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Effect of Strand Thinning on Yield and Quality Attributes of Date Palm (Phoenix Dactylifera) Cultivar Begum Jangi

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Abstract

In the cultivation of date palms, one of the cultural practices of enhancing the quality of fruits and controlling the number of fruits produced is strand thinning. This paper tested the impact of various strand thinning levels on yield and quality characteristics of date palm (Phoenix dactylifera L.) cultivar Begum Jangi on agro-climatic environment at Turbat, Balochistan. The experiment was done on twelve 31 years old palms in a randomized complete block design with four treatments, which are control (no thinning), 10 after, 20 after and 30 after. The stage of kimri was carried out by hand, and equalized agronomic practices were applied. The findings of ANOVA and Bayesian analyses showed that strand thinning showed significant effects on most yield and quality parameters. There was maximum bunch weight (6.060 kg) with minimal thinning and maximum individual fruit weight (13.100 g), fruit length (5.187 cm), fruit volume (10.467 3 cm), and dry weight (9.170 g) with intensive thinning (30%). The quality of the biochemicals also improved with the intensity of the thinning and there was a higher total soluble solid (34.367 ºBrix), higher content of ascorbic acid (48.733 mg/100g), higher pH, and lower titratable acidity. The weight of the seed was less influenced and the fruit diameter was not affected. In general, moderate thinning is acceptable to maximize yield whereas intensive thinning is useful to increase size and quality of fruits so that growers could maximize production to suit market demand.

1. Introduction

Date palm (Phoenix dactylifera) is a tropical palm, whose fruit is sweet, culturally important, as well as economically significant. It is widely grown in hot and dry areas, and Pakistan has about 90,000 ha of date plantation, which yields about 600,000 mt of date fruits each year (Shaikh et al., 2019). The provinces of Sindh and Balochistan have more than 90 percent of the national output with Balochistan alone producing 225, 000 tons with 42.3 thousand hectares which is 53 percent of the total output (Jahangeer et al., 2014). Mozawati, Begum Jangi, Kaharba, Sabzo, Haleni, Gookhnah, Jawan Sohr and Dashtari are some of the large cultivars that are cultivated in Balochistan. One of the most distinguished is Begum Jangi, with its small size of fruit, better taste, long shelf life, and ability to withstand the arid conditions, producing it mainly in the regions of Turbat and Panjgur (Jan et al., 2024).

The production of date palm is associated with economic and nutritional benefits of arid areas, and the cultural aspects of flower and fruit thinning are necessary to increase the quality of fruit and control the annual production as well as yield (Karmadi and Okoh, 2024). Thinning is done manually or through the use of the Ethephon chemical agent to reduce competition in fruits and enhance fruit weight, size, percentage of fruit pulp, total soluble solids and sugar content, but at the expense of the overall yield (Mostafa and El Akkad, 2011). Amry, Eziz, Haiany, Halawy, and Sewy cultivars have been studied and proven to be successful in maintaining physical fruit quality, alternating bearing, and avoiding bunch breakages in cases of cultivar thinning of fruits and strands (Hanieh et al., 2020).

Strand thinning is a vital agronomical process that requires selectively pulling out a section of flower clusters or fruit strands at an early fruit development stage, which leads to less bunch compactness, better distribution of nutrients, increased uniformity, taste, texture, and appearance of fruits, and avoids overbearing to maintain tree productivity in the following years (Faleiro and Kumar, 2022). Since its significance, the exact impact of strand thinning on Begum Jangi date palms in Makran region is not known well (Hammami et al., 2024). The issue is further aggravated by post-harvest effects on date palm fruits because of improper handling and poor storage coupled with vulnerability to physiological diseases that result in unwanted results in terms of texture, color and taste, thereby lowering consumer preference and marketability (Amen et al., 2007).

These challenges need to be dealt with in order to ensure the economic sustainability of the date palm business. Shifting to the impacts of strand thinning on yields and postharvest characteristics of Begum Jangi fruits especially in the city of Turbat in Balochistan, there is scarce literature to support the impact of the practice. Consequently, it is crucial to measure how thinning of the strands affects the fruit size, fruit weight, yield, and the overall postharvest quality of this cultivar so as to be able to enhance the production practices, fruit quality and economic returns to the growers.

2. Materials and Methods

The study was carried out at the Directorate of Agriculture Research (Dates) at Kech, Turbat in an orchard of 12 Begum Jangi date palms of 31 years of age that were flood irrigated in the Turbat Agriculture Research Farm. These are mature palms that are known to be high yielding and of high quality. Thinning of the strands was done manually where a section of fruit-bearing strands was removed at an early stage of kimri (around four weeks upon pollination). The interventions were control (no thinning), 10, 20 and 30 percent strand thinning. All treatments were subjected to standard agronomic activities as in irrigation, fertilization, and pest management and weather conditions, including the temperature, humidity, and rainfall, were recorded to be associated with yield and quality characteristics.

yield parameters were measured and they included the total fruit yield per palm, number of strands per palm and number of fruits per strand. The fruit was measured with regard to the fresh and dry weight using the standard procedures including the measurement of the weight of seeds, length and diameter of fruit, and volume using the digital balance and vernier caliper. At the tamer stage, quality of fruits was determined in terms of average weight, size, total soluble solids (TSS), moisture content, firmness, color, and sensory characteristics. Standard procedures were used to identify the existence of biochemical parameters including TSS, titratable acidity and ascorbic acid content (AOAC, 2000).

This experiment was designed in such a way that it was the randomized complete block design (RCBD), which comprised three replicas, four treatments, and three palms in each replicate. The SAS was used to analyze the data through ANOVA and compare mean to the LSD at a level of significance of 0.05 to determine the influence of strand thinning on the yield and quality of Begum Jangi date palm fruits.

3. Result

3.1 Descriptive Statistic

The descriptive statistics will give a picture of the data, the features and the variability of all the important parameters in the research on the topic of Effect of Strand Thinning on Yield and Quality Attributes of Date Palm (Phoenix dactylifera) Cultivar Begum Jangi. Figure 1 displays th e results of the statistics on the bunch weight, the fruit weight, the dimensions of the fruit, the seed weight, the volume of the fruit, and the dry weight. The mean weight of the bunches is 5.40 kg (4.47-6.10 kg) with the standard deviation of 0.60kg which means the variability is moderate. The mean weight of the fruit is 9.94 g (7.30 13.30 g, SD 2.23 g), which indicates more variability probably as a result of thinning treatments. The length and diameter of fruit are 4.11 cm and 2.37 cm, respectively, and the variability is moderate, whereas the seed weight is non-heterogeneous (0.23 g; SD 0.01455). The fruit volume and the average fruit dry weight are 9.38 ml (SD 0.80) and 7.72 g (SD 1.14), respectively, which shows variability that is significant to quality measurement. These findings point to the fact that fruit development and bunch traits were affected by strand thinning. The ANOVA of bunch weight indicates a very significant difference between four treatment groups with the value of between-group sum of squares of 40.839, mean square 13.613, F-value 82.475, and p = 0.000. This is further supported by the Bayes Factor of 15339.123 which is a good evidence against the null hypothesis. This proves that the strand thinning treatments had statistically significant differences in bunch weight and they affect the yield and quality of date palm.

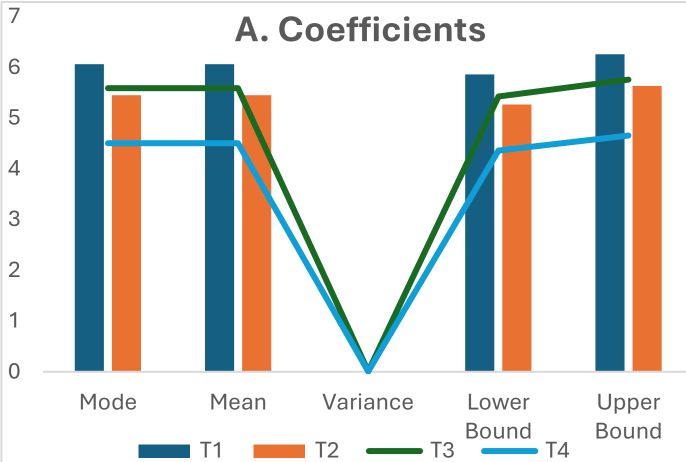
3.1.1 Coefficients

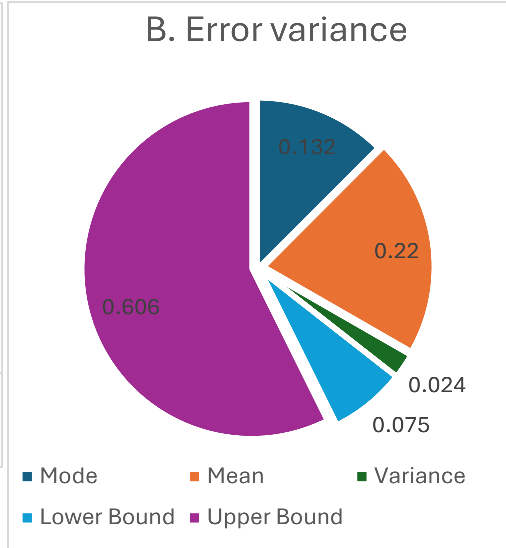
As in figure 2 A, Bayesian estimates on the effect of each treatment group on bunch weight on each group. The reported posterior mean of treatment group T1 is 6.060 kg, with a credible interval of 5.862 kg to 6.259 kg which means T1 treatment has the highest bunch weight of all the treatment groups discussed. The mean of treatment group T2 is 5.449 kg, whereas T3 has a mean of 5.592 kg, which is quite lower than T1 but still higher than T4, the mean weight of which is 4.506 kg. The standard deviations of these estimates are not very large, which implies that the observations present in each of the groups are tightly grouped around its respective means.

3.1.2 Error Variance

The analysis as presented in figure 2 B incorporates estimates on the error variance with a posterior mean of 0.220 and a credible interval of 0.075 to 0.606. This indicates variation in the data not due to the effects of treatment, giving information on how much variability there is in each of the treatment groups not due to thinning of the strands. According to the results of the ANOVA and a subsequent Bayesian estimate, it can be stated that the strand thinning has a significant impact on the yield (bunch weight) of Date Palm fruits, and the level of its effectiveness is different in various treatment operations. The findings form one of the valuable, types of information in the realization of how the agricultural practices can affect the quality of fruits and yield in the cultivation of Date Palm.

Figure 2: Bayesian Estimates of A. Coefficients and B. error variance





3.2 Fruit Weight

The outcomes of ANOVA show that there is a significant difference between the fruit weight in the four treatment groups (T1, T2, T3, T4). The value in between groups of 54.382 with 3 degrees of freedom produces a value of 18.127 mean square. The F-value is very large, standing at 356.607, and the p-value equals 0.000 that is significantly less than the traditional value of alpha of 0.05. This high level of significance implies that one of the treatment groups has a dissimilar mean fruit weight with other groups. These results are further supported by the Bayes Factor of 2461126.980, which is significant evidence against the null hypothesis that the means of all the treatments are equal. It indicates that the strand thinning treatments are highly influential on the fruit weight and therefore more studies should be conducted to determine the specific treatment that has the largest changes.

3.2.1 Coefficients

Bayesian estimates indicate clearly the quantitative impact of strand thinning on fruit weight in all treatments. The posterior mean fruit weight (Figure 3A) was progressively rising with the aid of the increase in the posterior mean fruit weight, which was 7.400 g in T1, 8.767 g in T2, and 13.100 g in T4 with the narrow credible intervals of the estimates (T1, T2, and T3). The consistent variance between all the treatment groups indicates consistent within-treatment variability. All these findings, in general indicate a large positive correlation between the intensity of thinning and the weight of fruits indicating that increases in aggressive thinning of strands increase the growth of the individual fruits. The Bayesian analysis gives strong evidence of the importance of strand thinning on the fruit weight of Begum Jangi cultivar and the relevance of the study to optimize the yield and fruit quality in the date palm production systems.

3.2.2 Error Variance

Figure 3B, indicates that a posterior mean error variance is 0.068 which is the average average unexplained variability of measurement in fruit weights in treatment effects. The respective value of variance-0.041 depicts a rather low extent of random variation of treatment groups. The credible interval (0.002 0.187) indicates that even though the major part of the variability is located around the mean, there is still some uncertainty. In general, this discussion indicates that although strand thinning has a great impact on the weight of the fruit, there is a little bit of variability in the measurement process that is relevant in determining the reliability and the accuracy of the results.

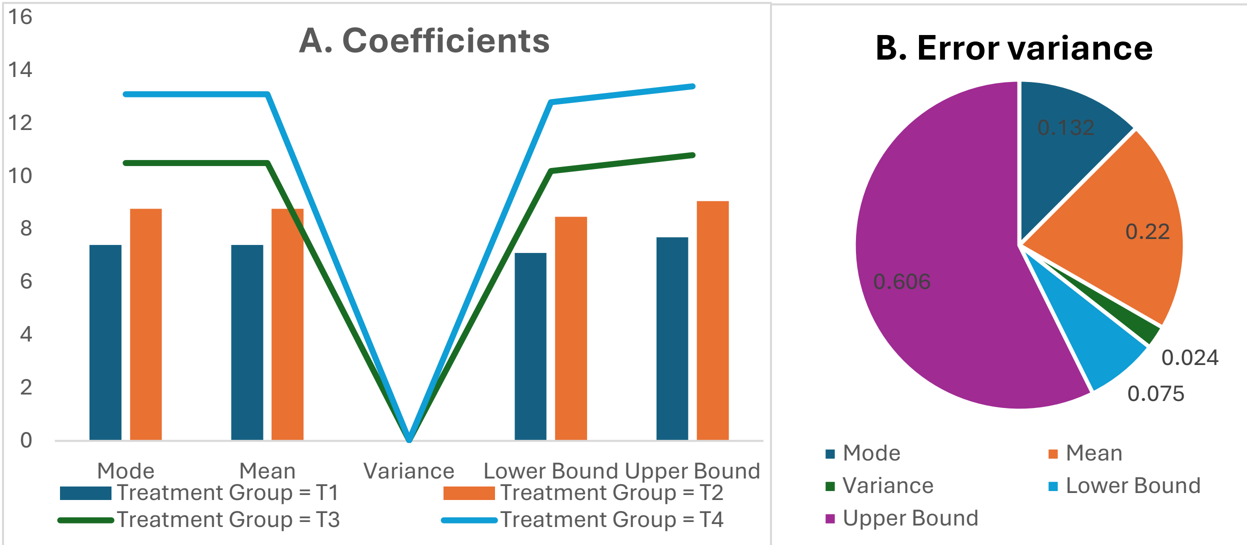


Figure 3: Bayesian Estimates of A. Coefficients and B. error variance

3.3 Length of the Fruit (CM)

The results of the ANOVA show a very significant difference in the length of the fruit in the four treatment groups (T1, T2, T3, T4). Sum of Squares between groups = 5.921 with 3 degrees of freedom which equals 1.974 Mean Square. The calculated F-value is truly high at 143.362, and the p-value is also reported as 0.000, which is too much below the traditional mark of 0.05 to be regarded as significant. This good evidence makes us discard the null hypothesis and accept the fact that at least one treatment group has a mean fruit length that is not significantly equal to other means. The Bayes Factor that was reported is 103526.645, which suggests that there is overwhelming evidence against the null hypothesis that all the treatment means are equal. This implies that fruit length is highly sensitive to strand thinning treatments and a more detailed study should be conducted on which of the particular treatments produce the greatest difference.

3.3.1 Coefficients

Bayesian estimates demonstrate that there is a clear trend of fruit length becoming longer as the intensity of strand thinning increases. There is an increasing value in the posterior mean length of fruits; in T1, the mean is 3.290 cm, and in T2 and T3, the means are 3.747 cm and 4.210 cm respectively which means that the fruit length was increasing with thinning. The longest mean length is recorded in T4 (5.187 cm), with a narrow credible interval (5.0305.343 cm) proving that it is effective in increasing the size of fruits. The variability of the results (Figure 4A) is consistent between treatments with a variance of approximately 0.006, which suggests a constant variability and a lot of confidence in these estimates.

3.3.2 Error Variance

Bayesian analysis of error variance in fruit length depicts that there is the low level of unexplained variability between treatment groups. The posterior mode and mean error variance are 0.011 and 0.018 respectively, which means that there is little error in measurements. The credible interval (0.006-0.051) indicates a lack of certainty but indicates low variability in general (Figure 4B). This pairing of the observations around the group means increases the level of trust in the reliability and precision of the estimates of the length of the fruits.

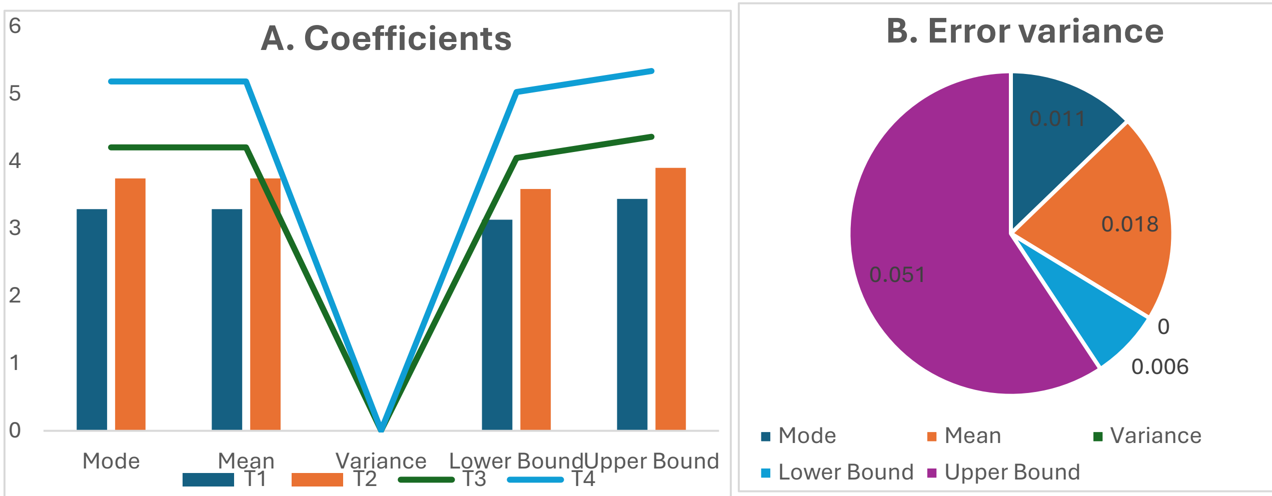


Figure 4: Bayesian Estimates of A. Coefficients and B. error variance

3.4 Diameter of Fruit (CM)

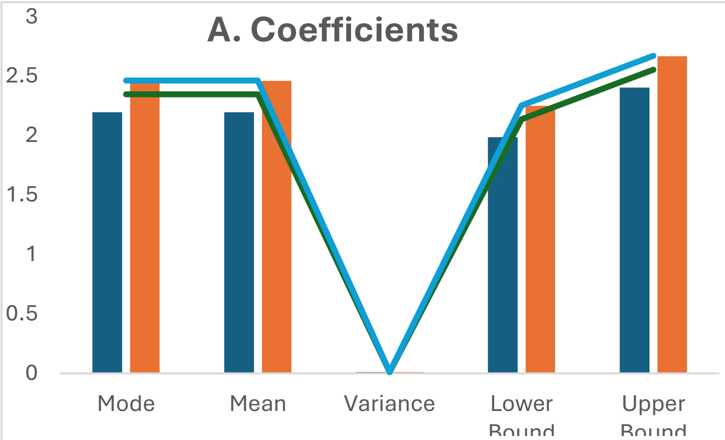
The results in the ANOVA indicated that all the four treatment groups have no statistically significant differences in terms of the diameter of the fruit. The between groups sum of squares is also relatively low with the value being 0.142, which indicates that the variability explained by the differences among treatment groups is small. The mean square between groups is calculated to be 0.047 with 3 degrees of freedom. The F-statistic is 1.935 that is not significant as a p-value of 0.203 shows that differences in the means are not significant at the traditional alpha (.05 or .01). In addition to this, the Bayes factor of 0.268 implies that there is no compelling evidence on alternative hypothesis, rather, it implies that there is no significant evidence of differences in the data between the treatment groups. Conversely, within groups the sum of squares is greater at 0.196 which shows that there is more variability within each treatment group than between the groups.

3.4.1 Coefficients

An analysis of the Bayesian estimates of the coefficients per treatment group in terms of the fruit diameter is given in the figure 5 A. These findings reveal that Treatment Group T1 has a mean diameter of fruit of about 2.197 cm and Treatment Group T2 has a mean diameter of about 2.460 cm, Treatment Group T3 has a mean diameter of about 2.347 cm and Treatment Group T4 has a mean diameter of about 2.463 cm. Although there are minor differences in mean diameters over treatment groups, these differences are minor and do not imply that the treatment groups have any significant effects on them, as is indicated by overlapping credible intervals of all the groups (e.g., T1: [1.988, 2.405] and T4: [2.255, 2.672]). Variance of each group is also always low with a consistency of.011 which indicates that the estimates are consistent across the samples.

3.4.2 Error Variance

Figure 5B gives the information about error variance of measurements of the fruit diameter of the treatment groups. The mode and mean error variance are low (.020 and .033 respectively) which means that there is a small number of differences that cannot be explained by differences in treatment groups. This indicates that a majority of observed changes in the diameter of fruit could be inherent group attributes and not due to random measurement error and sample variability. The error variance has a credible interval of between 0.011-0.90 indicating that there is some level of uncertainty but still establishes the fact that variability within groups is not high in comparison with the intergroup variability observed in the ANOVA results.



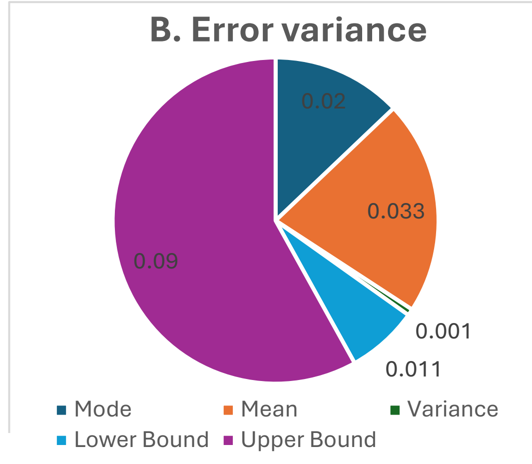


Figure 5: Bayesian Estimates of A. Coefficients and B. error variance

3.5 Seed Weight (g)

Result denotes that there are indications of large differences in weight of the seeds across the four treatment groups. Between groups, the number of squares is 0.002, a significant amount of variation that is ascribed to the differences between the treatment groups. The means square between groups with 3 degrees of freedom is found to be 0.001. The F-statistic is given as 6.089, which indicates that the difference between the treatment groups is a lot bigger than the difference within any of the treatment groups. The p-value of.018 also supports this conclusion as it is statistically significant at the traditional alpha values (e.g., 0.05), meaning that there is at least one group of treatments that is different than the rest when it comes to seed weight. Also, the Bayes factor of 3.557 is the moderate evidence of the support of the alternative hypothesis which indicates that there are significant differences in the means of the treatment groups. Conversely, within groups sum of squares is small at 0.001, which means that there is not much variability within each of the treatment groups.

3.5.1 Coefficients

The estimates of the coefficients of each treatment group on the seed weight are shown in Figure 6 in terms of Bayesian estimates. The findings suggest that Treatment Group T1 has the mean seed weight of about 0.217 g, Treatment Group T2 has the mean weight of about 0.221 g, Treatment Group T3 has the mean weight of about 0.237 g and Treatment Group T4 has the mean weight of about 0.246 g. These findings indicate that there is a tendency with the number of treatment groups to finally result in the increase of seed weight though the differences are not of a very large magnitude. The credible intervals of every group are close, and the lower and upper limits are about ±0.012 g of T1 to ±0.013 g of T4 which means that these estimates are accurate and it is safe to make conclusions about inter-group differences of seed weight.

3.5.2 Error Variance

The factors shedding light on the error variance of measurements of seed weight between the treatment groups. Both the mode and the mean error variance are zero (.000), which means that there is no unexplained variance in the weight of the seeds once the differences between the treatment groups were taken into consideration in this analysis scenario. This indicates that the model is incredibly fitting and that most of the observed differences can be explained by the treatments administered and not random measurement error and sample variation.

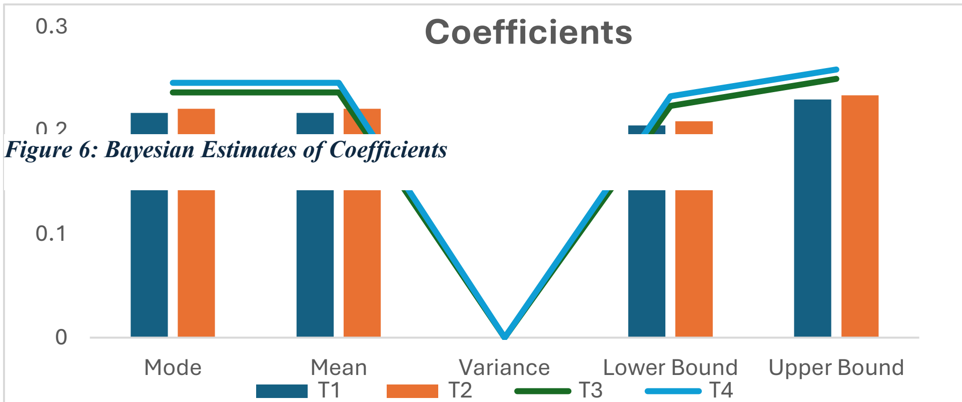


Figure 6: Bayesian Estimates of Coefficients

3.6 Fruit Volume (ml or cm³)

The ANOVA shows high significance of the variation of fruit volumes between the four treatment groups. The between-group sum of squares is significant of 6.872, which represents a large amount of variability due to differences between the treatment groups. The 3-degree of freedom between groups mean square is computed to be 2.291. The F-value is greater than usual, which stands at 77.970, indicating that the difference amongst treatment groups is significantly higher as compared to each group separately. This conclusion can be also further supported by a p-value of.000, which means that the difference between the two or more treatment groups is statistically significant when used at conventional alpha levels (e.g.,.05), a fact that strongly indicates that one of the treatment groups is not comparable to the others in their fruit volume. Also, it has a Bayes factor of 12645.566 which gives overwhelming evidence in support of the alternative hypothesis, which shows that there are significant differences in means between the treatment groups. On the contrary, the within groups sum of squares is low at 0.235 which implies that there is low variability within either group of treatment.

3.6.1 Coefficients

The Figure 7A shows the Bayesian estimates of coefficients of each of the treatment groups in terms of fruit volume. The findings imply that Treatment Group T1 has an average fruit volume of about 8.448 ml (or cm 3), Treatment Group T2 has an average volume of around 8.960 ml, Treatment Group T3 has an average volume of about 9.633 ml and Treatment Group T4 has an average volume of about 10.467 ml. These findings provide a graphic analysis, in which the volume of fruit grows with the number of treatment groups, and therefore it is possible that the more advanced treatment is, the more the fruit, in terms of volume, will grow. The low credibility of each group with a range of about ±0.228 ml to T1 up to T4- show the high accuracy in the estimates and it can be made with a lot of certainty on the distinction between the groups in terms of fruit volume.

3.6.2 Error Variance

The B7 figure gives information about the error variance of measurements of the volumes of the fruit in cases related to the involved treatment groups. The mode and the mean error variance are stated as.024 and.039 respectively, which means that there is a certain amount of unexplained variation having considered the differences between the treatment groups; nevertheless, the variation level is not so high in general in comparison with the variability between groups in the ANOVA results. The error variance ranges are very credible, with the lowest possible error variance standing between.013 and.108, and showing some uncertainty, but still, proves that the variability within the groups is not an issue, and does not significantly decrease the observed treatment effects.

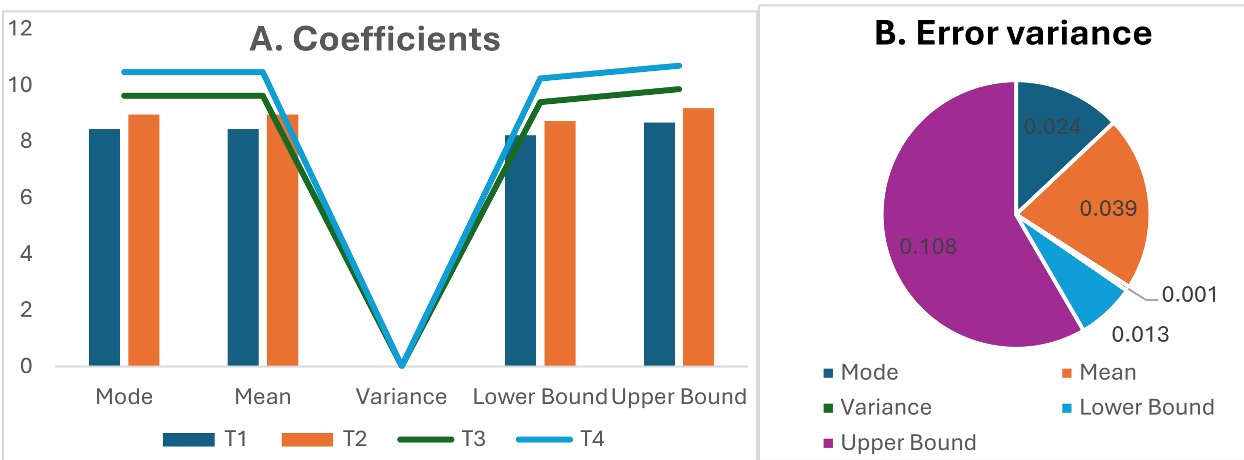


Figure 7: Bayesian Estimates of A. Coefficients and B. error variance

3.7 Dry Weight (g)

The outcome shows that there are significant differences in the dry weight of the four treatment groups which are highly significant. The between group sum of squares is also large 14.186 indicating a significant variability caused by the difference among groups of treatment. The between groups mean square has 3 degrees of freedom, which is 4.729. The F-statistic is rather large and stands at 252.190 which indicates that there is something bigger than the variation in each of the treatment groups. This is also indicated by a p-value of.000 that means that it is statistically significant at the traditional alpha (representing e.g. 0.05), which is a strong indication that at least one of the groups of treatments is not similar to the rest in terms of dry weight. Also, the Bayes factor of 736292.280 has overwhelming support in support of the alternative hypothesis, which implies that the treatment groups differ significantly in terms of their means. Conversely, the within groups sum of squares is small at 0.150 meaning that there was little variation within every treatment group.

3.7.1 Coefficients

The figure 8 A shows the Bayesian estimates of the coefficients of each treatment group in terms of dry weight. The findings reveal that the mean weight of Treatment Group T1 is about 6.323 g and the mean weight of Treatment Group T2 is about 7.103 g; Treatment Group T3 has a mean weight of about 8.263 g and the Treatment Group T4 has a mean weight of about 9.170 g. These findings depict a vivid pattern in which the number of treatment groups grows with the increase in dry weight, and thus the more advanced the treatment could be, the higher it could be in terms of biomass accumulation in the form of dry weight. These small range intervals of each group of about ±0.183 g of T1 to 0.182 g of T4 are a sign of high accuracy of these estimates that one can conclusively make about the differences in dry weights between the groups.

3.7.2 Error Variance

As it can be seen in the figure 8 B, the variance of error in measurements related to the mass of dry weights in the treatment groups is insightful. The mode and mean error variance are given at 0.015 and 0.025 respectively which represent some degree of the variability that cannot be explained by differences between the treatment groups; but overall, the degree of variability is quite small as compared to the group-to-group variability in the outcome of the ANOVA. The credible interval of error variance is 0.009 -0.069, which is not that certain but it indicates that the variability within the groups is not significant and it does not significantly obscure what is being observed.

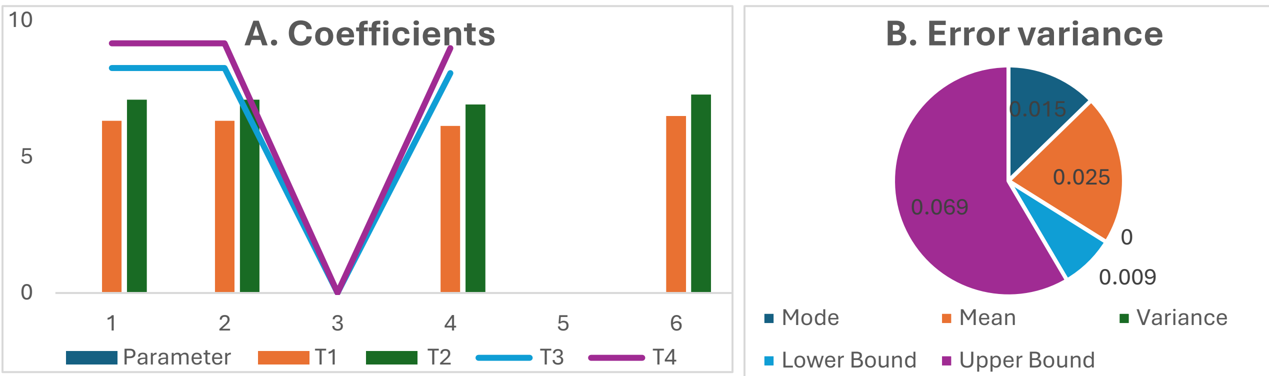


Figure 8: Bayesian Estimates of A. Coefficients and B. error variance

3.8 Fruit Characteristics

The presents mean data of the important fruit properties among four treatment groups (T1-T4) of bunch weight, fruit weight, fruit length, fruit diameter, seed weight, fruit volume, and dry weight. The findings reveal that there are evident and significant differences between treatments whereby T4 produced higher mean scores in most characteristics than T1. This tendency demonstrates that greater levels of thinning were more productive in enhancing the quality and the growth of fruits. These differences were statistically significant as ANOVA proved ($p < 0.001$). The chart shows clearly that most of the fruit characteristics respond positively as the intensity of treatment increases and therefore, treatment choice is important to maximize fruit yield and quality.

3.9 Titratable Acidity (%)

The results of the analysis indicated that the impact of various strand thinning interventions was strong and noticeable on titratable acidity in date palm fruits. The results of the ANOVA test were an F-value of 24.444 with a p-value of less than 0.001 indicating that the differences among treatments were statistically significant and unlikely to happen by chance. The Bayesian analysis provided a Bayes Factor of 250.944 and this indicates that there is very strong evidence that there actually was a difference in the acidity levels as a result of the treatments. The findings demonstrate that the treatment of thinning modified the sour or acidic nature of the fruit that is significant to taste and quality of the fruit.

3.9.1 Coefficients

The figure 9A, Bayesian results revealed a distinct and consistent reduction of the levels of acidity of the four treatments. The average acidity was highest in treatment T1 (1.800%), then T2 (1.567%), T3 (1.433%), and T4 had the lowest value (1.333%). The ranges of each treatment were very small (95 percent) and thus the results were not widely dispersed. The constant T1 to T4 decrease in acidity indicates that the strands thinned contributed to better ripening of the fruits. T4 had the greatest ability to reduce acidity, which is probably crucial in making the fruit taste sweeter and less sour significant characteristics to enhance the quality of dates. These are the Bayesian results that are consistent with the classical ANOVA results and they are further substantiated by a large Bayes Factor that further gives extra confidence that there were real and consistent effects of the treatments.

3.9.2 Error Variance

The error variance in figure 9B was a low Bayesian estimate, whose mean is 0.007 and the 95 percent credible interval is 0.002-0.018. This minimal range indicates that the results were stable and replications were consistent. A small error variance indicates that the difference between the treatments that were realized in the research was not a result of the random variation but probably the actual effect of thinning of the strands. This helps in persuading that the statistical model employed was sound, and that the treatment groups acted in a significant and measurable manner differently. These results bolster the belief in the Bayesian and classical ANOVA findings.

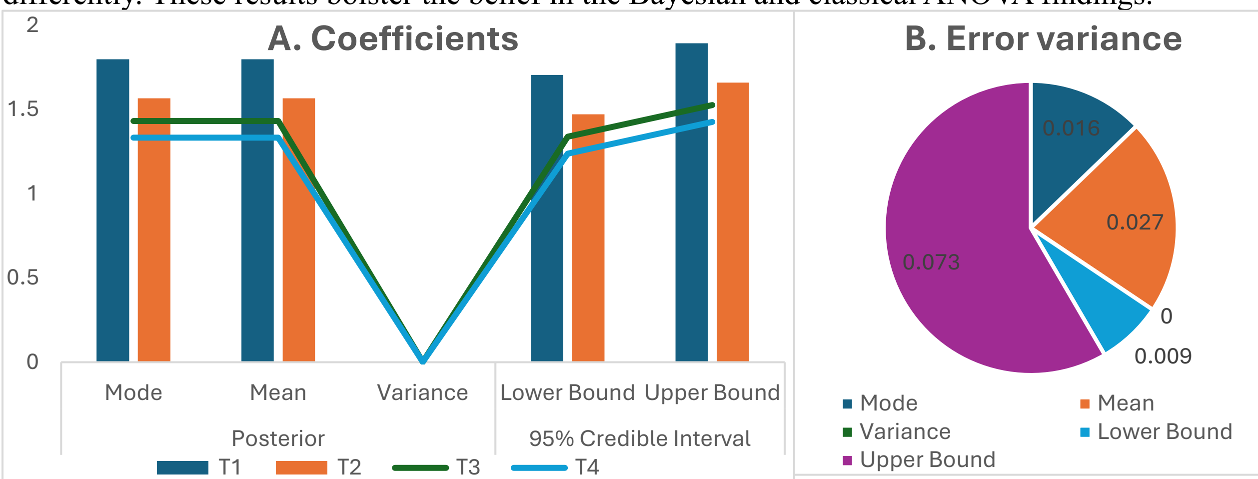


Figure 9: Bayesian Estimates of A. Coefficients and B. error variance

3.10 Total Soluble Solids (°Brix)

The one-way ANOVA test indicated that Total Soluble Solids (TSS) differed tremendously between the different treatments applied in thinning strand. The p-value was found to be below 0.001, with F-value of 515.611, this clearly shows that there was a real effect of the treatments on the sugar content (sweetness) of the fruits. This was a strong finding confirmed by the Bayesian analysis which had a Bayes Factor of 8,906,571.457. This incredibly huge figure implies that there is a great deal of evidence that the treatments caused the change in TSS and not random variation. These findings affirm that strand thinning enhanced sweetness of date fruits and out of the treatments, it is possible that Treatment 4 had the greatest effect of increasing the levels of TSS.

3.10.1 Coefficients

The Bayesian analysis indicated that the Total Soluble Solids (°Brix) continued to increase with Treatment 1 through Treatment 4. The average sweetness of treatment T1 was smallest with 30.233, and T4 had the highest with 34.367. T2 and T3 were found to be 30.733 o Brix and 32.200 o Brix respectively (Figure 10A). The credible intervals of the treatments were small indicating that the estimates were correct and consistent. This trend indicates that the more the treatments, the sweeter the fruits were because the process of strand thinning took place. T4 was the most effective as compared to all the treatments in the context of enhancing sweetness, which is one of the major quality factors in date palm fruits.

3.10.2 Error Variance

The Bayesian estimate in Figure 10B revealed that the error of Total Soluble Solids was low, and a posterior mean of 0.027. The 95 percent interval was 0.009 to 0.073 with the mode value standing at 0.016. This implies that the differences of the sweetness (TSS) in fruits were measured with high precision and low variation across the fruits as a result of random error. A small error variance indicates that the treatments themselves rather than unexplained or random differences were the main cause of change in TSS. This helps to justify the accuracy of the findings and is more encouraging that the treatments applied to the strands to increase fruit sweetness were real.

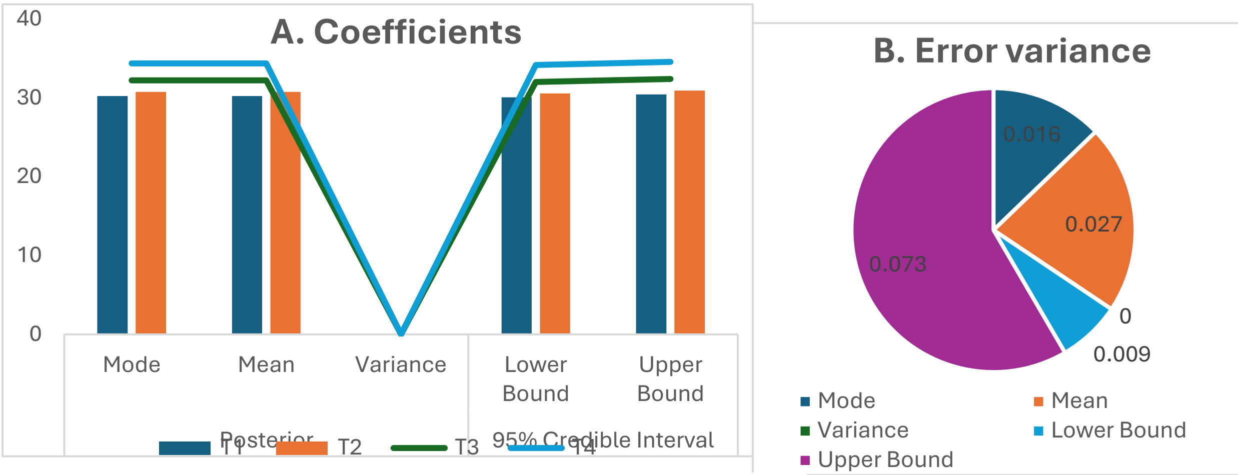


Figure 10: Bayesian Estimates of A. Coefficients and B. error variance

3.11 Ascorbic Acid (mg/100g)

The outcomes of the ANOVA indicated that the effect of the various treatments of strand thinning on the date palm fruits in terms of ascorbic acid content (Vitamin C) was very strong. The results were 50.853 F-value and p-value of less than 0.001 indicating that the differences between treatments were very significant. This finding was also justified by the Bayesian analysis and the Bayes Factor was 2,931.351. This is a very high value, which provides great arguments that the changes in the level of vitamin C did occur due to the treatments, and not by mere coincidence.

3.11.1 Coefficients

Upon the Bayesian analysis, it was observed that there was slow gradual increase in the content of ascorbic acid in the treatments. As it is illustrated in figure 11 A the lowest average of 46.167mg/100g was achieved with the treatment T1 and the highest (48.733mg/100g) with treatment T4. T2 and T3 were intermediary with a consistent increase. The credible intervals of each treatment were extremely small implying that the estimates are consistent and valid. The increase in T1 to T4 of vitamin C indicates that the more the strand thinning was administered the better it was to assist in enhancing the nutritional value of the fruit. These findings are in line with the classical ANOVA results and they tend to confirm the hypothesis that the strand thinning contributes positively to the rise in the level of ascorbic acid in the date palm fruits.

3.11.2 Error Variance

The Bayesian estimate of error variance of ascorbic acid was 0.111 with credible interval of 0.038-0.306 (figure 11B). The mode was 0.067. Such a moderate error variance indicates that there was variability in the content of vitamin C that could not be attributed to the treatments per se. The credible interval is not too huge and indicates that the model was also consistent and reliable. It ascertains that the difference in ascorbic acid in the observed treatments was significant enough not to be subject to normal variation.

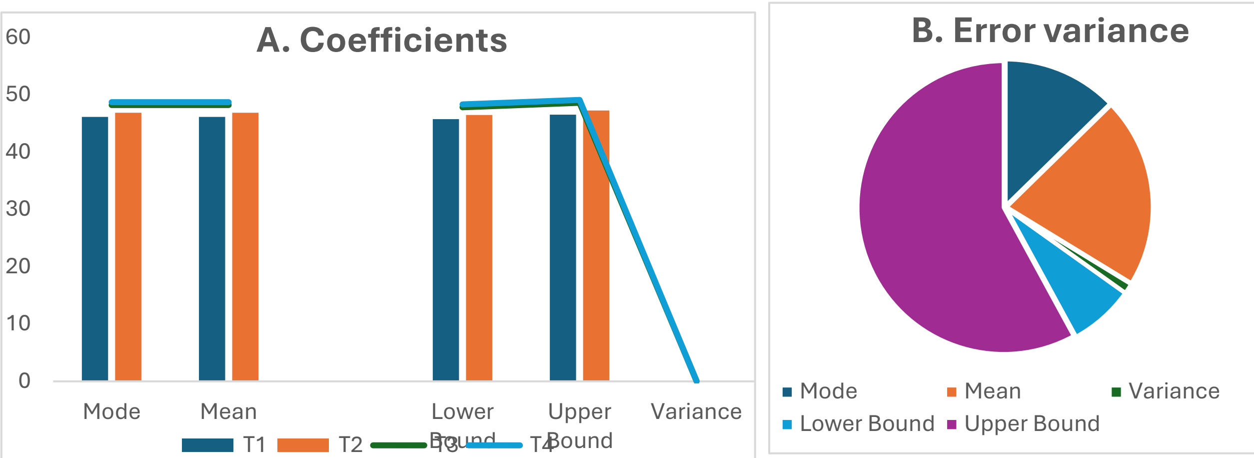


Figure 11: Bayesian Estimates of A. Coefficients and B. error variance

3.12 pH

The results of the ANOVA were that strong and significant effect on pH of date palm fruits was exercised by strand thinning treatments. The p- value was lower than 0.001 and the F-value was 46.833 indicating that the differences in the treatments were significant. This was also found in the Bayesian analysis with Bayes Factor of 2,215.834. This value is so high that it is good indication that this is a real change in pH and not just chance variation.

3.12.1 Coefficients

In the figure 12A, Bayesian results revealed slow but progressive increment in the pH of the fruit of Treatment 1 to Treatment 4. The mean pH in treatment T1 was the lowest (5.133), and in T4 was the highest (5.900). T2 and T3 were intermediary with a consistent increase. The results are reliable since narrow credible intervals were found in all the treatments. A higher PH level indicates that the fruit was less acidic and more neutral and this can enhance the taste and consumer preference. These findings validate the fact that strand thinning aided in the alleviation of acid and Treatment 4 was the most effective.

3.12.2 Error variance

Figure 12B, Bayesian estimate indicated that the error of variance of pH was extremely low and

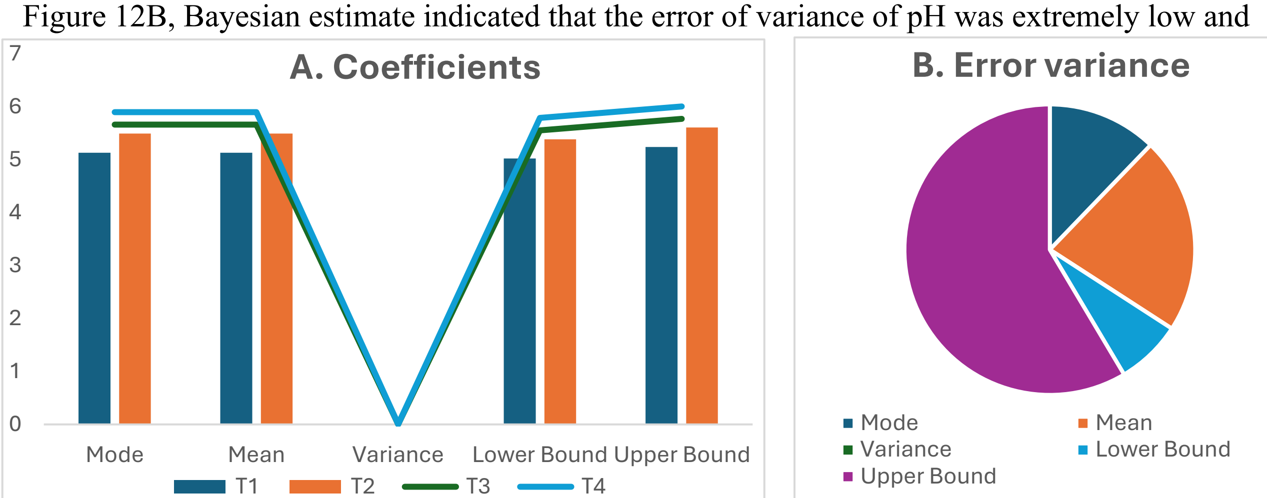


Figure 12: Bayesian Estimates of A. Coefficients and B. error variance

had a mean of 0.009 and a 95 percent interval of 0.003 to 0.024. This implies that there was minimal random variability in the measurements of pH. This small error value indicates that the treatments of the strand thinning were primarily the cause of the change of pH rather than the chance. This increases the validity of the results and proves that the treatments indeed did influence the level of acidity of the fruit.

3.13 Quality Parameters

The visual treatment of the findings is a clear explanation of how the straw thinning treatment affected the four key quality parameters of date palm fruits; titratable acidity, total soluble solids (TSS), ascorbic acid, and ph. There was a similar trend among all variables. Titratable acidity (%) significantly decreased between Treatment 1 to Treatment 4 which meant treatment levels of high thinning were effective in decreasing the acidity of the fruit. Conversely, the values of TSS (°Brix) and ascorbic acid (mg/100g) also rose gradually with the treatments indicating that the fruits grew sweeter and vitamin C richer as the intensity of thinning increased. Equally, pH numbers also rose as the level of treatment rose, which also supported the acidity reduction and change in favor of a

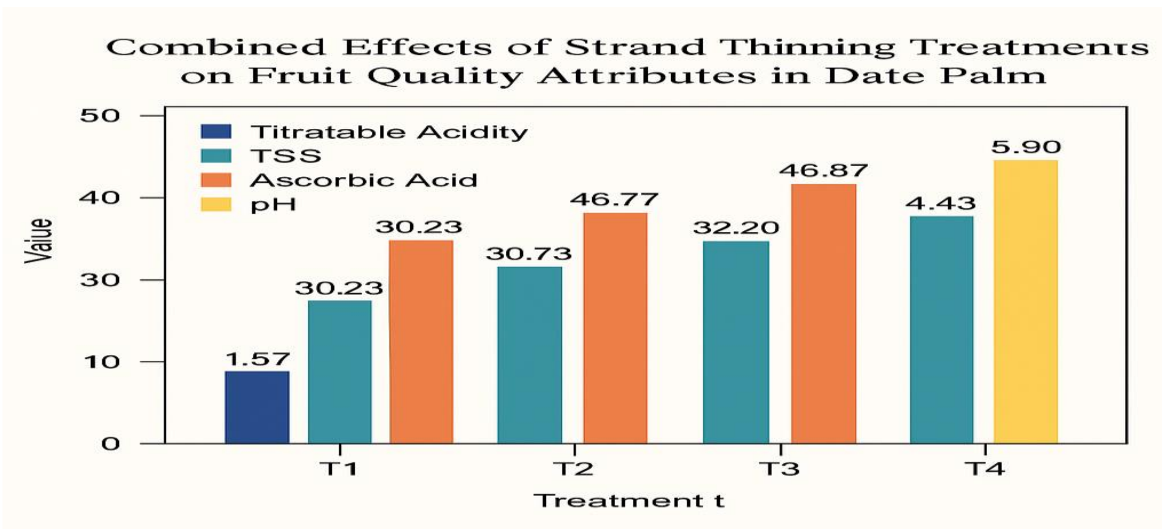


Figure 13: Bar Chart, Combined Effect of Treatments on Quality Parameters

more balanced taste. Of all the treatments, Treatment 4 was the one that had the most appealing results: the lowest acidity level, the highest level of sweetness, the improved nutritional value and the improved pH level. All these findings lead to the conclusion that thinning of the strands has a positive impact on the chemical composition and sensory quality of the date palm fruits.

4. Discussion

Findings of this research paper show that strand thinning has a big impact on physical and biochemical properties of Begum Jangi date palms. Bunch weight had the greatest in low aggressiveness treatments (T1 = 6.060 kg) and the lowest was recorded in the most aggressive treatment (T4 = 4.506 kg), demonstrating that moderate thinning enables improved resource allocation in the bunch. The statistical significance of these differences was proved by the results of ANOVA ($F = 82.475$, $p < 0.001$) and a Bayes Factor of 15,339.123. The response of fruit weight to intensive thinning was positive, where T4 had the greatest weight (13.100 g) than T1 (7.400 g) and hence, the competition among the fruits was minimized and this resulted in the growth of individual fruits. The length of fruit also rose with the intensity of thinning, and the diameter fruit was rather insensitive to it, indicating that length and weight are more susceptible to thinning than diameter. The weights of the seeds were consistent across treatments, suggesting they are genetically controlled but the fruit volume and dry weight varied moderately thus there could be changes in the moisture content or density. Also, biochemical parameters enhanced as intensity of thinning: titratable acidity was reduced, total soluble solids and ascorbic acid were elevated, and pH increased, showing a better taste, sweetness and nutritional quality in massively thinned fruits. These results indicate that moderate thinning is the most effective in maximizing the total bunch yield, but intensive thinning improves single fruit size and quality. In general, strand thinning is a good agronomical technique to balance yield and fruit quality that enables the growers to modify the management methods based on the market demand and targeted production.

5. Conclusion

The results of this paper give significant information concerning the impacts of strand thinning on yield and quality Phoenix dactylifera cultivar Begum Jangi. Strand thinning was a major factor that affected bunch and fruit traits. Light thinning (T1) brought out the highest bunches (6.060 kg) indicating that lighter thinning preserves more resources in the cluster whereas intensive thinning (T4) brought the highest individual fruits (13.100 g) by diminishing rivalry among fruits. Fruit length was also growing with the intensity of thinning, but the increase in fruit diameter and seed weight were relatively smaller, showing that some physical characteristics are not so sensitive to agronomic intervention. The volume and the dry weight of fruits were relatively variable with predictable patterns depending on the intensity of thinning. There was better intensive thinning of biochemical properties of total soluble solids, titratable acidity, and ascorbic acid, which emphasized increased sweetness, flavor, and nutritional value. These findings indicate that strand thinning can enable growers to effectively control the resources within the fruit clusters so as to achieve a balance between the yield and the quality based on marketing requirements. The overall yield should be as high as possible which implies less aggressive thinning whereas intensive thinning is desirable to get high-quality fruits of high size and better physical qualities. Although these findings have been made, the limitations that do not allow generalization would include a small sample size and a single cultivar. In future studies, a variety of cultivars should be considered, they should investigate the long-term effects on the health and productivity of the trees, the interplay of their outcomes with other agronomic activities, and reproduce the results in different environmental settings to enhance the generalizability of these findings. In sum, this paper affirms that strand thinning is an effective agronomic technique that can be used to maximize output and commercialization of date palm plants and offers a basis upon which future studies can be done to enhance sustainable date palm production.

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