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Effect of good viticultural practices to reduce bunch compactness and berry size improvement in grapes cv. 'crimson seedless

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Abstract
The Grape variety, Crimson Seedless suffers from berry size and bunch compactness, which has bearing with its marketability and economic returns. The objective of this study was to evaluate various viticultural techniques, such as berry thinning (at 8-10 mm berry size), basal leaf removal, bunch covering and ethrel dip @ 500 ppm (at veraison stage) either in single or in different combinations to prevent bunch compactness and physiological loss in weight, and improve in berry size. The experiment was conducted during two consecutive seasons (2015-2017) in a vineyard located at ICAR-Indian Institute of Horticultural Research, Bengaluru, India. The prevalence of bunch compactness was evaluated considering the levels of compact ratio. The physical characteristics of bunches and the berries were also evaluated. Among the treatments, the highest mean bunch weight of 699.83 and 663.40 g, better bunch compactness ratio of 1.799 and 1.617, berry diameter of 18.31 and 19.03 mm, 50 berry weight of 230 and 274.40 g, and pulp to peel ratio of 9.246 and 9.243, and lower physiological loss in weight (PLW) of 24.82 and 15.49% during season-I and season-II, respectively were recorded under the combinations of berry thinning + 500 ppm ethrel dip + basal leaf removal. Berry thinning at 8-10 mm in diameter is efficient for reducing bunch compactness, as it resulted in a higher incidence of medium loose and lower incidence of very dense bunches with optimum PLW and higher berry size in Crimson Seedless grapes

Keywords: viticultural, thinning, bunch compactness and Crimson Seedless

Introduction
Grape (*Vitis vinifera* L.) is one of the important fruit crops of India. It is cultivated on an area of more than 1.38 lakh hectare with the annual production of 29.67 lakh tonnes (Indian Horticulture Database, 2017) [9]. The major grape growing states are Karnataka, Andhra Pradesh, Telangana and Tamil Nadu in the South, Maharashtra in the West and Punjab, Haryana and Uttar Pradesh in the North. Among grape growing states, Karnataka stands second in area after Maharashtra. In mild tropics of Karnataka, area under coloured grapes is increasing steadily due to introduction of new exotic cultivars.

'Crimson Seedless' is a novel cultivar of seedless table grape recommended for cultivation in tropical and subtropical areas, with excellent horticultural performance. Its berries are firm, crisp and have good flavour with skin colour varying from cherry red to black. This grape is an excellent option for the overseas market because of its firmness and flavour, but it has the inconvenience of presenting compact bunches and uneven colour development (Maia *et al*., 2014; Khamis *et al*., 2015) [15, 11].

Good quality in table grape represents a combination of medium size uniform bunches, perfect berries with the characteristic colour, bold berries, pleasing flavour, and texture of the variety. Thus, the production focused on the quality seedless grape market is increasingly demanding skilled labour, specialized services and the use of new technologies, such as specific thinning techniques. The berry thinning is an important cultural practice in grape production which helps in preventing the bunch compactness by making assimilates available for the growth and development of remaining berries (Leao and Soares, 2010) [14].

For some varieties of seedless grapes, chemical thinning can be accomplished with the use of the plant growth regulator, gibberellic acid (GA_3), applied during flowering (Gonzaga and Ribeiro, 2009; Hanni *et al*., 2013) [7, 8]. However, this technique does not allow the extraction of berries in a uniform and systematic manner. Flower cluster thinning prior to anthesis or manual thinning at 8-10 mm berry size stage, widely used for table grapes

(Kishino and Roberto, 2007) [12]. Rodriguez *et al*. (2013) [23] suggested in removal of 25-30% berries located in compact portions at fruit set stage along both sides of the rachis, followed by bunch tipping. It is highly effective technique for berry thinning. These techniques ensures berries reaching maximum size, besides avoiding deformation of berries and discoloration, and reduce physiological loss in weight and improves sweetness due to higher source/drain ratio and imprinting quality of the remaining berries (Preszler *et al*., 2010; Pastore *et al*., 2011) [20, 19].

In the present investigation, we evaluated good viticultural techniques at fruit setting stage to prevent bunch compactness and improve berry size with a minimum physiological loss in weight. The study will largely help grape growers to produce good quality grapes and earn better returns from quality grapes.

Materials and Methods

Grapevine growing conditions

This study was conducted in the vineyard of 4 years old Crimson Seedless vines grafted on 'Dogridge' rootstock, located at ICAR-Indian Institute of Horticultural Research, Bengaluru, India (13°58'N latitudes, 77°E longitudes and altitude 890 m), in two consecutive crop seasons of 2015-16 and 2016-17. The vines were trained on Y-trellis and spaced at 3 × 2.5 m apart. The soil was predominantly red sandy loam having a pH ranged 5.2 - 6.4. During the experimentation mean maximum temperature ranged from 30.4°C to 34.5°C and the minimum from 17.4°C to 20.8°C. The experimental vines were fertilized with organic manure and commercial inorganic fertilisers as per the recommendations made for this region. The details of seven treatmental combinations along with one control were as follows: berry thinning (at 8-10 mm berry size), basal leaf removal, bunch covering and ethrel application @ 500 ppm (during veraison stage) either in alone or in combinations.

The berry thinning operations in both the seasons were carried out after winter pruning when the berries were 8-10 mm size, and all other treatments were imposed at veraison stage. Thinning was done manually with scissors, in which 25-30% of pea sized berries were removed in a zig zag manner, so as to give proper space between the berries with in a rachis (Fitzgerald and Patterson, 1994; Palliotti and Cartechini, 1998) [5,17]. Ethrel @ 500 ppm was prepared and bunch was dipped under each treatment immediately after veraison stage. Basal leaf removal was also implemented at veraison stage where the basal leaves in a shoot bearing bunch was removed. It allowed the berries for getting proper sunlight and more translocation of assimilates from the remaining leaves. The treatment with bunch covering was done at veraison stage using locally available news paper. The field experiment was designed as randomized block design with eight treatments and four replications. Each replication consisted of four vines for recording all the observations.

Bunch physical characteristics

Harvested bunches from the treated vines were weighed by using electronic balance, computed for mean bunch weight and expressed in grams. The bunch volume was determined by the conventional water displacement method and expressed in cubic centimetres. The number of berries per bunch was recorded by counting the total number of berries in each of selected bunches per replication per treatment and average number of berries in a bunch was computed.

The bunch compactness was computed by dividing the total number of berries per bunch to the rachis length and the ratio was depicted according to Gonzaga and Ribeiro (2009) [7], and expressed as number of berries per centimetre length.

$$\textbf{Compact ratio} = \frac{\text{Total number of berries in a bunch}}{\text{Total length of rachis in a bunch}} \times 100$$

Berry physical characteristics

Randomly selected ten berries in each replication per treatment were used for measuring the diameter at the broadest region by using digital vernier callipers. Average berry diameter was calculated and expressed in millimetre. Mean fifty berry weight of all the treatments was calculated separately and expressed in grams. For calculating pulp to peel ratio, 10 berries were dissected and the peel was separated from pulp and seeds. The pulp and peel weight was recorded separately in milligrams and the pulp to peel ratio was worked out. Maturity Index is dependent on total soluble solids and per cent acidity. It was calculated by dividing the total soluble solids content (ºbrix) of the juice by corresponding titratable acidity.

Physiological loss in weight (PLW)

The selected bunches from each treatment was kept at room temperature for the assessment of berry weight loss. Percent loss in weight was calculated using the following formula suggested by Srivastava and Tandon (1968) [26]. The mean physiological loss in weight (PLW) was worked out until week days after harvest, and it was expressed as percentage.

$$\text{PLW (\%)} = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

All the data were subjected to statistical analysis using online OPSTAT software and analyzed as per Panse and Sukhatme (1985) [18] to separate the means at 5% level of significance.

Results and Discussion

Agro techniques such as ethrel dip, berry thinning and basal leaf removal are important for quality grape production. Our experimental results showed that bunch compact ratio varied significantly among different treatments, and the minimum ratio considered the better cluster compactness. The treatment combination of berry thinning, ethrel dip @ 500 ppm and basal leaf removal yielded better cluster compactness of 1.799 and 1.617 in bunches as compared to control, followed by berry thinning + ethrel dip (500 ppm) + basal leaf removal + bunch covering (1.862 and 1.676) during both the seasons (Table 1). The lower bunch compactness might be due to thinning practice along with application of basal leaf removal that help in making higher assimilates available for better growth and development of berries. The basal leaf removal is also advantageous in minimizing the shade on clusters, and thereby aiding lower parasitism of older leaves. The higher cluster compactness of 3.125 and 2.502 was registered with untreated control, where no thinning practice was applied. Additionally, less compaction in berries allows the applied fungicides better absorptivity to protect against attack by pathogenic fungi or saprophytes (Kishino and Roberto, 2007; Pastore *et al*., 2011) [12, 19].

Different viticultural practices significantly influenced mean bunch weight either in season-I or season-II. The maximum bunch weight of 699.83 and 663.40 g was recorded in the treatment combination of berry thinning + ethrel dip (500 ppm) + basal leaf removal during both the seasons (Table 1). The higher bunch weight might be due to more translocation of assimilates to developing bunches from shoots that are leaf removed. Besides, ethrel application favours in better cell division at intitial stage of development and cell expansion at later stages (Pastore *et al*., 2011) [19]. These results are in conformity with the findings of Morris *et al*. (2004) [16] that cluster thinning helped in increasing bunch weight in cultivars Chancellor and Villard Noir. Similar findings were also reported by Somkuwar *et al.* (2008a); Roberto *et al*. (2015) [25, 22].

During first season, the maximum bunch volume of 783.33 cm^3 was recorded in the treatmental combination of berry thinning + ethrel dip (500 ppm) + basal leaf removal + bunch covering. But in case of season-II, the maximum bunch volume of 615 cm^3 was registered in berry thinning, 500 ppm ethrel dip and basal leaf removal, which was superior over control (Fig. 1). The combinations of ethrel dip along with berry thinning and basal leaf removal have acted on powerful sinks, triggered the enhanced flow of metabolites that resulted in increased bunch volume. A similar finding was supported by Cawthon and Morris (1982) [1].

The maximum number of berries per bunch of 224.33 and 178.00 was recorded in untreated control, as it was expected due to no thinning practices, However, the treatment combination with berry thinning, ethrel dip @ 500 ppm and basal leaf removal recorded optimum number of berries per bunch of 165.67 and 114.00 during season-I and II, respectively (Table 1). The loss in berry number per bunch seems to be well compensated by increased berry weight at later stages. These results are supported by the findings of workers in 'Perlette' by Dhillon *et al*. (1988) and Cheema *et al*. (1997) [3, 2] and, 'Merlot' and 'Cabernet Sauvignon' by Karoglan *et al*. (2014) [10].

The increase in berry size, which is the most characteristic response of grape varieties, can be a major factor contributing to the bunch weight. The maximum berry diameter of 18.31 and 19.03 mm was recorded by treating the bunches with combination of berry thinning, ethrel dip @ 500 ppm and basal leaf removal and it was significantly superior over other treatments in both the seasons (Table 2). Increased berry size might be due to thinning effect along with ethrel and leaf removal was able to mobilize the carbohydrates, for better growth and development through cell expansion and cell division. Some other worker have also reported increase in berry size with berry thinning along with 500 ppm ethrel dip at veraison stage in grape cultivar Thompson Seedless by Saad *et al*. (1979) [24].

The maximum 50-berry weight of 230.00 and 274.40 g was recorded in the treatment combination of berry thinning, ethrel dip (500 ppm) and basal leaf removal (Table 2). This is in consistent with the results of higher berry diameter. The berry thinning is expected to minimize the number of berries per bunch, which reduces the competition between the berries on essential metabolites. Also, the positive action of ethrel application on stimulating cell elongation process, enhancing the water absorption by roots and stimulating the biosynthesis of proteins (Roberto *et al*. (2017) [21] will lead increased berry weight. The lower berry weight in untreated control and bunch covering treatments was due to no berry thinning effect. This is consistent with the other results that showed cluster thinning resulted in increased cluster weight in Thompson Seedless by Somkuwar *et al.*, 2008a) [25].

In Crimson Seedless, during first year crop, the maximum pulp to peel ratio of 9.246 was recorded through berry thinning at 8-10 mm size and in case of second season, berry thinning, ethrel dip (500 ppm) and basal leaf removal (9.243) which was superior to other treatments (Table 2). This variation in pulp to peel ratio may be due to various viticultural practices applied coupled with ethrel dip. Similar results were recorded by Venkataram Prasad (1989) [27] in Thompson Seedless and Anab-e-Shahi grapes.

Maturity index dependent on total soluble solids and acidity; is an important attributes of harvest and quality of table grapes. In the present study, a significant difference in the TSS/TA ratio was recorded among various treatments in both the seasons. The maximum maturation index of 83.53 was recorded in bunches treated with combination of berry thinning, ethrel dip (500 ppm) and basal leaf removal during season-I, while in season-II, it was 85.52 in berry thinning along with 500 ppm ethrel dip treatment (Fig. 2). As the fruit flavour is mostly derived from the balance between sugars and organic acids (TSS/TA), a high value of this index is considered desirable tract for marketability. The increased TTS/TA due to berry thinning along with other treatments could be the outcome of better carbohydrate translocation into sinks to facilitate improved berry growth and hastened ripening.

A grape being a non climacteric fruit gets subjected to physiological deterioration and physiological loss in weight (PLW) during storage especially at room temperature. The minimum PLW is signatory to better shelf life of grapes.

Among the treatments, the minimum PLW of 23.56% was recorded in berry thinning, ethrel dip (500 ppm) along with basal leaf removal, while it was 15.49% during season-II with the treatment combination of berry thinning + ethrel dip (500 ppm) + basal leaf removal + bunch covering (Fig. 3). The maximum PLW of 32.83% was registered with control during season-I and at season-II with bunch covering at veraison stage (21.01%). Higher physiological loss in weight (PLW) could be due to greater transpirational moisture losses from berries, and increased respiratory activity and degradative processes occurring during storage. The higher moisture loss in most of the table grapes during storage and transport is expected to hamper grape quality and economic returns. Similar observations was recorded by Kumar and Chharia (1990); Doshi and Adsule (2008); Gill *et al*. (2015) [13, 4, 6].

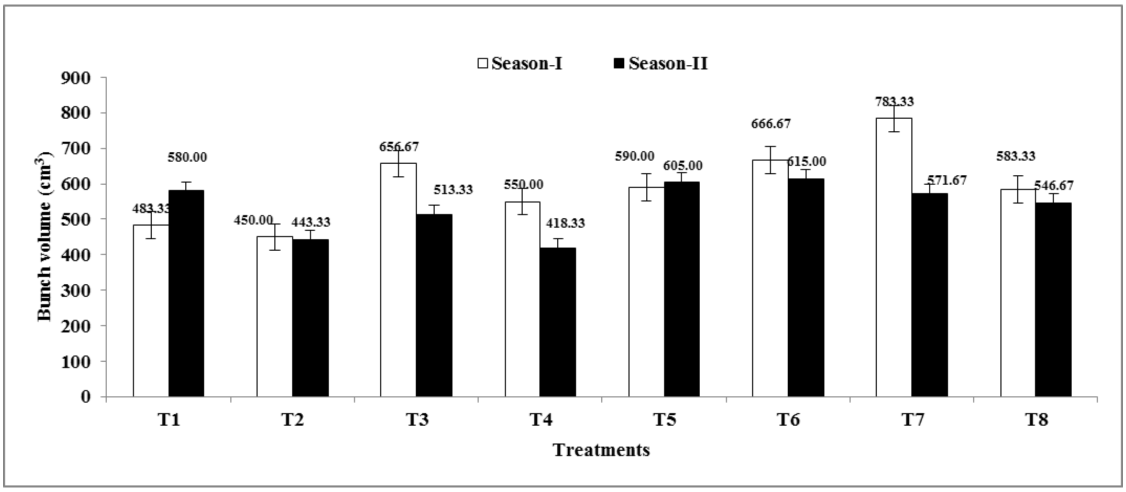

Fig 1: Effect of various viticultural practices on bunch volume in grapes cv. Crimson Seedless
Treatments: T_1 – Berry thinning at 8-10 mm size; T_2 – Ethrel (500 ppm) at veraison; T_3 – Basal leaf removal at veraison; T_4 – Bunch covering at veraison; T_5 – Berry thinning + Ethrel (500 ppm); T_6- Berry thinning + Ethrel (500 ppm) + Basal leaf removal; T_7- Berry thinning + Ethrel (500 ppm) + Basal leaf removal + Bunch covering; T_8 - Control

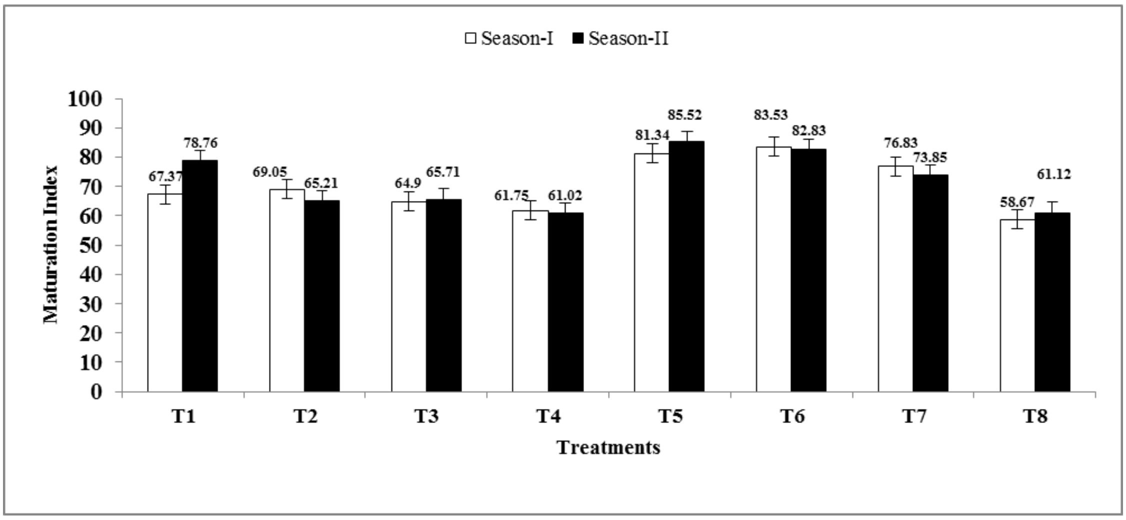

Fig 2: Effect of various viticultural practices on maturation index of grapes cv. Crimson Seedless
Treatments: T_1 – Berry thinning at 8-10 mm size; T_2 – Ethrel (500 ppm) at veraison; T_3 – Basal leaf removal at veraison; T_4 – Bunch covering at veraison; T_5 – Berry thinning + Ethrel (500 ppm); T_6- Berry thinning + Ethrel (500 ppm) + Basal leaf removal; T_7- Berry thinning + Ethrel (500 ppm) + Basal leaf removal + Bunch covering; T_8 - Control

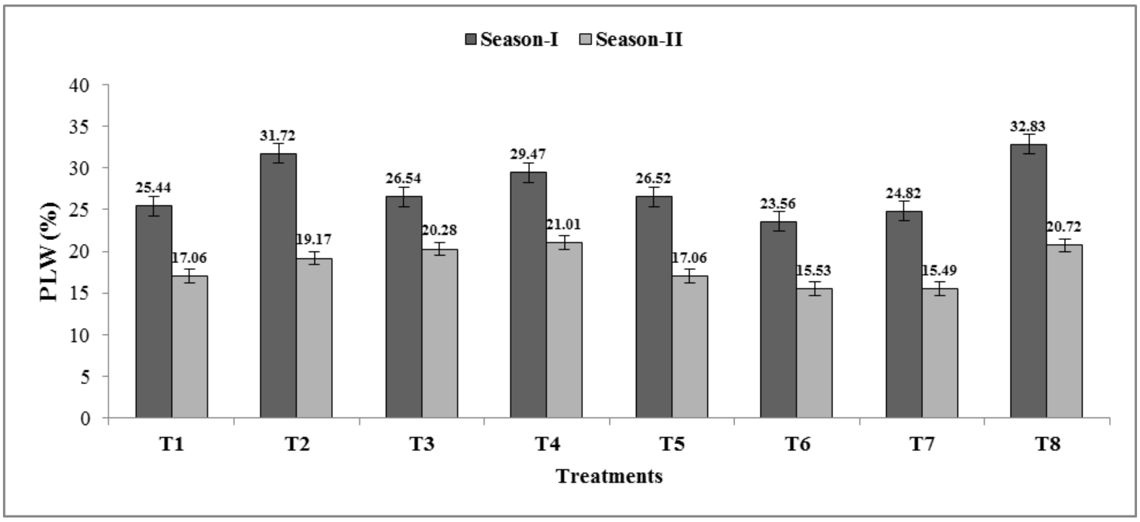

Fig 3: Effect of various viticultural practices on physiological loss in weight of grapes cv. Crimson Seedless
Treatments: T_1 – Berry thinning at 8-10 mm size; T_2 – Ethrel (500 ppm) at veraison; T_3 – Basal leaf removal at veraison; T_4 – Bunch covering at veraison; T_5 – Berry thinning + Ethrel (500 ppm); T_6- Berry thinning + Ethrel (500 ppm) + Basal leaf removal; T_7- Berry thinning + Ethrel (500 ppm) + Basal leaf removal + Bunch covering; T_8 - Control

Table 1: Effect of various viticultural practices on bunch characteristics of grapes cv. Crimson Seedless

Treatments	Cluster compactness		Mean bunch weight (g)		No. of berries per bunch	
	Season I (2015-16)	Season II (2016-17)	Season I (2015-16)	Season II (2016-17)	Season I (2015-16)	Season II (2016-17)
Berry thinning at 8-10 mm size	1.881	1.853	503.33	655.93	122.33	119.00
Ethrel dip (500 ppm) at veraison	2.482	2.049	467.83	503.93	181.33	147.67
Basal leaf removal at veraison	2.723	2.473	548.67	549.37	198.67	143.00
Bunch covering at veraison	2.057	1.922	538.67	561.50	191.33	129.67
Berry thinning + Ethrel dip (500 ppm)	1.858	1.908	690.00	658.63	152.00	123.00
Berry thinning + Ethrel dip (500 ppm) + Basal leaf removal	1.799	1.617	699.83	663.40	165.67	114.00
Berry thinning + Ethrel dip (500 ppm) + Basal leaf removal + Bunch covering	1.862	1.676	536.50	576.87	127.67	124.33
Control	3.125	2.502	457.67	559.23	224.33	178.00
SE (m)±	0.082	0.079	10.965	11.647	11.434	11.244
CD (p ≤ 5%)	0.253	0.242	33.581	35.671	35.016	34.435

Table 2: Effect of various viticultural practices on berry characteristics of grapes cv. Crimson Seedless

Treatments	Berry diameter (mm)		50-Berry weight (g)		Pulp-Peel ratio	
	Season I (2015-16)	Season II (2016-17)	Season I (2015-16)	Season II (2016-17)	Season I (2015-16)	Season II (2016-17)
Berry thinning at 8-10 mm size	17.71	18.63	212.00	248.47	9.265	8.222
Ethrel dip (500 ppm) at veraison	16.56	17.99	200.33	239.17	7.209	7.039
Basal leaf removal at veraison	17.09	18.35	199.67	214.00	7.289	7.598
Bunch covering at veraison	16.61	18.10	181.00	242.10	7.186	7.691
Berry thinning + Ethrel dip (500 ppm)	17.12	18.91	201.33	264.73	8.217	8.189
Berry thinning + Ethrel dip (500 ppm) + Basal leaf removal	18.31	19.03	230.00	274.40	9.246	9.243
Berry thinning + Ethrel dip (500 ppm) + Basal leaf removal + Bunch covering	17.73	18.91	215.00	255.53	8.768	8.289
Control	16.23	17.24	175.33	214.60	7.217	7.458
SE (m)±	0.236	0.254	9.079	10.273	0.177	0.205
CD (p ≤ 5%)	0.721	0.778	27.807	31.463	0.542	0.627

Conclusion

In summary, berry thinning practice in ‘Crimson Seedless’ is suggested an important table grape activity to obtain high quality bunches with less physiological loss in berry weight. It was found that the ethrel dip along with other good viticultural practices helped in advancing the berry ripening and improving its quality attributes in terms of berry size and bunch decompaction as well as better maturation index. In commercially important grape variety ‘Crimson Seedless’ concluded that, the treatment with combination of berry thinning + ethrel dip (500 ppm) + basal leaf removal can be followed to overcome the unfavourable characteristics of its clusters, to produce decompact bunches with best presentation shape and quality.

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