Effect of Fruit Thinning on 'Hosui' Pear Fruit Quality and Yield

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ABSTRACT

In Bhutan, naturally occurring local type of pears were grown. Asian or Nashi pears are recent introduction which have become quite popular in eastern Bhutan since it was promoted by Agriculture Research and Development Centre (ARDC) Wengkhar. Although, horticulture has been gaining momentum in recent years, many growers in Bhutan follow traditional methods of crop cultivation and thus, majority of farmers still do not adopt important aspects of fruit production like fruit thinning. In commercial fruit farms elsewhere, fruit thinning is an essential management practice. However, in Bhutan, it is rarely practiced and there is no empirical study on its benefits. Fruit thinning is believed to be beneficial in increasing yield efficiency whilst also sustaining or increasing market returns by improving the fruit size and quality. Thus, a study was conducted in 2019 and 2020 at ARDC, Wengkhar. Effect of hand thinning on Hosui pear was assessed by randomly sampling 15-year-old Hosui trees with four replications – each tree treated as an experimental unit. Canopy of these trees were divided into two equal halves so that one half represents thinning and the other half non-thinning treatments. The treatments were randomly assigned to the two halves of each tree. Hand thinning resulted in significant increase in the fruit weight by 39%, fruit diameter by 12% and fruit height by 12 % over the non-thinning treatments; Total Soluble Solids (TSS) content, an indicator of taste, was greater by 9%. However, the overall yield was lower in the thinning treatments but in the second year of the study, the mean fruit yield in thinning treatments increased by 55% while the yield of non-thinning treatments plummeted by 33%. Hence, the study indicates that fruit thinning has significant effect on fruit quality and yield stability.

Keywords: *Fruit firmness; Fruit size; Fruit yield; Hand thinning; Hosui; TSS*

1. Introduction

In general, pears are grown between an altitude of 955 to 2700 m above mean sea level in the country but Asian pear gained popularity in the east after its introduction to ARDC Wengkhar in 2002 (Phuntsho et al., 2011). In Bhutan, it was mostly the naturally occurring local type with egg sized fruit with hard pulp (Brix of 12 %) consumed after drying (Phuntsho et al., 2010). A robust promotional program on horticulture in the eastern region led to farmers taking up mixed fruit farming of pear, peach, plum and persimmon (Katwal, 2013) but agriculture in Bhutan is still traditional in nature and majority of farmers are illiterate so research and extension programs play key role in the promotion of vibrant agricultural sector (Tobgay, 2006).

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Fruit thinning is one of the critical aspects of commercial fruit farming in many developing and advanced countries. However, in Bhutan, it is rarely practiced and farmers are yet to realize its real benefits. Fruit thinning basically means removal of excess fruits especially those that are misshaped, weak and diseased so as to maintain ideal ratio of leaves to fruits numbers so that fruits are supplied with adequate amount of metabolites. In general, almost all fruits exhibit on and off years resulting in heavy production one year and very low production in the following year. Thus, pear orchards often have problems of vigorous growth and production in one year followed by biennial bearing in the ensuing year (Lafer, 2007). Biennial bearing behavior of fruit trees is also reported by other studies and it is considered as undesirable (Jonkers, 1979). Thinning of fruits during the "on" year has been found to be valuable means to overcome alternate bearing in fruit trees (Monselise & Goldschmidt, 1982). Hence, fruit thinning remains one of the most important and effective cultural management tools to not only avoid undesirable effects of biennial bearing but also to improve fruit size and fruit quality (Greene & Costa, 2012).

Fruit thinning can be done both through use of chemicals and manually. Hand thinning is considered the most reliable although it is the most expensive method (Costa, Blanke, & Widmer, 2012). According to a study by Duhanaj, Susaj, Roshanji, and Susaj (2015), even taking into consideration the cost of hand thinning, it can be recommended especially for small growers and small areas under cultivation like in Bhutan. For chemical thinning, the main drawback is the unpredictability of the results arising from weather and tree factors which might hinder its efficacy (Wertheim, 2000). Hand thinning is an environmentally acceptable method of reducing crop load (Chabikwa, 2008) and it supports the country's efforts towards going organic (Duba, Ghimiray, & Gurung, 2008). Even though, chemical thinning might seem alluring due to its labor efficiency and reduced cost, hand thinning is the way forward for Bhutanese farmers in view of the country's orientation towards organic farming.

2. Materials and Method

The trial was established at a research orchard block at ARDC Wengkhar located 1583 m above mean sea level (27°16. 315' N,091°16.214'E), Mongar, Bhutan. The experiment was carried out using completely randomized design (CRD) with one factor having two levels - thinning and non-thinning treatments. The study used four 15-year-old Hosui trees. Each tree was divided into two parts. Thinning and non-thinning treatments were allotted randomly to each part of the tree which amounted to four thinning treatments and four non-thinning treatments. Fruit thinning was performed with the help of a Japanese Okatsune thinning/harvest shear.

Fruit thinning is usually carried out after the June natural drop. However, physiological fruit drop leads to a reduction of the fruit number per tree (Costa et al., 2012) and early thinning reduces natural drop of remaining fruitlets; so the severe thinning before the first drop reduces the need for later hand thinning (Burge, Spence, & Dobson, 1991). Further, early thinning treatments tend to increase fruit size by causing some stimulation in cell volume in addition to a marked increase in cell number (Sharples, 1968). Hence, the first and second fruit thinning were carried out by the 6th

and 29th of May respectively in both the years. Hand thinning helps eliminate fruits with poor characteristics, such as undersized, dark-green fruit close to the tree trunk or scab or hail affected fruits (Costa et al., 2012). Trees should be thinned so that the potential difference in size can be manifested at harvest (Burge et al., 1991), and therefore, undesirable fruits were removed to maintain only 2 to 3 fruits per each fruit cluster on the experimental units for thinning treatment. The experimental units were covered with a bird net to manage bird damage to fruits.

Fruits were harvested on 12th August in 2019 as well as in 2020. The yield of each experimental unit was measured, and 20 fruits from the eight experimental units were collected for analysis of quality parameters like fruit weight, fruit height, fruit diameter, TSS and firmness. The fruit weight was measured with a digital weighing balance. Fruit height and fruit diameter were measured with a digital vernier caliper. TSS was measured with digital refractometer while a penetrometer was used to measure fruit firmness.

Data was recorded in Microsoft Excel sheet and the Statistical Tool for Agricultural Research (STAR) software was used to analyze pooled data for two years using Analysis of Variance (ANOVA) model.

3. Results and Discussion

Effect of thinning on fruit quality and yield are discussed in terms of fruit quality parameters like TSS, weight, height, firmness and stability of yield.

3.1. Fruit Weight

Reducing levels of fruit set is desirable in order to reduce inter-fruitlet competition for the tree's available resources. Excessive fruit set often results in poor fruit size at harvest (Webster, 2000) but hand thinning induces the production of heavier or larger size fruits (Stampar & Hudina, 2007). Studies conducted have negatively correlated mean fruit weight with crop load (Link, 2000) and the mean fruit weight was found to be increased by hand-thinning treatment (Bound, 2000). Bigger fruits exceeding 170 g fetch better price in the market (Buwalda, Klinac, & Meekings, 1989). In our study, the average weight of fruit from thinning was found to be 273.8 g while the mean weight for fruits from non-thinning treatment was 197.4 g. ANOVA analysis found that thinning produces significantly heavier fruits by LSD ($P < 0.001$) (Table 1). Large pear fruit size is critical to economic success in many markets (Dussi & Sugar, 2010) which can be achieved by thinning of fruits. Fruit thinning consequently helps in fetching good economic return.

3.2. Fruit size (Height and diameter)

Fruit size is also one of the important criteria. Consumers often prefer bigger fruits over smaller ones. Where fruit set is excessive and natural abscission of fruitlets inadequate, methods of increasing their abscission must be employed if large fruit size at harvest is to be achieved (Webster, 2000). The practice of hand thinning can be beneficial to increase fruit size and color by

singling fruit within the cluster; it also reduces the incidence of pest and diseases (Robinson, Lakso, Greene, & Hoying, 2013). As indicated in Table 1, fruits from thinned treatments are significantly greater in both mean height and diameter ($P<0.001$). The mean height of fruits on the thinned treatments was 6.9 cm and for the non-thinning treatments was 6.2 cm. The mean diameter of fruits from experimental units subjected to thinning was 8.2 cm in comparison to 7.3 cm for those from the non-thinning experimental units. This clearly indicates that fruit thinning at appropriate time can significantly increase the fruit sizes.

3.3. Fruit TSS

One of the most important parameters in fruits is TSS, which indicates the taste of the fruits. Usually, higher the TSS, better the quality is. In our case, on average, fruits from thinning treatments had 12.1%-degree brix while, non-thinning treatments had 11.1%-degree brix (Table 1). As per our study, fruits from the thinning treatments achieved significantly higher TSS as compared to the non-thinning treatments ($P<0.001$). This result is in conformity with the study that found hand thinning had an influence on soluble solids, increasing them in both the years of study (Stampar & Hudina, 2007). In another study, it was seen that the sugar content of the fruit increased significantly with fruit thinning (Maas & Van der Steeg, 2010). Similarly, fruit thinning increased the TTS in fruits which in turn improved the taste (Link, 2000). Therefore, all these studies clearly show that fruit thinning helps in improving TSS in addition to fruit weight and size.

3.4. Yield

Consistency in yield is an important factor in commercial farming. For the investment in pear orchard to be justified, it is essential to increase yield efficiency, whilst also sustaining or increasing market returns by improving the fruit size and quality grade outs (Webster, 2000). In our study, thinned treatments had an average yield of 28.1 kg while non-thinned treatments had 51.7 kg per tree (Table 1). The average yield from the thinned treatments is significantly lower in comparison with non-thinned treatments ($P=0.016$). This is also in agreement with what other studies have reported. One of the studies reported that yield per tree and per hectare was significantly lower following hand thinning (Stampar & Hudina, 2007).

However, this low yield can be compensated by high quality fruits which fetch better prices than by non-thinned fruits. Further, although thinning treatments gave lower yield as compared to the non-thinning treatments, in the second year of our study, thinned units gave significantly higher average yield of 34 kg per unit compared to 22.3 kg in the previous year. In the case of the non-thinned units, in the second year, the average yield per unit dropped drastically from 61 kg per tree to 42 kg per tree (Figure 1). This clearly indicates that in the long run, thinning trees will give not only better fruits in terms of quality and size but also yield stable production over the years unlike non-thinned trees that yield unstable production with poor quality fruits. This result is also in consonant with what other studies have reported. Thinning results in fewer kilos of small and more kilos of large fruits (Link, 2000), and the increasing economic value per unit fruit weight with

increasing fruit size demonstrates the merit of carrying out thinning (Buwalda et al., 1989). Therefore, the fruit yield might be reduced after fruit thinning but it helps to produce more marketable fruits. To keep producing marketable fruit and to ensure regular cropping it is essential to reduce the number of developing fruits in "on" years (Menzies, 1980).

Buwalda et al. (1989) reported that leaving trees un-thinned increased the incidence of natural drop before harvest, and this presumably resulted in the reduced fruit yield, which may be responsible for the apparent yield drop in non-thinning treatments. For the thinning treatments, as stated by Webster (2000), reducing level of fruit set due to thinning might have reduced fruitlet competition for the tree's available resources which led to the increased production.

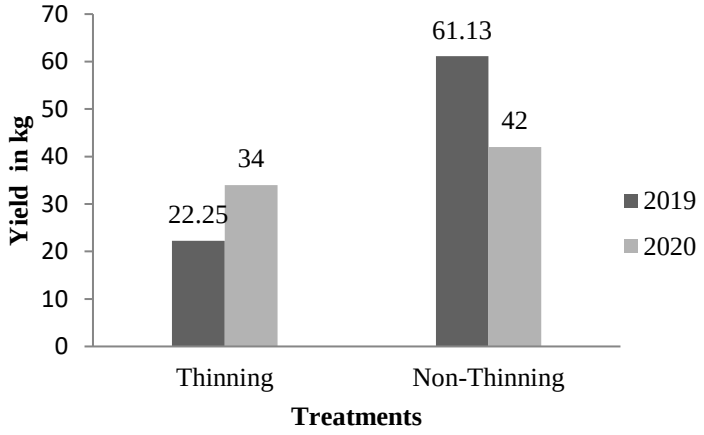

Figure 1. Yield variation in thinning and non-thinning treatments in 2019 and 2020

3.5. Fruit firmness

In the case of fruit firmness, there was no significant difference between the two treatments (*P* =0.075) though non-thinning treatment had slightly higher firmness than thinned ones.

Table 1. Comparison of means of fruit quality parameters for thinning and non-thinning treatments.

Treatments	Fruit weight(g)	Height(cm)	Diameter(cm)	TSS (%)	Firmness(kg/cm^2)	Yield(kg)
Non-thinning	197.4^b	6.2^b	7.3^b	11.1^b	0.67	51.6^a
Thinning	273.8^a	6.9^a	8.2^a	12.1^a	0.57	28.1^b
P value	<0.001	<0.001	<0.001	<0.001	0.075	0.016

Superscripts with dissimilar alphabetical letters are significantly different at alpha level 0.05.

Overall, thinned trees produce more marketable fruits which fetch better prices in the market. Thus, superior quality fruits from the trees which had undergone fruit thinning fetch Nu.50 per kg in the local market whereas fruits from the trees which had not undergone fruit thinning fetch Nu.30 per

kg. In due course of time, overall returns from thinned trees are likely to increase further since thinning helps in maintaining the health and productivity of the trees.

4. Conclusion

Hand thinning of Hosui pear had a positive impact on fruit quality parameters like fruit weight, fruit diameter, fruit height and TSS. The mean fruit weight for thinning treatments was 38.7% greater than that of non-thinning treatments. Average TSS of thinning fruits was 9% higher than the non-thinning fruits which contributed to sweeter taste in thinned treatments. The fruits from the thinned treatments were apparently bigger than the ones from the un-thinned treatments. As for the fruit yield, the thinned treatments had lower productivity in the first year of trial but there was a remarkable increase in the second year whereas, the fruit yield decreased for the no-thinned treatments in the second year of study. This might imply that, if the trees are left un-thinned, it will lead to reduction in yield over the years.

Thus, we can infer that hand thinning will aid in the production of bigger fruits with better taste. Hand thinning will also help mitigate the problem of alternate bearing in pome fruits like pear. Hand thinning might require more labor and time as compared to chemical thinning but chemical thinning is unreliable and there is health and environmental cost to it which is against the country's effort to go organic in the long run.

Hand thinning can be performed by pear farmers in Bhutan as the number of trees is not much as compared to huge commercial farms in other countries. Also, hand thinning is a precise and an organic way to remove the crop load in line with the organic vision of our country. Hand thinning can be performed without any adverse effect on the environment and it will lead to production of quality produce as borne out by this study. Hence, hand thinning in fruits need to be encouraged by all the fruit growers in the country.

Acknowledgement

Authors are thankful to the Program Director, ARDC-Wengkhar, for his immense support and encouragement in research work. We would also like to thank Mandira Acharya (Agriculture Supervisor) for helping us with the fruit analysis and Tshering Pem (Agriculture officer) for her unceasing support while writing this paper.

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