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Effect of chemical thinning on fruit and leaf mineral content of apple (*Malus* × *domestica* Borkh) cv. Red Braeburn under high density planting system

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Abstract
The present investigation entitled "Effect of chemical thinning on fruit and leaf mineral content of apple (*Malus x domestica*) *cv.* Red Braeburn with chemicals under high density planting system" was conducted in the Experimental fields of Division of Fruit Science, SKUAST, Shalimar during the year 2021-22. Four year old trees of exotic apple *cv.* "Red Braeburn" grafted on M-9 T337 rootstock, planted at a distance of 3 m× 1m and trained on tall spindle system were selected for experimentation. The experiment was laid out in Randomized Block Design (two factorial) and comprised of 17 different treatment combinations for blossom thinning chemicals which were applied at three different stages *viz*, 50% bloom, 100% bloom and 50% petal fall. Each treatment combination was replicated thrice. The different thinning treatments and their time of application showed significant effect on fruit and leaf nutrient content. Maximum fruit and leaf nitrogen, fruit and leaf phosphorus, fruit and leaf potassium and minimum fruit calcium was observed in T_8 (NAA 20 ppm + BA 150 ppm) during both the years of study. Minimum fruit and leaf nitrogen, fruit and leaf phosphorus, fruit and leaf potassium and maximum fruit calcium was observed in T_{17} (Control) during both the years of investigation. Significant effect of the time of application of thinning chemical on fruit mineral content was observed. Maximum fruit nitrogen, fruit phosphorus, fruit potassium was observed when the treatments were applied at 50% petal fall. Minimum fruit nitrogen, fruit phosphorus, fruit potassium was observed when treatments were applied at 50% bloom. Effect of thinning chemicals on leaf calcium was found to be insignificant. From the present investigation it was concluded that that chemical thinning may affect the accumulation of some nutrients and thereby improves the fruit quality.

Keywords: Ammonium thiosulphate, Potassium thiosulphate, Lime sulphur, Potassium bicarbonate

Introduction
Apple (*Malus* ×*domestica* Borkh) is one of the most ubiquitous and well-adapted species of temperate fruits of the world, grown particularly in North-Western Himalayas at an elevation range of 1,500-2,700 m amsl. It is known as the king of temperate fruits and is fourth among the most widely produced fruits in the world after banana, orange and grapes. It belongs to genus *Malus* of family Rosaceae and order Rosales. The total area under cultivation of apple in India is 3.13 lakh hectares with a production of 2.3 million, MT (FOA, 2022). Jammu and Kashmir is the largest producer of apple in India with an area of about 1.65 lakh hectares and production of 20 lakh MT (Anonymous, 2020) [1], contributing more than 70 percent of the total apple production in India.

High-density planting system (HDP) is now being conceived as an alternative production system having a potential for improving productivity, increasing yield efficiency, reducing input cost, minimizing risks and maximizing returns. The use of highly feathered trees and efficient orchard training systems often leads to over bearing of trees, which in turn leads to biennial bearing. That is the trees bear abundantly in one year (ON –year) whereas the bearing in the next year is greatly reduced and in some cases trees may have zero bearing (OFF –year). Besides the presence of large number of fruits results in smaller size of the fruit, which in turn reduces the economic value of the fruit. Thus, flower and fruit thinning of apple is an important practice used to regulate crop load and improve fruit quality at harvest. Traditionally, thinning of blossoms or fruit-lets had been carried out manually and is still in practice. However, hand thinning is more expensive and time consuming.

Therefore, the trend has shifted towards chemical thinning using different agents such as plant growth regulators like ethrel, NAA, thidiazuron and chemicals like urea, thiourea, ammonium thiosulphate etc. However the effectiveness of these chemicals depend on weather conditions, primarily temperature, and cultivar sensitivity (Wertheim, 2000) [17]. It is also possible that such thinning practices affect leaf and fruit mineral compositions. Concentrations of mineral elements such as calcium (Ca), magnesium (Mg), potassium (K) and nitrogen (N) in apple fruits at harvest time can influence postharvest fruit quality in storage (Kadir, 2004; Opara and Tadesse, 2000) [12, 13]. Thinning of flowers or fruitlets usually decreases Ca and increases K concentrations in the fruit (Fallahi and Simons, 1993; Johnson, 1994) [5, 11]. However, in some cases Ca concentrations have either increased or not been affected when applying flower and fruitlet removal (Qunlan, 1969) [14] Keeping in view the above points, the present investigation was carried out in apple high density blocks with the objective to quantify the effect of blossom thinning chemical on nutrient concentrations of fruit and leaf of 'Red Braeburn' apple.

Materials and Methods

The present experiment was conducted on Four year old trees of exotic apple *cv*. "Red Braeburn" grafted on M-9 T337 rootstock, planted at a distance of 3 m× 1m and trained on tall spindle system. The experiment was laid out in Randomized Block Design (two factorial) and comprised of 17 different treatment combinations for blossom thinning chemicals which were applied at three different stages *viz*, 50% bloom, 100% bloom and 50% petal fall. The different blossom thinning treatments included: T_1: Naphthalene acetic acid (NAA) @ 10ppm, T_2: NAA @ 20ppm, T_3: Benzyl adenine (BA) @ 100 ppm, T_4: BA @ 150 ppm, T_5: NAA (10 ppm) + BA (100 ppm), T_6: NAA (10 ppm) + BA (150 ppm), T_7: NAA (20 ppm) + BA (100 ppm), T_8: NAA (20 ppm) + BA (150 ppm), T_9: Ammonium thiosulphate (ATS) @ 0.5%, T_{10}: ATS @ 1.0%, T_{11}: Potassium thiosulphate (KTS) @ 1.0%, T_{12}: KTS @ 2.0%, T_{13}: Lime sulphur (LS) @ 3%, T_{14}: LS @ 4%, T_{15}: Potassium Bicarbonate (KH_2CO_3) @ 0.5%, T_{16}: KH_2CO_3 @ 0.5% and T_{17}: control. Fruit samples (8 numbers in each treatment) were collected at harvest time, while leaf samples (40-50) were collected from the mid-point of the current season's terminal growth during mid July. Fruit samples were first washed with tap water followed by labolene wash and finally by distilled water to be dried on newspapers overnight and then transferred to oven for drying till constant weight at 60 ºC. Then the samples were crushed in stainless steel blender and stored in polythene bags for analysis. After collected leaf samples were thoroughly washed first with tap water, and then dipped in 0.1N HCl and then in distilled water. After air drying samples were dried in an oven at 60 ºC till constant weight was obtained (Chapman, 1964) [4]. The dried leaves were ground in steel Willey mill and then kept in butter bags for chemical analysis. To estimate nutrient elements other than nitrogen *viz*. phosphorus, potassium and calcium, fruit and leaf samples were digested separately in diacid mixture of nitric acid and perchloric acid (in the ratio of 9:4). The digestion of samples for the estimation of nitrogen was carried out in concentrated sulphuric acid by adding digestion mixture or sulphate mixture. Total nitrogen in leaves was determined by modified Kjeldhals method as outlined by Jackson (1973) [10]. Phosphorus content was estimated from digested samples by Vandate molybdate yellow colour method with the help of the Spectrophotometer (Jackson, 1973) [10]. Potassium content was determined using flame photometer (Jackson, 1973) [10]. Calcium content was determined by versenate titration method (Jackson, 1973) [10]. The experimental data was then subjected to statistical analysis as per the standard statistical procedure given by Gomez and Gomez (1984) [9].

Results and Discussion

As evident from the data presented in Table-1, the effect of various blossom thinning chemicals and their time of application had a significant influence on fruit nitrogen. Maximum fruit nitrogen was observed in T_8 (NAA 20 ppm + BA 150 ppm) [0.202% and 0.225%] during the year 2021 and 2022 respectively. Minimum fruit nitrogen (0.164% and 0.183%) was observed in T_{17} (Control) during both the years of investigation. Significant effect of the time of application of thinning chemical on fruit nitrogen was observed [Table-1]. Maximum fruit nitrogen (0.191% and 0.213%) was observed when the treatments were applied at 50% petal fall during the years 2021 and 2022 respectively. Minimum fruit nitrogen (0.189% and 0.211%) was observed when treatments were applied at 50% bloom. The interaction effect of thinning treatment and time of application of thinning treatment on fruit nitrogen was found to be non-significant during both the years of study (Table-1). Data presented in Table-2 reveals significant effect of various blossom thinning chemicals and their time of application fruit phosphorus. Maximum fruit phosphorus was observed in T_8 (NAA 20 ppm + BA 150 ppm) [0.119% and 0.121%] which was statistically at par with T_{12} (KTS @ 2%) [0.102% and 0.120%], T_7 (NAA 20 ppm + BA 100 ppm) [0.101% and 0.119%] and T_6 (NAA 10 ppm + BA 150 ppm) [0.100% and 0.118%] during both the years of study. Minimum fruit phosphorus (0.040% and 0.057%) was observed in T_{17} (Control) during both the years of investigation. Significant effect of the time of application of thinning chemical on fruit phosphorus was observed [Table-2]. Maximum fruit phosphorus (0.089% and 0.107%) was observed when the treatments were applied at 50% petal fall during the years 2021 and 2022 respectively. Minimum fruit phosphorus (0.084% and 0.102%) was observed when treatments were applied at 50% bloom. The interaction effect of thinning treatment and time of application of thinning treatment on fruit phosphorus was found to be non-significant during both the years of study (Table-2). Perusal of the data presented in Table-3 reveals that the effect of various blossom thinning chemicals and their time of application had a significant influence on fruit potassium. Maximum fruit potassium was observed in T_8 (NAA 20 ppm + BA 150 ppm) [0.746% and 0.786%] during both the years. Minimum fruit potassium (0.600% and 0.640%) was observed in T_{17} (Control) during both the years of investigation. Significant effect of the time of application of thinning chemical on fruit potassium was observed [Table-3]. Maximum fruit potassium (0.675% and 0.715%) was observed when the treatments were applied at 50% petal fall during the years 2021 and 2022 respectively. Minimum fruit potassium (0.663% and 0.703%) was observed when treatments were applied at 50% bloom during the year 2021 and 2022 respectively. The interaction effect of thinning treatment and time of application of thinning treatment on fruit potassium was found to be non-significant during both the years of study (Table-3). Perusal of

the data presented in Table-4 reveals that the effect of various blossom thinning chemicals had a significant influence on fruit calcium. Minimum fruit calcium was observed in T_8 (NAA 20 ppm + BA 150 ppm) and T_{12} (KTS @ 2%) [0.446% and 0.466%] during the year 2021 and 2022 respectively. Maximum fruit calcium (0.457% and 0.478%) was observed in T_{17} (Control) during both the years of investigation. The effect of the time of application of thinning chemical and also the interaction effect of thinning treatment and time of application on fruit calcium was found to be non-significant during both the years of study (Table-4).

Data presented in Table-5 reveals a significant effect of various blossom thinning chemical and their time of application on the leaf nitrogen content. Maximum leaf nitrogen content (2.233% and 2.298%) was observed in T_8 (NAA 20 ppm + BA 150 ppm) during the year 2021 and 2022 respectively. However this treatment was statistically at par with T_{12} i.e KTS @ 2% (2.226% and 2.290%), T_7 (NAA 20 ppm + BA 100 ppm) [2.218% and 2.282%], T_6 (NAA 10 ppm + BA 150 ppm) [2.213% and 2.278%], T_5 (NAA 10 ppm + BA 100 ppm) [2.207% and 2.271%], T_2 (NAA @ 20 ppm) [2.200% and 2.264%], T_{11} (KTS @ 1%) [2.190% and 2.254%], T_{10} (ATS @ 1%) [2.180% and 2.244%] and T_9 (ATS @ 0.5%) [2.164% and 2.229%] during the year 2021 and 2022 respectively. Minimum leaf nitrogen (2.094% and 2.227%) was recorded in control (T_{17}) during the year 2021 and 2022 respectively. Significant effect of the time of application of thinning chemical on leaf nitrogen content was observed [Table-5]. Maximum leaf nitrogen (2.227% and 2.294%) was observed when the treatments were applied at 100% bloom. Minimum leaf nitrogen (2.132% and 2.205%) was observed when treatments were applied at 50% bloom during both the years of study. The interaction effect of thinning treatment and time of application of thinning treatment on leaf nitrogen was found to be non-significant during both the years of study (Table-5). Data presented in Table-6 reveals a significant effect of various blossom thinning chemical and their time of application on the leaf phosphorus content. Maximum leaf phosphorus content (0.256% and 0.292%) was observed in T_8 (NAA 20 ppm + BA 150 ppm) during both the years of study. However this treatment was statistically at par with T_{12} i.e KTS @ 2% (0.253% and 0.291%) and T_7 (NAA 20 ppm + BA 100 ppm) [0.251% and 0.286%] during the year 2021 and 2022 respectively. Minimum leaf phosphorus (0.183% and 0.217%) was recorded in control (T_{17}). Significant effect of the time of application of thinning chemical on leaf phosphorus content was observed [Table-6]. Maximum leaf phosphorus (0.232% and 0.272%) was observed when the treatments were applied at 100% bloom during both the years of study. Minimum leaf phosphorus (0.222% and 0.255%) was observed when treatments were applied at 50% bloom. The interaction effect of thinning treatment and time of application of thinning treatment on leaf phosphorus was found to be non-significant during both the years of study (Table-6). Perusal of the data presented in Table-7 reveals a significant effect of various blossom thinning chemical and their time of application on the leaf potassium content. Maximum leaf potassium content (1.826% and 1.863%) was observed in T_8 (NAA 20 ppm + BA 150 ppm) which was statistically at par with T_{12} i.e KTS @ 2% (1.823% and 1.861%) and T_7 (NAA 20 ppm + BA 100 ppm) [1.821% and 1.858%] during the year 2021 and 2022 respectively. Minimum leaf potassium (1.762% and 1.797%) was recorded in control (T_{17}). Significant effect of the time of application of thinning chemical on leaf potassium content was observed in the year 2021 and non significant effect in the year 2022 [Table-7]. Maximum leaf potassium (1.804% and 1.837%) was observed when the treatments were applied at 100% bloom during the years 2021 and 2022 respectively. Minimum leaf potassium (1.794% and 1.834%) was observed when treatments were applied at 50% bloom. The interaction effect of thinning treatment and time of application of thinning treatment on leaf potassium was found to be non-significant during both the years of study (Table-7). Perusal of the data presented in Table-8 reveals a non-significant effect of various blossom thinning chemical, their time of application as well as their interaction on the leaf calcium content.

Thinning of flowers or fruitlets usually decreases Ca and increases K concentrations in the fruit (Fallahi and Simons 1993, Johnson, 1994) [5,11]. Szot (2010) [15] showed that fruits from apple trees subjected to flower thinning had the highest P and K content, but tended to have the smallest Ca content and the biggest K/Ca ratio. High K and low Ca in fruits may have an adverse relationship with storage, but higher P in fruits from trees subjected to thinning is likely to reduce their susceptibility to low temperature injury. Johnson (1994) [11] reported increase in fruit Phosphorus content for Cox's Orange Pippin apples by means of chemical thinning. Volz and Ferguson (1999) [16] also reported similar findings with 'Braeburn' apple trees, where they concluded that fruit K concentrations were greater in thinned trees than unthinned trees Baninasab *et al*. (2007) [2] also reported that macronutrient contents were affected by crop load in pistachio trees. They found that N and phosphorous (P) concentrations in many organs of pistachio trees from ON trees were the lowest as compared to that of OFF trees. In contrast to N and P, Ca and Mg of most organs were greater in heavily cropping trees than in lighter cropping trees. It is unclear whether changes in mineral composition in response to thinning are simply due to the effects of fruit size or other factors associated with crop load Baninasab *et al*., (2007) [2]; Ferguson and Watkins (1992) [7] and Zeng and Brown (2001) [19]. Zarei *et al*., (2013) [18] also reported that chemical thinners increased leaf N in apples. He also observed significant increase in leaf Phosphorus in plants treated with NAA @ 10 ppm and NAD @ 50 ppm and significant increase in K concentration of leaves compared with the non-treated control. Greater leaf mineral concentration in trees with less fruit was also observed by Brown *et al*. (1995) [3], Baninasab *et al*. (2007) [8] (for pistachio trees) and Fernandez-Escobar *et al*. (for olive leaves) (1999). The effect of thinning on leaf Ca was found insignificant in our study. Similar results were observed by Johnson (1994) [11] and Zarei *et al*., (2013) [18].

Table 1: Effect of blossom thinning chemicals on fruit nitrogen (%) of apple cv. Red Breaburn under high density planting system.

	2021				2022				Pooled			
	50% Bloom	100% Bloom	50% Petal fall	Mean	50% Bloom	100% Bloom	50% Petal fall	Mean	50% Bloom	100% Bloom	50% Petal fall	Mean
T_1: NAA @ 10 ppm	0.193	0.193	0.194	0.194	0.215	0.216	0.217	0.216	0.204	0.205	0.205	0.205
T_2: NAA @ 20 ppm	0.198	0.198	0.198	0.198	0.220	0.221	0.221	0.221	0.209	0.210	0.210	0.209
T_3: BA @ 100 ppm	0.187	0.188	0.188	0.188	0.209	0.210	0.211	0.210	0.198	0.199	0.199	0.199
T_4: BA @ 150 ppm	0.189	0.189	0.190	0.190	0.211	0.212	0.458	0.212	0.200	0.201	0.201	0.201
T_5: NAA 10 ppm+ BA 100 ppm	0.199	0.199	0.199	0.199	0.221	0.222	0.222	0.222	0.210	0.211	0.211	0.210
T_6: NAA 10 ppm+ BA 150 ppm	0.198	0.199	0.200	0.199	0.220	0.222	0.223	0.222	0.209	0.211	0.212	0.213
T_7: NAA 20 ppm+ BA 100 ppm	0.199	0.200	0.201	0.200	0.221	0.223	0.224	0.223	0.210	0.212	0.213	0.212
T_8: NAA 20 ppm+ BA 150 ppm	0.202	0.202	0.203	0.202	0.224	0.225	0.225	0.225	0.213	0.214	0.214	0.214
T_9: ATS @ 0.5%	0.191	0.191	0.192	0.192	0.213	0.214	0.215	0.214	0.202	0.203	0.203	0.203
T_{10}: ATS @ 1.0%	0.195	0.195	0.195	0.195	0.217	0.218	0.218	0.218	0.206	0.207	0.207	0.206
T_{11}: KTS@ 1.0%	0.197	0.197	0.197	0.197	0.219	0.220	0.220	0.219	0.208	0.208	0.209	0.208
T_{12}: KTS @ 2.0%	0.200	0.200	0.201	0.200	0.222	0.223	0.223	0.223	0.211	0.212	0.212	0.211
T_{13}: LS @ 3%	0.170	0.173	0.173	0.172	0.192	0.195	0.196	0.194	0.181	0.184	0.184	0.183
T_{14}: LS @ 4%	0.175	0.176	0.176	0.175	0.197	0.198	0.199	0.198	0.186	0.187	0.187	0.187
T_{15}: Potassium Bicarbonate @ 0.5%	0.180	0.181	0.181	0.180	0.202	0.203	0.204	0.203	0.191	0.192	0.192	0.192
T_{16}: Potassium Bicarbonate @ 1.0%	0.182	0.183	0.184	0.183	0.204	0.205	0.206	0.205	0.193	0.194	0.194	0.194
T_{17}: Control	0.161	0.164	0.164	0.164	0.183	0.183	0.183	0.183	0.173	0.173	0.173	0.173
Mean	0.189	0.190	0.191		0.211	0.212	0.213		0.200	0.201	0.202	
C.D. (≤ 0.05)			C.D. (2021)				C.D. (2022)				Pooled	
Treatment (T)			0.001				0.001				0.001	
Time of application (A)			0.001				0.001				0.001	
Treatment (T) X Time of application (A)			NS				NS				NS	

Table 2: Effect of blossom thinning chemicals on Fruit phosphorus (%) of apple cv. Red Breaburn under high density planting system.

	2021				2022				Pooled			
	50% Bloom	100% Bloom	50% Petal fall	Mean	50% Bloom	100% Bloom	50% Petal fall	Mean	50% Bloom	100% Bloom	50% Petal fall	Mean
T_1: NAA @ 10 ppm	0.095	0.096	0.097	0.096	0.112	0.115	0.114	0.114	0.104	0.106	0.106	0.105
T_2: NAA @ 20 ppm	0.097	0.098	0.099	0.098	0.114	0.117	0.116	0.116	0.106	0.108	0.108	0.107
T_3: BA @ 100 ppm	0.086	0.086	0.094	0.089	0.103	0.106	0.111	0.107	0.095	0.096	0.103	0.098
T_4: BA @ 150 ppm	0.093	0.093	0.095	0.094	0.110	0.113	0.112	0.112	0.102	0.103	0.104	0.103
T_5: NAA 10 ppm+ BA 100 ppm	0.098	0.099	0.100	0.099	0.115	0.118	0.117	0.117	0.107	0.109	0.109	0.108
T_6: NAA 10 ppm+ BA 150 ppm	0.099	0.100	0.101	0.100	0.116	0.119	0.118	0.118	0.108	0.110	0.110	0.109
T_7: NAA 20 ppm+ BA 100 ppm	0.100	0.101	0.102	0.101	0.117	0.120	0.119	0.119	0.109	0.111	0.111	0.110
T_8: NAA 20 ppm+ BA 150 ppm	0.102	0.103	0.104	0.119	0.122	0.121	0.121	0.121	0.111	0.113	0.113	0.112
T_9: ATS @ 0.5%	0.094	0.094	0.096	0.095	0.111	0.114	0.113	0.113	0.103	0.104	0.105	0.104
T_{10}: ATS @ 1.0%	0.095	0.096	0.097	0.096	0.112	0.115	0.114	0.114	0.104	0.106	0.106	0.105
T_{11}: KTS@ 1.0%	0.096	0.097	0.098	0.097	0.113	0.116	0.115	0.115	0.105	0.107	0.107	0.106
T_{12}: KTS @ 2.0%	0.101	0.102	0.103	0.102	0.118	0.121	0.120	0.120	0.110	0.112	0.112	0.111
T_{13}: LS @ 3%	0.046	0.046	0.060	0.051	0.063	0.066	0.077	0.069	0.055	0.056	0.069	0.060
T_{14}: LS @ 4%	0.056	0.056	0.070	0.061	0.073	0.076	0.087	0.079	0.065	0.066	0.079	0.070
T_{15}: Potassium Bicarbonate @ 0.5%	0.066	0.066	0.080	0.071	0.083	0.086	0.097	0.089	0.075	0.076	0.089	0.080
T_{16}: Potassium Bicarbonate @ 1.0%	0.076	0.076	0.090	0.081	0.093	0.096	0.107	0.099	0.085	0.086	0.099	0.090
T_{17}: Control	0.040	0.040	0.040	0.040	0.057	0.057	0.057	0.057	0.048	0.048	0.048	0.048
Mean	0.084	0.085	0.089		0.102	0.105	0.107		0.094	0.095	0.098	
C.D. (≤ 0.05)			C.D. (2021)				C.D. (2022)				Pooled	
Treatment (T)			0.003				0.004				0.003	
Time of application (A)			0.001				0.002				0.001	
Treatment (T) X Time of application (A)			NS				NS				NS	

Table 3: Effect of blossom thinning chemicals on fruit potassium (%) of apple cv. Red Breaburn under high density planting system.

	2021				2022				Pooled			
	50% Bloom	100% Bloom	50% Petal fall	Mean	50% Bloom	100% Bloom	50% Petal fall	Mean	50% Bloom	100% Bloom	50% Petal fall	Mean
T_1: NAA @ 10 ppm	0.660	0.664	0.674	0.666	0.700	0.704	0.714	0.706	0.684	0.687	0.697	0.689
T_2: NAA @ 20 ppm	0.690	0.694	0.704	0.696	0.730	0.734	0.744	0.736	0.714	0.717	0.727	0.719
T_3: BA @ 100 ppm	0.630	0.634	0.644	0.636	0.670	0.674	0.684	0.676	0.654	0.657	0.667	0.659
T_4: BA @ 150 ppm	0.640	0.644	0.654	0.646	0.680	0.684	0.694	0.686	0.664	0.667	0.677	0.669
T_5: NAA 10 ppm+ BA 100 ppm	0.700	0.704	0.714	0.706	0.740	0.744	0.754	0.746	0.724	0.727	0.737	0.729

T_6: NAA 10 ppm+ BA 150 ppm	0.710	0.714	0.724	0.716	0.750	0.754	0.764	0.756	0.734	0.737	0.747	0.739
T_7: NAA 20 ppm+ BA 100 ppm	0.720	0.724	0.734	0.726	0.760	0.764	0.774	0.766	0.744	0.747	0.757	0.749
T_8: NAA 20 ppm+ BA 150 ppm	0.740	0.744	0.754	0.746	0.780	0.784	0.794	0.786	0.764	0.767	0.777	0.769
T_9: ATS @ 0.5%	0.650	0.654	0.664	0.656	0.690	0.694	0.704	0.696	0.674	0.677	0.687	0.679
T_{10}: ATS @ 1.0%	0.670	0.674	0.684	0.676	0.710	0.714	0.724	0.716	0.694	0.697	0.707	0.699
T_{11}: KTS@ 1.0%	0.680	0.684	0.694	0.686	0.720	0.724	0.734	0.726	0.704	0.707	0.717	0.709
T_{12}: KTS @ 2.0%	0.730	0.734	0.744	0.736	0.770	0.774	0.784	0.776	0.754	0.757	0.767	0.759
T_{13}: LS @ 3%	0.607	0.610	0.614	0.610	0.647	0.647	0.654	0.649	0.630	0.630	0.637	0.633
T_{14}: LS @ 4%	0.610	0.614	0.620	0.615	0.650	0.650	0.660	0.654	0.634	0.634	0.644	0.637
T_{15}: Potassium Bicarbonate @ 0.5%	0.614	0.620	0.624	0.619	0.654	0.657	0.664	0.658	0.637	0.640	0.647	0.641
T_{16}: Potassium Bicarbonate @ 1.0%	0.624	0.630	0.634	0.629	0.664	0.667	0.674	0.668	0.647	0.650	0.657	0.651
T_{17}: Control	0.600	0.600	0.600	0.600	0.640	0.640	0.640	0.640	0.624	0.624	0.624	0.624
Mean	0.663	0.667	0.675		0.703	0.706	0.715		0.687	0.690	0.698	
C.D. (≤ 0.05)			C.D. (2021)		C.D. (2022)				Pooled			
Treatment (T)			0.004		0.004				0.004			
Time of application (A)			0.002		0.002				0.002			
Treatment (T) X Time of application (A)			NS		NS				NS			

Table 4: Effect of blossom thinning chemicals on fruit calcium (%) of apple cv. Red Breaburn under high density planting system.

	2021				2022				Pooled			
	50% Bloom	100% Bloom	50% Petal fall	Mean	50% Bloom	100% Bloom	50% Petal fall	Mean	50% Bloom	100% Bloom	50% Petal fall	Mean
T_1: NAA @ 10 ppm	0.451	0.451	0.451	0.451	0.473	0.469	0.470	0.470	0.462	0.460	0.460	0.461
T_2: NAA @ 20 ppm	0.449	0.449	0.449	0.449	0.470	0.467	0.468	0.468	0.460	0.458	0.458	0.459
T_3: BA @ 100 ppm	0.453	0.453	0.453	0.453	0.475	0.471	0.472	0.472	0.464	0.462	0.462	0.463
T_4: BA @ 150 ppm	0.453	0.452	0.452	0.452	0.474	0.470	0.471	0.472	0.463	0.461	0.462	0.462
T_5: NAA 10 ppm+ BA 100 ppm	0.449	0.448	0.449	0.449	0.470	0.466	0.467	0.468	0.459	0.457	0.458	0.458
T_6: NAA 10 ppm+ BA 150 ppm	0.448	0.447	0.448	0.447	0.469	0.465	0.466	0.467	0.458	0.456	0.457	0.457
T_7: NAA 20 ppm+ BA 100 ppm	0.448	0.447	0.448	0.448	0.469	0.465	0.467	0.467	0.459	0.456	0.457	0.457
T_8: NAA 20 ppm+ BA 150 ppm	0.447	0.446	0.447	0.446	0.468	0.464	0.466	0.466	0.457	0.455	0.456	0.456
T_9: ATS @ 0.5%	0.452	0.451	0.452	0.452	0.473	0.469	0.470	0.471	0.463	0.460	0.461	0.461
T_{10}: ATS @ 1.0%	0.450	0.450	0.450	0.450	0.472	0.468	0.469	0.470	0.461	0.459	0.460	0.46
T_{11}: KTS@ 1.0%	0.450	0.449	0.450	0.450	0.471	0.467	0.468	0.469	0.460	0.458	0.459	0.459
T_{12}: KTS @ 2.0%	0.446	0.445	0.446	0.446	0.467	0.466	0.465	0.466	0.457	0.456	0.456	0.456
T_{13}: LS @ 3%	0.456	0.455	0.456	0.456	0.477	0.473	0.474	0.475	0.467	0.464	0.465	0.465
T_{14}: LS @ 4%	0.455	0.455	0.455	0.455	0.477	0.473	0.474	0.474	0.466	0.464	0.464	0.465
T_{15}: Potassium Bicarbonate @ 0.5%	0.455	0.454	0.454	0.454	0.476	0.472	0.473	0.474	0.465	0.463	0.464	0.464
T_{16}: Potassium Bicarbonate @ 1.0%	0.454	0.453	0.454	0.454	0.475	0.471	0.472	0.473	0.465	0.462	0.463	0.463
T_{17}: Control	0.457	0.457	0.457	0.457	0.478	0.478	0.478	0.478	0.467	0.467	0.467	0.467
Mean	0.451	0.451	0.451		0.473	0.469	0.470		0.462	0.460	0.461	
C.D. (≤ 0.05)			C.D. (2021)		C.D. (2022)				Pooled			
Treatment (T)			0.001		0.002				0.001			
Time of application (A)			NS		NS				NS			
Treatment (T) X Time of application (A)			NS		NS				NS			

Table 5: Effect of blossom thinning chemicals on Leaf Nitrogen (%) of apple cv. Red Breaburn under high density planting system.

	2021				2022				Pooled			
	50% Bloom	100% Bloom	50% Petal fall	Mean	50% Bloom	100% Bloom	50% Petal fall	Mean	50% Bloom	100% Bloom	50% Petal fall	Mean
T_1: NAA @ 10 ppm	2.137	2.110	2.147	2.131	2.203	2.177	2.207	2.196	2.173	2.147	2.180	2.167
T_2: NAA @ 20 ppm	2.163	2.263	2.173	2.200	2.230	2.330	2.233	2.264	2.200	2.300	2.207	2.236
T_3: BA @ 100 ppm	2.107	2.210	2.117	2.144	2.173	2.277	2.177	2.209	2.143	2.247	2.150	2.180
T_4: BA @ 150 ppm	2.117	2.220	2.127	2.154	2.183	2.287	2.187	2.219	2.153	2.257	2.160	2.190
T_5: NAA 10 ppm+ BA 100 ppm	2.170	2.270	2.180	2.207	2.237	2.337	2.240	2.271	2.207	2.307	2.213	2.242
T_6: NAA 10 ppm+ BA 150 ppm	2.177	2.280	2.183	2.213	2.243	2.347	2.243	2.278	2.213	2.317	2.217	2.249
T_7: NAA 20 ppm+ BA 100 ppm	2.180	2.283	2.190	2.218	2.247	2.350	2.250	2.282	2.217	2.320	2.223	2.253
T_8: NAA 20 ppm+ BA 150 ppm	2.197	2.300	2.203	2.233	2.263	2.367	2.263	2.298	2.233	2.337	2.237	2.269
T_9: ATS @ 0.5%	2.127	2.230	2.137	2.164	2.193	2.297	2.197	2.229	2.163	2.267	2.170	2.200
T_{10}: ATS @ 1.0%	2.143	2.243	2.153	2.180	2.210	2.310	2.213	2.244	2.180	2.280	2.187	2.216
T_{11}: KTS@ 1.0%	2.153	2.253	2.163	2.190	2.220	2.320	2.223	2.254	2.190	2.290	2.197	2.226
T_{12}: KTS @ 2.0%	2.187	2.293	2.197	2.226	2.253	2.360	2.257	2.290	2.223	2.330	2.230	2.261
T_{13}: LS @ 3%	2.067	2.170	2.077	2.104	2.133	2.237	2.137	2.169	2.103	2.207	2.110	2.140
T_{14}: LS @ 4%	2.077	2.180	2.087	2.114	2.143	2.247	2.147	2.179	2.113	2.217	2.120	2.150
T_{15}: Potassium Bicarbonate @ 0.5%	2.087	2.190	2.097	2.124	2.153	2.257	2.157	2.189	2.123	2.227	2.130	2.160

T_{16}: Potassium Bicarbonate @ 1.0%	2.097	2.200	2.107	2.134	2.163	2.267	2.167	2.199	2.133	2.237	2.140	2.170
T_{17}: Control	2.094	2.094	2.094	2.094	2.227	2.227	2.227	2.227	2.110	2.110	2.110	2.110
Mean	2.132	2.227	2.141		2.205	2.294	2.207		2.171	2.264	2.178	
C.D. (≤ 0.05)			C.D. (2021)			C.D. (2022)			Pooled			
Treatment (T)			0.081			0.072			0.076			
Time of application (A)			0.034			0.047			0.040			
Treatment (T) X Time of application (A)			NS			NS			NS			

Table 6: Effect of blossom thinning chemicals on Leaf Phosphorus (%) of apple cv. Red Breaburn under high density planting system.

	2021				**2022**				**Pooled**			
	50% Bloom	**100% Bloom**	**50% Petal fall**	**Mean**	**50% Bloom**	**100% Bloom**	**50% Petal fall**	**Mean**	**50% Bloom**	**100% Bloom**	**50% Petal fall**	**Mean**
T_1: NAA @ 10 ppm	0.223	0.233	0.230	0.229	0.257	0.277	0.267	0.267	0.243	0.257	0.253	0.251
T_2: NAA @ 20 ppm	0.233	0.243	0.240	0.239	0.267	0.287	0.277	0.277	0.253	0.267	0.263	0.261
T_3: BA @ 100 ppm	0.213	0.223	0.220	0.219	0.247	0.267	0.257	0.257	0.233	0.247	0.243	0.241
T_4: BA @ 150 ppm	0.217	0.227	0.223	0.222	0.250	0.270	0.260	0.260	0.237	0.250	0.247	0.244
T_5: NAA 10 ppm+ BA 100 ppm	0.237	0.247	0.243	0.242	0.270	0.290	0.280	0.280	0.257	0.270	0.267	0.264
T_6: NAA 10 ppm+ BA 150 ppm	0.240	0.250	0.247	0.246	0.273	0.290	0.280	0.281	0.260	0.273	0.267	0.267
T_7: NAA 20 ppm+ BA 100 ppm	0.245	0.253	0.250	0.251	0.277	0.293	0.287	0.286	0.263	0.277	0.273	0.273
T_8: NAA 20 ppm+ BA 150 ppm	0.254	0.260	0.257	0.256	0.287	0.300	0.290	0.292	0.273	0.283	0.277	0.278
T_9: ATS @ 0.5%	0.220	0.230	0.227	0.226	0.253	0.270	0.260	0.261	0.240	0.253	0.247	0.247
T_{10}: ATS @ 1.0%	0.227	0.237	0.233	0.232	0.260	0.277	0.270	0.269	0.247	0.260	0.257	0.254
T_{11}: KTS@ 1.0%	0.230	0.240	0.237	0.236	0.263	0.280	0.277	0.273	0.250	0.263	0.260	0.258
T_{12}: KTS @ 2.0%	0.250	0.257	0.253	0.253	0.283	0.300	0.290	0.291	0.270	0.280	0.277	0.276
T_{13}: LS @ 3%	0.193	0.207	0.203	0.201	0.227	0.247	0.240	0.238	0.213	0.230	0.227	0.223
T_{14}: LS @ 4%	0.197	0.210	0.207	0.204	0.230	0.250	0.247	0.242	0.217	0.233	0.230	0.227
T_{15}: Potassium Bicarbonate @ 0.5%	0.203	0.217	0.213	0.211	0.237	0.257	0.250	0.248	0.223	0.240	0.237	0.233
T_{16}: Potassium Bicarbonate @ 1.0%	0.210	0.220	0.217	0.216	0.243	0.260	0.257	0.253	0.230	0.243	0.240	0.238
T_{17}: Control	0.183	0.183	0.183	0.183	0.217	0.217	0.217	0.217	0.203	0.203	0.203	0.203
Mean	0.222	0.232	0.228		0.255	0.272	0.265		0.242	0.255	0.251	
C.D. (≤ 0.05)			**C.D. (2021)**			**C.D. (2022)**			**Pooled**			
Treatment (T)			0.006			0.007			0.006			
Time of application (A)			0.002			0.003			0.003			
Treatment (T) X Time of application (A)			NS			NS			NS			

Table 7: Effect of blossom thinning chemicals on Leaf Potassium (%) of apple cv. Red Breaburn under high density planting system.

	2021				**2022**				**Pooled**			
	50% Bloom	**100% Bloom**	**50% Petal fall**	**Mean**	**50% Bloom**	**100% Bloom**	**50% Petal fall**	**Mean**	**50% Bloom**	**100% Bloom**	**50% Petal fall**	**Mean**
T_1: NAA @ 10 ppm	1.797	1.807	1.800	1.801	1.837	1.840	1.840	1.839	1.820	1.827	1.823	1.823
T_2: NAA @ 20 ppm	1.807	1.817	1.810	1.811	1.847	1.850	1.850	1.849	1.830	1.837	1.833	1.833
T_3: BA @ 100 ppm	1.783	1.793	1.787	1.788	1.823	1.827	1.827	1.826	1.807	1.813	1.810	1.810
T_4: BA @ 150 ppm	1.787	1.803	1.790	1.793	1.827	1.837	1.827	1.830	1.810	1.823	1.813	1.816
T_5: NAA 10 ppm+ BA 100 ppm	1.810	1.820	1.813	1.814	1.850	1.853	1.850	1.851	1.833	1.840	1.837	1.837
T_6: NAA 10 ppm+ BA 150 ppm	1.813	1.823	1.817	1.818	1.853	1.857	1.857	1.856	1.837	1.843	1.840	1.840
T_7: NAA 20 ppm+ BA 100 ppm	1.818	1.823	1.820	1.821	1.857	1.857	1.860	1.858	1.842	1.843	1.843	1.844
T_8: NAA 20 ppm+ BA 150 ppm	1.823	1.827	1.827	1.826	1.863	1.860	1.867	1.863	1.847	1.847	1.850	1.848
T_9: ATS @ 0.5%	1.793	1.803	1.797	1.798	1.833	1.837	1.837	1.836	1.817	1.823	1.820	1.820
T_{10}: ATS @ 1.0%	1.800	1.810	1.803	1.804	1.840	1.843	1.840	1.841	1.823	1.830	1.827	1.827
T_{11}: KTS@ 1.0%	1.803	1.813	1.807	1.808	1.843	1.847	1.847	1.846	1.827	1.833	1.830	1.830
T_{12}: KTS @ 2.0%	1.820	1.827	1.823	1.823	1.860	1.860	1.863	1.861	1.843	1.847	1.847	1.846
T_{13}: LS @ 3%	1.763	1.777	1.767	1.769	1.803	1.810	1.803	1.806	1.787	1.797	1.790	1.791
T_{14}: LS @ 4%	1.767	1.780	1.770	1.772	1.807	1.813	1.807	1.809	1.790	1.800	1.793	1.794
T_{15}: Potassium Bicarbonate @ 0.5%	1.773	1.787	1.777	1.779	1.813	1.820	1.813	1.816	1.797	1.807	1.800	1.801
T_{16}: Potassium Bicarbonate @ 1.0%	1.780	1.793	1.783	1.786	1.820	1.827	1.820	1.822	1.803	1.813	1.807	1.808
T_{17}: Control	1.762	1.762	1.762	1.762	1.797	1.797	1.797	1.797	1.780	1.780	1.780	1.780
Mean	1.794	1.804	1.797		1.834	1.837	1.835		1.817	1.824	1.820	
C.D. (≤ 0.05)			C.D. (2021)			C.D. (2022)			Pooled			
Treatment (T)			0.005			0.006			0.004			
Time of application (A)			0.002			NS			0.002			
Treatment (T) X Time of application (A)			NS			NS			NS			

Table 8: Effect of blossom thinning chemicals on Leaf Calcium (%) of apple cv. Red Breaburn under high density planting system.

	2021				2022				Pooled			
	50% Bloom	100% Bloom	50% Petal fall	Mean	50% Bloom	100% Bloom	50% Petal fall	Mean	50% Bloom	100% Bloom	50% Petal fall	Mean
T_1: NAA @ 10 ppm	1.783	1.787	1.783	1.784	1.817	1.820	1.810	1.816	1.803	1.807	1.800	1.803
T_2: NAA @ 20 ppm	1.793	1.790	1.793	1.792	1.827	1.837	1.823	1.829	1.813	1.817	1.810	1.813
T_3: BA @ 100 ppm	1.783	1.783	1.783	1.783	1.797	1.800	1.803	1.800	1.793	1.793	1.797	1.794
T_4: BA @ 150 ppm	1.783	1.783	1.783	1.783	1.803	1.807	1.810	1.807	1.797	1.797	1.800	1.798
T_5: NAA 10 ppm+ BA 100 ppm	1.793	1.790	1.790	1.791	1.830	1.863	1.823	1.839	1.817	1.830	1.807	1.818
T_6: NAA 10 ppm+ BA 150 ppm	1.793	1.790	1.790	1.791	1.833	1.560	1.827	1.740	1.817	1.680	1.810	1.769
T_7: NAA 20 ppm+ BA 100 ppm	1.793	1.793	1.793	1.793	1.833	1.843	1.843	1.840	1.817	1.823	1.820	1.820
T_8: NAA 20 ppm+ BA 150 ppm	1.793	1.830	1.830	1.818	1.837	1.833	1.830	1.833	1.817	1.833	1.833	1.828
T_9: ATS @ 0.5%	1.783	1.780	1.783	1.782	1.810	1.813	1.817	1.813	1.800	1.800	1.803	1.801
T_{10}: ATS @ 1.0%	1.787	1.787	1.790	1.788	1.820	1.827	1.830	1.826	1.807	1.810	1.813	1.810
T_{11}: KTS@ 1.0%	1.790	1.793	1.793	1.792	1.823	1.833	1.833	1.830	1.810	1.817	1.817	1.814
T_{12}: KTS @ 2.0%	1.793	1.793	1.793	1.793	1.840	1.840	1.847	1.842	1.820	1.820	1.823	1.821
T_{13}: LS @ 3%	1.783	1.780	1.783	1.782	1.787	1.790	1.793	1.790	1.787	1.787	1.790	1.788
T_{14}: LS @ 4%	1.783	1.783	1.780	1.782	1.793	1.797	1.800	1.797	1.790	1.793	1.793	1.792
T_{15}: Potassium Bicarbonate @ 0.5%	1.783	1.780	1.780	1.781	1.790	1.793	1.797	1.793	1.790	1.790	1.790	1.790
T_{16}: Potassium Bicarbonate @ 1.0%	1.783	1.783	1.780	1.782	1.793	1.797	1.800	1.797	1.790	1.793	1.793	1.792
T_{17}: Control	1.690	1.690	1.690	1.690	1.708	1.708	1.708	1.708	1.701	1.701	1.701	1.701
Mean	1.772	1.788	1.789		1.813	1.802	1.803		1.795	1.798	1.798	
C.D. (≤ 0.05)			C.D. (2021)			C.D. (2022)			Pooled			
Treatment (T)			NS			NS			NS			
Time of application (A)			NS			NS			NS			
Treatment (T) X Time of application (A)			NS			NS			NS			

Conclusion

From this study it was concluded that chemical thinning had a significant effect on fruit and leaf mineral concentrations. With increase in the thinning concentration and decrease in crop load, the fruit N, P, K increases and Ca concentration decreases. Also thinning resulted in increase in leaf N, P and K. However the effect of thinning on leaf calcium content was found to be insignificant.

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