (2017), Tiwari et al., (2017) in Aonla, Anushi et al., (2021), Rajak et al., (2010), Khan et al., (2022) in Mango.

The plants treated with NAA @50ppm produced fruits having significantly more amount of ascorbic acid (39.83 and 40.97 mg/100g pulp) closely followed by 37.48 and 38.75 mg/100g pulpfrom NAA @ 75ppm treated plants, whereas, fruits with minimum ascorbic acid content (33.21 and 34.75 mg/100g pulp) was harvested from the plants which were kept under control treatment. This increased ascorbic acid content in fruit juicemight be due to an increase in the synthesis of catalytic activity of enzymes and coenzymes, which are represented in ascorbic acid synthesis. These findings are in close accordance with the results of Chandra et al.,(2015), Kumar et al., (2017), Tiwari et al., (2017) in Aonla, Rajak et al., (2010), Anushi et al., (2021), Khan et al., (2022) in mango and Lal et al., (2016) in Kinnow.

The combined use of zinc sulphate and NAA on the leaves had a significant impact on the ascorbic acid content in the fruits. The highest levels of ascorbic acid (41.22 and 41.64 mg/100g pulp) were observed in fruits harvested from plants treated with N2Z2 (50ppm of NAA + 0.4% of zinc sulphate), followed by 39.96 and 41.22 mg/100g pulp from N2Z3. The lowest levels of ascorbic acid (32.64 and 33.26 mg/100g pulp) were found in fruits from plants under control conditions (N0Z0).This increase in ascorbic acid content in fruit might be due to an increase in catalytic activity of enzymes and coenzymes which enhanced the ascorbic acid synthesis. An adequate amount of zinc improves the auxin content and it also acts as a catalyst in the oxidation process. These findings are in close accordance with the results of Chandra et al.,(2015), Kumar et al., (2017), Tiwari et al., (2017) in Aonla, Rajak et al., (2010), Khan et al., (2022), Anushi et al., (2021) in Mango, Tripathi and Shukla (2008) who also found increased ascorbic acid content in strawberry.

3.7 Organoleptic Taste: The fruits obtained from the plants treated with foliar spray of micronutrient *i.e.*, zinc zinc sulphate have considerably increased the rating of fruits and a significantly maximum rating for organoleptic taste (76.21 and 77.27) documented in 0.6% zinc sulphatefollowed by 75.64 and 77.00 rating under 0.4% of zinc sulphate, whereas the lowest rating for organoleptic taste (73.71 and 74.66) was exhibited under controlfruits(Table 3). The application of zinc also proved highly helpful in the process of photosynthesis, mobilization of food materials, and accumulation of quality constituents promoting chemical attributes like total sugars and TSS which ultimately increased the organoleptic taste values. These findings are by the reports of Devaraja et. al., (2019), Megu et. al., (2021) in Litchi, Mishra et. al., (2012); Yadav et al., (2010);Tripathi and VivekaNand (2022) in Aonla.

The organoleptic rating reached its peak under the treatment of NAA @ 50ppm, with scores of 81.14 and 82.19, closely followed by scores of 77.12 and 78.15 from fruits treated with NAA @ 75ppm during both years of the experiment. In contrast, the control treatment resulted in a minimum score of 69.22 and 70.32 for organoleptic rating.The fruits treatment from the adequate concentration of NAA were designated as having the best taste, and mouth aroma withthe highest sweetness and were also classified among those having the lowest acidity, best flavor, and best aftertaste. These findings are under the reports of Megu et. al., (2021) in Litchi,Mishra et. al., (2012); and Tripathi and VivekaNand (2022) in Anola.The interactive influence of NAA and Zinc was found to be non-significantfor the organoleptic rating of fruits during both years of experimentation.

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4.0 CONCLUSION

Based on results obtained in the present investigation it is concluded that individual application of NAA and zinc sulphate brought about significant changes in plant metabolism. Combined use NAA@ 50ppm and zinc sulphate @ 0.6% showed significantly better results over other treatments in reducing fruit cracking and maintaining the chemical quality of litchi fruit *i.e.*, TSS, total sugars, ascorbic acid, and juicecontent with reduced acid contents.The organoleptic quality of fruits also got better with the same treatment. Therefore, based on the aforementioned results, it is recommended that litchi growers utilize 50ppm of NAA in conjunction with 0.4% zinc sulphate to effectively reduce fruit cracking and enhance the chemical quality parameters of the fruits

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Table 1: Effect of foliar sprays of NAA, Zinc and their interactions on fruit yield, juice content and TSS

Parameter	Doses	Zinc % (B)									
	NAA	2022					2023				
	ppm (A)	B_0 Control	B_1 0.2	B_2 0.4	B_3 0.6	Mean A	B_0 Control	B_1 0.2	B_2 0.4	B_3 0.6	Mean A
Juice Content	A_0 Control	53.223	53.827	54.300	54.960	54.078	53.813	54.367	55.073	55.260	54.628
	A_1 25	55.397	56.137	57.060	57.073	56.417	55.477	56.537	57.000	56.990	56.501
	A_2 50	60.780	61.597	63.637	62.570	62.146	61.720	62.447	64.227	63.640	63.008
	A_3 75	57.693	58.450	58.850	59.283	58.569	58.617	58.960	59.890	60.683	59.538
	Mean B	56.773	57.503	58.462	58.472		57.407	58.078	59.048	59.143	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	1.138	0.556	0.393			0.438	0.214	0.151		
	B	1.138	0.556	0.393			0.438	0.214	0.151		
	A X B	N/A	1.112	0.787			N/A	0.428	0.303		
TSS	A_0 Control	16.403	16.597	16.863	16.900	16.691	16.453	16.727	16.740	17.623	16.886
	A_1 25	16.777	16.867	17.190	17.130	16.991	16.587	16.457	17.327	17.520	16.973
	A_2 50	17.527	17.440	18.090	17.593	17.663	17.623	17.470	18.387	18.300	17.945
	A_3 75	17.030	17.167	17.060	17.347	17.151	16.700	16.960	17.157	17.267	17.021
	Mean B	16.934	17.018	17.301	17.243		16.841	16.903	17.699	17.381	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	0.440	0.215	0.152			0.448	0.219	0.155		
	B	N/A	0.215	0.152			0.448	0.219	0.155		
	A X B	N/A	0.430	0.304			N/A	0.438	0.310		
Total sugars	A_0 Control	14.123	14.353	14.667	14.720	14.466	14.177	14.490	14.513	15.427	14.652
	A_1 25	14.607	14.700	15.020	14.967	14.823	14.410	14.280	15.157	15.353	14.800
	A_2 50	15.390	15.307	15.963	15.467	15.532	15.507	15.357	16.217	16.300	15.845
	A_3 75	14.873	15.010	14.907	15.203	14.998	14.537	14.820	15.030	15.147	14.883
	Mean B	14.748	14.843	15.139	15.089		14.658	14.737	15.229	15.557	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	0.445	0.217	0.154			0.447	0.218	0.154		
	B	N/A	0.217	0.154			0.447	0.218	0.154		
	A X B	N/A	0.435	0.307			N/A	0.437	0.309		

Table 2: Effect of foliar sprays of NAA, Zinc and their interactions on total sugars, titratable acidity and TSS: acid ratio

Parameter	Doses	Zinc % (B)									
	NAA	2022					2023				
	ppm (A)	B_0 Control	B_1 0.2	B_2 0.4	B_3 0.6	Mean A	B_0 Control	B_1 0.2	B_2 0.4	B_3 0.6	Mean A
Titratable acidity	A_0 Control	1.474	1.442	1.391	1.375	1.421	1.472	1.433	1.422	1.391	1.430
	A_1 25	1.367	1.362	1.362	1.357	1.362	1.372	1.371	1.366	1.364	1.368
	A_2 50	1.332	1.331	1.323	1.325	1.328	1.315	1.308	1.280	1.284	1.297
	A_3 75	1.356	1.353	1.348	1.342	1.350	1.358	1.335	1.321	1.318	1.333
	Mean B	1.382	1.372	1.356	1.350		1.379	1.362	1.347	1.340	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	0.013	0.006	0.004			0.010	0.005	0.003		
	B	0.013	0.006	0.004			0.010	0.005	0.003		
	A X B	0.025	0.012	0.009			0.020	0.010	0.007		
TSS: acid ratio	A_0 Control	11.127	11.513	12.120	12.283	11.761	11.173	11.677	11.773	12.663	11.822
	A_1 25	12.270	12.380	12.613	12.590	12.463	12.087	11.993	12.687	12.837	12.401
	A_2 50	13.153	13.103	13.673	13.273	13.301	13.400	13.350	14.310	14.293	13.838
	A_3 75	12.557	12.680	12.653	12.923	12.703	12.293	12.703	12.980	13.097	12.768
	Mean B	12.277	12.419	12.765	12.768		12.238	12.431	12.933	13.227	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	0.377	0.184	0.130			0.323	0.158	0.112		
	B	0.377	0.184	0.130			0.323	0.158	0.112		
	A X B	N/A	0.368	0.260			N/A	0.315	0.223		
Sugar: acid ratio	A_0 Control	9.585	9.962	10.545	10.703	10.199	9.629	10.119	10.209	11.089	10.262
	A_1 25	10.688	10.795	11.025	11.027	10.884	10.505	10.412	11.100	11.252	10.817
	A_2 50	11.554	11.506	12.047	11.694	11.700	11.795	11.739	12.669	12.690	12.223
	A_3 75	10.970	11.092	11.061	11.331	11.114	10.706	11.103	11.376	11.493	11.170
	Mean B	10.699	10.839	11.170	11.189		10.659	10.843	11.338	11.631	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	0.370	0.181	0.128			0.323	0.158	0.112		
	B	0.370	0.181	0.128			0.323	0.158	0.112		
	A X B	N/A	0.362	0.256			N/A	0.316	0.223		

Table 3: Effect of foliar sprays of NAA, Zinc and their interactions on total sugar: acid ratio ascorbic acid and organoleptic taste

Ascorbic acid	A_0 Control	16.403	16.597	16.863	16.900	16.691	16.453	16.727	16.740	17.623	16.886
	A_1 25	16.777	16.867	17.190	17.130	16.991	16.587	16.457	17.327	17.520	16.973
	A_2 50	17.527	17.440	18.090	17.593	17.663	17.623	17.470	18.387	18.300	17.945
	A_3 75	17.030	17.167	17.060	17.347	17.151	16.700	16.960	17.157	17.267	17.021
	Mean B	16.934	17.018	17.301	17.243		16.841	16.903	17.699	17.381	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	0.440	0.215	0.152			0.448	0.219	0.155		
	B	N/A	0.215	0.152			0.448	0.219	0.155		
	A X B	N/A	0.430	0.304			N/A	0.438	0.310		
Organoleptic test	A_0 Control	68.233	68.777	69.260	70.610	69.220	69.313	69.907	70.380	71.710	70.328
	A_1 25	71.447	72.627	73.420	73.820	72.828	72.527	73.777	74.860	75.117	74.070
	A_2 50	79.730	80.737	82.367	81.760	81.148	80.610	81.897	83.827	82.450	82.196
	A_3 75	75.433	76.870	77.540	78.663	77.127	76.193	77.670	78.950	79.813	78.157
	Mean B	73.711	74.753	75.647	76.213		74.661	75.813	77.004	77.273	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	1.121	0.548	0.388			1.121	0.548	0.388		
	B	1.121	0.548	0.388			1.121	0.548	0.388		
	A X B	N/A	1.096	0.775			N/A	1.096	0.775		

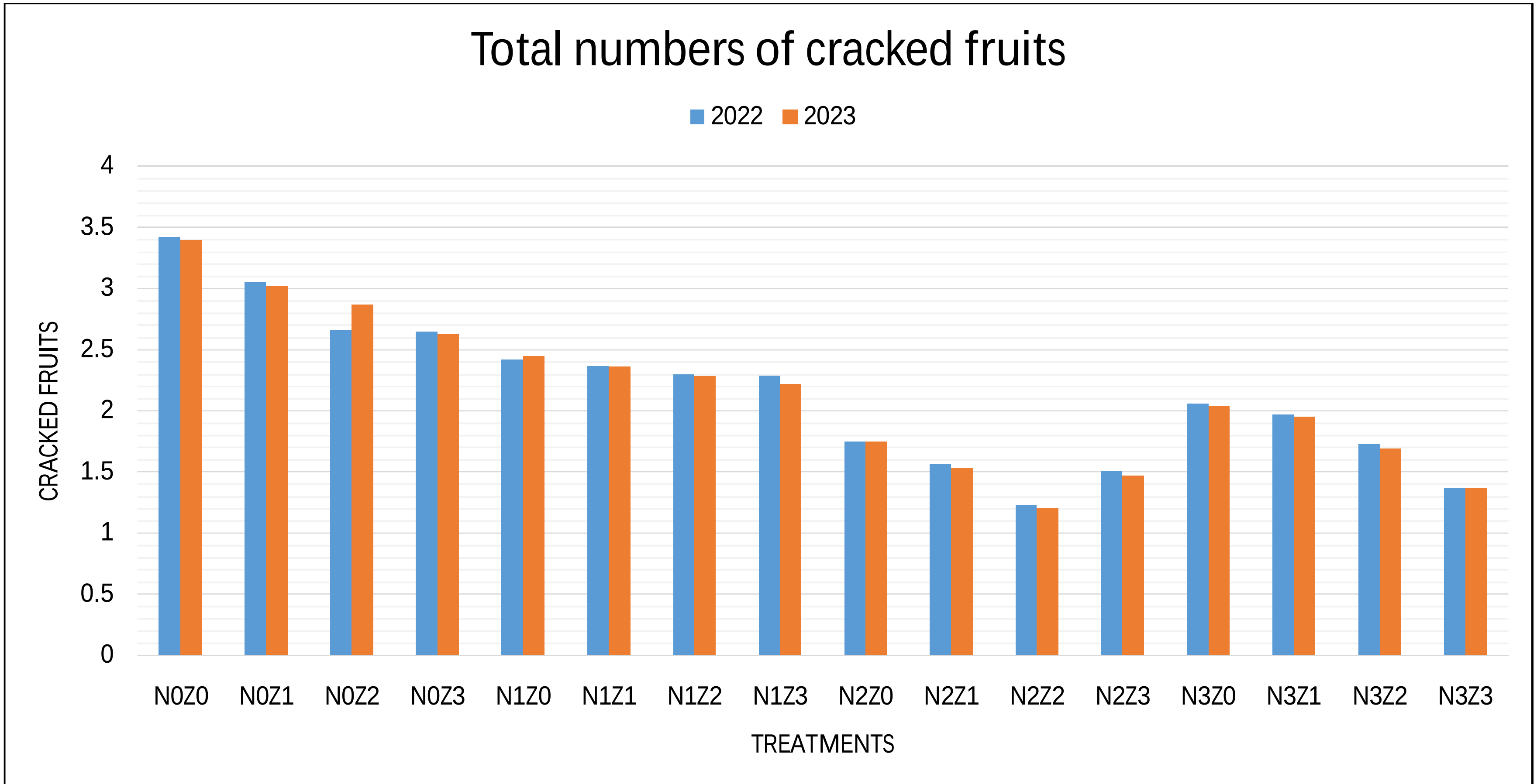

Fig. 1: Effect of foliar sprays of NAA, Zinc and their interactions on number of cracked fruits

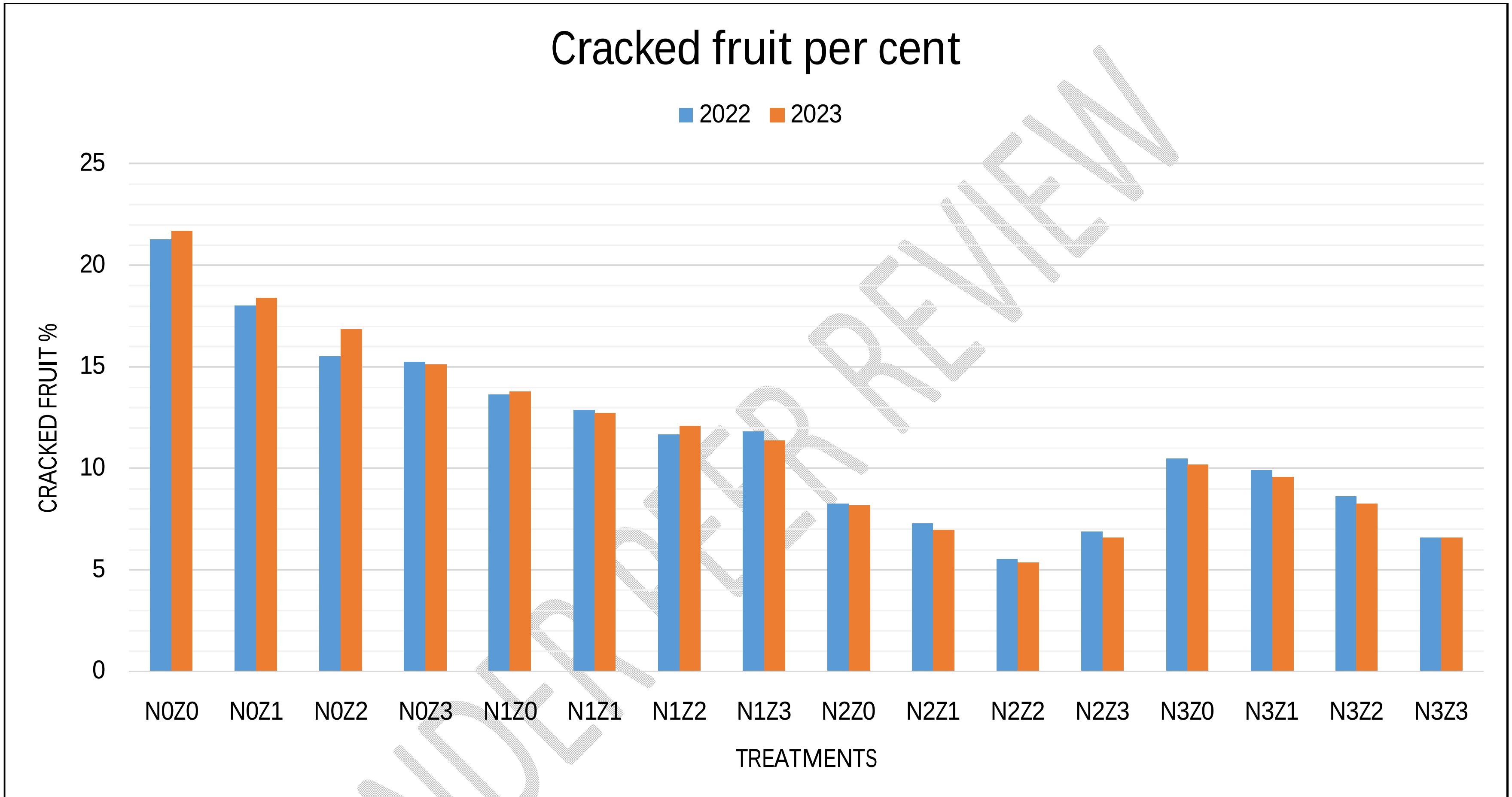

Fig. 2: Effect of foliar sprays of NAA, Zinc and their interactions on fruit cracking percent