Article

Effects of Branch Number on Quality Traits and Yield Properties of European Hazelnut (*Corylus avellana* L.)

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Abstract: Despite being the world leader in the production of hazelnuts, Turkey's nut yield per hectare is quite behind other producer countries. The main reasons for low yield are the completion of the economic life of hazelnut orchards and the lack of pruning following the technique. Hazelnuts are being grown with the 'ocak' system in Turkey. The ocak system is a bush-like growing technique that does not contain the main trunk but consists of shoots instead. It is necessary to maintain the optimum number of shoots per ocak to increase yield and quality in this system. The effects of different branch numbers on yield and fruit quality parameters of 'Tombul' and 'Palaz' hazelnut cultivars were investigated in Ordu ecological conditions. 'Palaz' had the highest yield per ocak in 8 branches (1460.19 g), while 'Tombul' had in the 5 branched ocak (2170.47 g). 'Palaz' and 'Tombul' had the highest fruit weights in 4 and 4–6 branches, respectively. The highest oil ratio of 'Palaz' was observed in 4 branches, while 'Tombul' had the highest in 5 branches. The highest kernel ratio was determined in 6 and 5 branches in 'Palaz' and 'Tombul', respectively. The ocaks with 4 and 5 branches were mostly expressed higher values, and it is foreseen that the number of branches should not exceed 6 to reduce the competition of the branches and to obtain good quality products.

Keywords: hazelnut; branch removal; yield; fruit quality; 'ocak'

1. Introduction

Hazelnut is one of the important Turkey-originated fruit species. Turkey has quality cultivars and suitable areas for hazelnut production. The hazelnut growing areas in Turkey are at 40–41° North and 37–42° East coordinates. The Black Sea coast is the most suitable area in terms of ecologic conditions for hazelnut cultivation within these limits [1–3]. On the Black Sea coast, hazelnut growing areas reach 80 km from the coast and 1300 m altitude [4].

In Turkey, hazelnut is cultivated in 16 provinces, including the oldest grower provinces, Giresun and Ordu. The hazelnut production area reached 706 thousand ha while it was 650 thousand in 2004 with an increment of 8.17% increase. Turkey constitutes 66% of world hazelnut production. Ordu province is the leading producer province in Turkey with 217,000 t [5] and provides 27.97% of production by itself [6].

Turkey is dramatically behind the other hazelnut-producing countries in terms of nut yield despite being the leading hazelnut exporting country. It ranks 10th with 64.2 kg·ha^{-1} yield while the USA has 269 kg·ha^{-1}, France has 221.3 kg·ha^{-1}, and China has 197.9 kg·ha^{-1} yields. The unpleasantly low yield is due to cultivation with old branches, deficits in technique, and completion of the economic lives of orchards [6].

Researchers made efforts to maintain a quality fruit in most of the fruit species. Special efforts on hazelnut mainly focused on pollinizers [7], grafting [8], canopy [9], fertilization [10,11], planting density [12], and training systems [13]. Climatic conditions, cultivar, and location are some of the other variables that affect hazelnut's fruit quality and chemical composition [14]. In Turkey, the 'ocak' system (Figure 1) is used in the

cultivation of hazelnuts, and ocaks comprise old and plenty of branches. Ocak is a bush-like growing system that consists of no main trunk as a tree. Branches are all considered as a tree without connecting a trunk. Even though this system is suggested for flatlands by many researchers [4,15,16], cultivation with this system is being used in all growing areas of Turkey. Pruning application is generally performed as removing excessively old branches or newborn suckers and pruning on branches is not performed. In recent years, the studies about the ocak system [17–19] and its effects on yield and quality increased significantly. However, these studies are still insufficient, and there need to be a lot more studies describing the ocak system and its effects. Clarifying the effects of branch numbers in ocak is one of the most crucial issues among all studies. This study was carried out to determine the effect of the number of branches in ocaks on fruit quality parameters in 'Palaz' and 'Tombul' cultivars.

Figure 1. Ocak system with low (**a**) and high (**b**) branch density (photos were taken by the author).

2. Materials and Methods

2.1. Material

This study was conducted in a farmer's orchard during the 2008 and 2009 seasons. 'Palaz' and 'Tombul,' which are the most cultivated hazelnut cultivars in Turkey, were used as material. The planting age of the orchard was 60. There was no pruning application on branches. Only sucker removal had been performed as a pruning application since the establishment of the orchard.

'Palaz': This hazelnut variety, which has medium taste and quality, is widely grown in Ordu. The fruit is round and flat, the top is wide, and the tip is fluffy. There is a brown, thin integument attached to the flesh on the inner fruit. The fruit is white with a relatively large kernel cavity. It can grow even in clayey, sandy, and gravelly soils with low soil depth. 'Palaz' wakes up relatively earlier than other hazelnut varieties in spring, making it more sensitive to late spring frost. Çotanaks of this cultivar varies between 2 and 4. Husks are generally 1.5 times the length of the fruits [20].

'Tombul': It is considered the most important hazelnut cultivar grown in Turkey. It is widely grown in Giresun province. The very good fruit quality has made it the most demanded hazelnut in international markets. Although it tends to periodicity, it gives regular and very high yield every year under good cultivation conditions. Its ripe fruit is plump and regular. It expands towards the table part, narrows evenly towards the end, and ends with a pointed tip. 'Tombul' has a very high percentage of oil, and it is sensitive to mechanical damage due to this characteristic. The husks are generally 2.5 times the length of the fruit [20].

2.2. Method

All ocaks had 12–15 branches before the trial was conducted. Extra branches of ocaks were removed, and the number of branches in ocaks was set as 4, 5, 6, 7, 8, 9, and 10 according to the experimental plan. The branch removal application was performed only in the 1st year, and only suckers were removed in the 2nd year. Irrigation was not performed in the orchard as it was in all Ordu province. In the 1st year of the study, CAN (calcium ammonium nitrate, 26% N) fertilizer was applied to ocaks 2 times (7 April and 15 May). In the second year, CAN was applied to the orchard 2 times on 30 March and 15 May when leaves and fruits reached lentil-sized, respectively. In both years, fruits were harvested on 8 August. Weed control was carried out by mowing the weeds in the orchard with an automatic scythe in mid-July.

At harvest, all ocaks were harvested separately. For each ocak, 30 fruits were randomly selected, and these fruits were dried until 12% moisture, and analyses were conducted on these samples. Fruit weight and kernel weight was determined by weighing with 0.001 g sensitive digital scales (Neck, Model WT-3000). Shell thickness and kernel cavity were determined by measuring with 0.01 mm sensitive caliper (D&W, Model DW1KDS15). The number of nuts per cluster was determined by counting 40 randomly selected clusters. Kernel ratio was calculated as a percentage of total fruit weight to total kernel weight [6,21]. Protein, fat, and ash properties were measured according to the method reported by Kaçar and İnal [22].

2.3. Experimental Design

The treatments consisted of 7 different branch numbers per tree (4, 5, 6, 7, 8, 9, and 10) with 3 replications according to the Random Parcels Trial Pattern. Data were analyzed by R Studio statistical software. Data of 2 years was evaluated together to have more reliable results due to yield fluctuations (periodicity-like) characteristic of hazelnut. Analysis of variance (ANOVA) was performed to clarify the effect of branch numbers on the quality traits, and differences were appointed according to Tukey's honestly significant differences (HSD) test. Data of all repetitions (ocaks) were used to perform analysis. To explain the relationships between fruit quality traits in terms of branch number, Principal Component Analysis (PCA) was performed for both cultivars. Correlations were conducted with the package 'corrplot' [23], and PCA was performed with 'ggplot2' [24].

3. Results and Discussions

The effect of branch number on the yield was significant in 'Tombul' and was not in 'Palaz' ($p < 0.01$). The yield of 'Palaz' ranged from 1024.66 g (5 branches) to 1460.19 g (8 branches) and the yield of 'Tombul' was 737.82 g (10 branches) to 2170.47 g (5 branches) (Table 1). Yield fluctuated in both cultivars according to years, however, as the number of branches decreased, the yield increased in general (Figure 2). In a similar study, the yield of 'Palaz' ranged from 1223 g (5 branches) to 7290 g (14 branches) and was significantly higher from our study [18]. Hazelnut's yield was affected by plenty of independents. Cultivar differences, poor soil conditions, climatic conditions, fertilization, and irrigation status of orchards were some of the main causes of yield differentiation. The study Çalışkan et al. [18] conducted and our study had almost the same conditions (they were both in Blacksea conditions) other than the planting age of orchards that it was carried out on a 20-year-old orchard while ours was 60 years. Even though the branches that reached the age of 10 were systematically removed and rejuvenated by new branches, the results of this study clarified that the yield was decreasing with the increasing age of ocaks supporting Kırca, who reported a significant decrease in yield, especially after 50 years [15].

Table 1. Fruit quality criteria according to different branch numbers.

Cultivars	Properties	Branch Numbers							
		4	5	6	7	8	9	10	*p*-Value
'Palaz'	The Number of Nuts in Cluster	2.76 ns	3.15	2.99	3.08	3.12	3.17	3.77	0.0691
	Yield (g)	1152.5 ns	1024.66	1244.07	1443.66	1460.19	1246.99	1210.54	0.5433
	Fruit Weight (g)	1.91 a	1.88 a	1.84 a	1.82 a	1.66 ab	1.65 ab	1.54 b	<0.0001
	Kernel Weight (g)	1.02 a	0.99 a	0.99 ab	0.94 ab	0.86 abc	0.85 bc	0.77 c	<0.0001
	Kernel Ratio (%)	53.28 a	52.93 a	54.24 a	51.67 ab	51.95 ab	51.44 ab	50.56 b	0.0439
	Kernel Cavity (mm)	1.16 c	1.78 b	1.83 ab	1.81 ab	2.04 ab	2.23 a	1.98 ab	0.0001
	Shell Thickness (mm)	1.10 ab	1.08 b	1.17 ab	1.19 ab	1.21 ab	1.28 a	1.24 ab	0.0008
'Tombul'	The Number of Nuts in Cluster	3.30 c	3.50 bc	3.58 abc	3.79 abc	3.76 abc	4.10 ab	4.21 a	0.8619
	Yield (g)	1367.39 b	2170.47 a	1787.71 ab	1665.73 ab	1640.67 ab	1304.86 b	737.82 c	<0.0001
	Fruit Weight (g)	1.79 a	1.78 a	1.79 a	1.71 ab	1.62 ab	1.57 b	1.54 b	<0.0001
	Kernel Weight (g)	0.95 a	0.95 a	0.94 a	0.91 ab	0.85 bc	0.82 bc	0.80 c	<0.0001
	Kernel Ratio (%)	52.98 ns	53.12	52.25	52.92	52.44	52.12	51.92	0.0621
	Kernel Cavity (mm)	0.88 b	1.04 ab	1.21 ab	1.24 ab	1.18 ab	1.32 ab	1.60 a	0.0003
	Shell Thickness (mm)	1.09 c	1.08 c	1.14 bc	1.23 a	1.25 ab	1.27 ab	1.27 a	0.0001

Different letters in the same row indicate significant differences. ns: Not significant.

It was necessary to evaluate the number of fruits in the cluster in two ways. As the number of fruits in the cluster increased, the yield increased, which was the desired condition. However, as the number of fruits in clusters increased, the fruit became smaller. Small fruit was undesirable. For this reason, the number of fruits in the cluster was very crucial [6]. In this study, the branch number significantly affected the number of fruits in the cluster in 'Tombul' (*p* < 0.01) and was not significant in 'Palaz'. The number of fruits in the cluster varied between 2.76 (4 branches) and 3.77 (10 branches) in 'Palaz' and ranged from 3.30 (4 branches) to 4.21 (10 branches) in 'Tombul' (Table 1). Although fluctuations have been observed in both cultivars, the number of fruits in the clusters decreased with decreasing branch numbers (Table 1) Çalışkan et al. [18] reported fruit numbers in clusters varied between 2.35 (6 branches) and 2.65 (5 branches) in 'Palaz'. The results from our study were similar to those previously reported. The high-yielding ocaks, 7 and 8 branches, had an average of approximately 3 fruits in clusters and statistically higher fruit weights. Our results clearly appointed that 7–8 branches per ocak were optimal.

The effect of branch number on fruit weight was statistically significant in both cultivars (*p* < 0.01). In general, fruit weight increased as the number of branches decreased for both cultivars. Fruit weight ranged from 1.54 g (10 branches) to 1.91 g (4 branches) in 'Palaz' and 1.54 g (10 branches) to 1.79 g (4 and 6 branches) in 'Tombul' (Table 1). In similar studies, the fruit weight of 'Tombul' was 1.60–1.87 g, 1.71−1.80 g, 1.67–2.19 g, and 1.82–2.03 g [14,21,25,26], respectively. The fruit weight of 'Palaz' was reported between 2.11–2.29 g by Gülsoy et al. [26]. Fruit weights reported in previous studies were consistent with our findings. On the other hand, it was seen that fruit weight changed in a wide range both in previous studies and in our study. High fruit weight was one of the most prominent fruit quality criteria, and the results revealed that 5 to 7 branched ocaks had more desirable fruit weight without causing yield reduction.

High kernel weight was a crucial characteristic affecting the yield per unit area. In this study, kernel weight was negatively related to the branch number for both cultivars (*p* < 0.01). Kernel weights ranged from 0.77 g (10 branches) to 1.02 g (4 branches) in 'Palaz', and 0.80 g (10 branches) to 0.95 g (4 and 5 branches) in 'Tombul' (Table 1). Previous researchers reported the kernel weight of 'Tombul' varied between 0.76 g (10 branches) to 1.02 g (5 branches), 0.67 to 1.13 g, 0.87 g to 1.03 g [21,27,28], and the kernel weight of 'Palaz' varied between 1.12 to 1.14 g [26]. Our results were in harmony with previous studies.

Kernel ratio was one of the most important fruit quality characteristics directly affecting the price of fruit. The kernel ratio showed a seasonal variation. While 'Palaz' was negatively affected by branch number ($p < 0.05$), the effect of brunch number was insignificant in 'Tombul'. The kernel ratio of 'Palaz' varied between 50.56% (10 branches) to 54.24% (6 branches), while it was between 51.92% (10 branches) to 53.12% (5 branches) in 'Tombul' (Table 1), respectively. The kernel ratio of 'Palaz' was previously reported as 49.8% [1], 47.3% [3], 52.25–54.00% [26], and the kernel ratio of 'Tombul' was 51.7% [1], 48.20% [27], 49.9% [3], 45.11–54.07 [25]. Bostan [27] stated a negative relationship between the number of branches and kernel ratio, and the highest kernel ratio was in 5–6 branches while the lowest was in 9–10 branches. The kernel ratios obtained in this study were totally consistent with those stated by Bostan [27] and higher than some others. Moreover, high kernel ratios were realized in a positive relationship with the yield being in high yield branch numbers. This result indicated that choosing the proper branch number by the goal of yield will also provide the highest quality kernel ratio nuts.

Shell thickness was a substantial criterion that needed to be improved, as it affected the kernel ratio. Shell thickness increased with the increment of branch number for both cultivars ($p < 0.01$) (Table 1). Shell thickness ranged from 1.08 mm (5 branches) to 1.28 mm (9 branches) and 1.08 mm (5 branches) to 1.27 mm (9 and 10 branches) in 'Palaz' and 'Tombul', respectively (Table 1). Islam [29] reported shell thicknesses between 1.08–1.04 mm in 'Palaz' and 0.94–0.96 mm in 'Tombul'. In another study, Karadeniz and Islam [21] reported the shell thickness of 'Tombul' varying between 0.86–1.01 mm. In other studies that investigated the effect of the number of branches on fruit quality characteristics of hazelnuts, Bostan [27] reported the shell thickness of the 'Tombul' as 0.93 mm (4 branches)—1.00 mm (10 branches) while Çalışkan et al. [18] reported the shell thickness of 'Palaz' varying between 1.08 mm (14 branches) and 1.20 (7 branches). While our results overlap those of Bostan [27] stated, they contradict those of Çalışkan et al. [18]. Researchers noted that fertilization did not affect shell thickness significantly [30,31]. In this perspective, the main difference seems to be the ages of ocaks in the studies. Çalışkan et al. [18] studied a 20-year-old orchard while ours were 60 years. This result supported the knowledge that the increasing root age increased shell thickness [15].

Increasing kernel cavity caused nigresence over time, and the fruit began to deteriorate. Thus, a small kernel cavity was appealing. In this study, the kernel cavity increased with the increasing number of branches ($p < 0.01$). The kernel cavity ranged from 1.16 mm (4 branches) to 2.23 mm (9 branches) and 0.88 mm (4 branches) to 1.60 mm (10 branches) in 'Palaz' and 'Tombul', respectively (Table 1). Previous researchers reported the kernel cavity values as 0.44 mm (4 branches) and 1.37 mm (10 branches) [27], 0.00–1.84 mm [28], and 0.52–1.75 mm [21] in 'Tombul' and 2.95–3.96 mm in 'Palaz' [29]. The kernel cavity values determined in our study were usually smaller than previously reported, and it was thought to occur by branch removal. As it is stated in the methods, root ages were all in the same age, which indicates that they were all developed equally, and their nutrition uptake potential from the soil was approximately equal, meaning that equal amounts of nutrients were utilized by fewer branches. Thereby, removing excess branches was evaluated as especially crucial in the cultivars that had a high kernel cavity.

Increasing branch number caused a statistical diminish in protein content for both cultivars ($p < 0.01$). The protein contents ranged from 10.64% (10 branches) and 15.06% (5 branches) and 12.83% (10 branches) and 18.08% (6 branches) in 'Palaz' and in 'Tombul', respectively (Table 2). The protein content of the 'Palaz' was reported between 13.1% (8 branches) and 14.6 (5 branches) by Çalışkan et al. [18]. Karadeniz and Bostan [32] stated the protein ratio of 'Tombul' between 16.76% and 17.83%. Besides coinciding with the previous studies, there was a wider range of protein in our study. The variation may be due to the high number of samples, the differences in the ecology of the studies, and the cultural management of the orchards. On the other hand, the dramatic decrease of protein ratios when branch numbers exceeded 7 was not negligible. Fewer competition thanks to decreasing branch numbers provided a clear enhancement in protein content.

Proteins consisted of amino acids, and they used Nitrogen and Sulfur as a source. Ocaks were supplemented with calcium ammonium nitrate with the same concentrations. Thus, nitrogen uptake per branch decreased for each increment in the branch number resulting in a decline in protein content. Similar metabolisms have been reported in some annuals [33], perennials [34], and in vitro [35].

Fats and fatty acids affect the quality, storage time, processing, and many other properties of hazelnuts. Fat ratios were significantly affected for both cultivars ($p < 0.01$). The fat ratios ranged from 60.88% (10 branches) to 66.56% (4 branches) and 62.82% (9 branches) to 67.95% (5 branches) in 'Palaz' and in 'Tombul', respectively. Almost a linear decrease was observed with the increment of branch numbers (Table 2). The fat ratios of 'Palaz' reported varying between 63.9% (14 branches) and 68.0 (8 branches) [18]. The fat ratio of 'Tombul' was reported between 65.92–67.98% [1]. Fat ratios of fruits were similar to previous studies proving that the heritability of fat content was significantly high [36], and it mostly depended on the cultivar. On the other hand, although it had a high inheritance, the results have proven that differences in fat content may occur with cultural treatment differentiations. Furthermore, the improvement of the fat ratio by branch number decrease was related to nutrient uptake and insertion. Seeds (kernels) store nitrogen-free materials, proteins, and oil. Protein and oil fulfill the remaining space in the kernels [37]. Therefore, the determination of the maximum kernel weight and fat ratios in the same branch numbers clearly indicates that identifying the optimal conditions for yield and yield parameters also provides optimal protein and oil synthesis since stems and shoots serve as a sink for both vegetative and reproductive parts.

Table 2. Changes in fat, protein, and ash values according to different branch numbers.

Cultivars	Properties	Branch Numbers							
		4	**5**	**6**	**7**	**8**	**9**	**10**	**_p_-Value**
'Palaz'	Protein (%)	13.90 ab	15.06 a	14.15 ab	12.70 abc	12.64 abc	11.37 bc	10.64 c	<0.0001
	Fat (%)	66.56 a	66.29 a	64.37 ab	63.02 ab	63.10 ab	61.27 b	60.88 b	<0.0001
	Ash (%)	2.30 a	2.29 a	2.01 b	1.87 bc	1.79 bc	1.82 c	1.76 c	<0.0001
'Tombul'	Protein (%)	15.76 abc	15.76 abc	18.08 a	17.09 ab	14.24 bc	13.36 bc	12.83 c	0.0007
	Fat (%)	66.30 ab	67.95 a	66.79 ab	66.18 ab	65.32 ab	62.82 b	63.08 b	<0.0001
	Ash (%)	2.05 ab	2.23 a	2.06 ab	1.94 ab	1.91 b	1.83 b	1.83 b	0.0027

Different letters in the same row indicate significant differences.

Branch number negatively affected the ash ratios of both cultivars ($p < 0.01$). The ash ratio ranged from 1.76% (10 branches) to 2.30% (4 branches) and from 1.83% (9 and 10 branches) to 2.23% (5 branches) in 'Palaz' and in 'Tombul', respectively (Table 2). The ash ratios of 'Tombul' were reported to vary between 1.97–2.60% [21]. The ash ratios of 'Palaz' were reported to range from 2.03 (5 branches) to 2.21 (6 branches) [18]. Although increasing branches caused a decrease in the ash content of both cultivars, 'Palaz' showed almost a linear decline in the as ratio while it changed in a narrow range in 'Tombul'. Cultivars' responses to branch numbers proved that genetics was one of the main factors affecting nutrient accumulation and metabolization.

Correlation analysis revealed crucial results that need to be paid attention to. The yield, being one of the most important characteristics in all fruit species, was positively correlated to nut numbers in the cluster in 'Palaz', but it was negligible, being close to zero. Besides, there was a relatively high negative relationship between yield and nut numbers in the cluster, even though it was not statistically significant. Similar contradicting results were observed between yield and protein. The fat ratio was considerably high and positively related to protein, kernel weight, and shelled fruit weight in both cultivars. On the other hand, it was negatively correlated with the kernel cavity and nut numbers in the cluster in both cultivars. Furthermore, the biological traits (ash, fat, and protein)

were positively correlated with the same significance level in both cultivars. Similar results were reported by İşbakan and Bostan [38]. These results indicate that the biological traits are more relevant to each other, while agronomic traits differ with the alteration such as ecology, cultivation, and genetic. Therefore, when evaluating plant characteristics, it was clearly seen that the evaluations should be faded down from species to cultivar.

Shelled fruit weight had a significant positive association with kernel weight in both cultivars. Shelled fruit weight, kernel weight, and fat decreased with the increment of nut-number in the cluster in both cultivars. While nut number in cluster increased shell thickness of 'Tombul', it decreased that of 'Palaz'. Kernel ratio was not significantly related to all other traits in both cultivars except kernel weight in 'Palaz'. The fact that the kernel ratio was used as the main feature in determining the price of hazelnuts in the marketing process was a clear indication that this feature should be evaluated thoroughly in all aspects. In previous studies, contrary to our study, some significant relationships between kernel ratio and yield and some other traits were reported [17,38]. Indeed, as kernel ratio was not statistically affected by other features shows that the desired values can always be reached under the right cultivation conditions. Because all the cultivation processes in the orchard have been applied completely in order to be sure the data obtained in this study to be exactly correct. These results also confirmed the information 'fruit trees will maintain their existing productivity in their genetic potential when adequate cultivation conditions are created' [39]. Correlations between fruit characteristics for both hazelnut cultivars are shown in Figure 2 in detail.
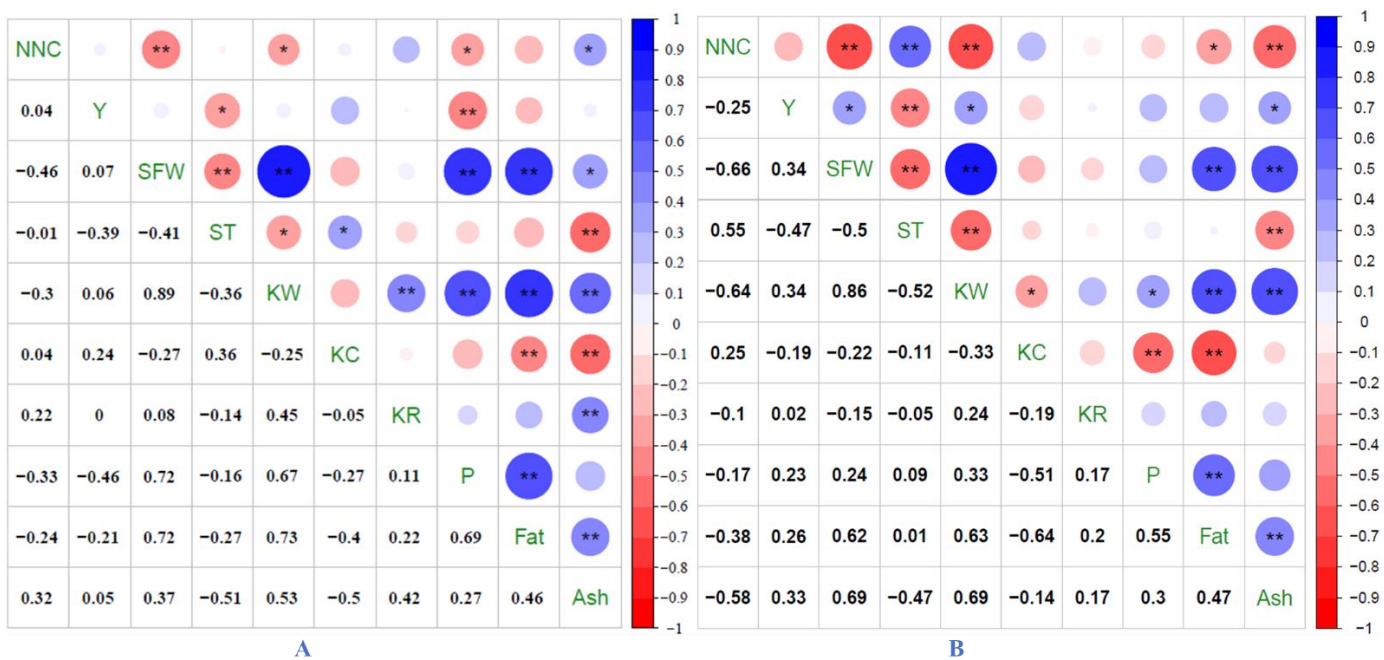

Figure 2. Correlations between fruit characteristics in 'Palaz' (**A**) and 'Tombul' (**B**) cultivars. Y: Yield, P: Protein, SFW: Shelled Fruit weight, KW: Kernel weight, KC: Kernel cavity, KR: Kernel ratio, NNC: Nut number in the cluster, ST: Shell thickness. *, ** indicate significant at $p < 0.05$ and $p < 0.01$, respectively.

The principal component analysis was performed on cultivars to further understand how the features are related among themselves and with the number of branches. In 'Palaz', the first two components explained 59.4% of the data. The most important characteristic that affects the PC1 was kernel weight (0.45), while the most prominent characteristic in PC2 was nut number in the cluster (0.50). The first two components described 62.2% of the data in 'Tombul'. As it was in 'Palaz', kernel weight was the most important characteristic that affecting PC1 (0.43). Kernel cavity had the most effect on PC2 (−0.50). PCA clarified the relationships between the number of branches crucial traits. In both varieties, 4, 5, and 6 branches were grouped together with high kernel and shelled weight, protein, fat, and

ash values while 7, 8, and 9 branches were opposite to them being illustrated by kernel cavity, nut number in the cluster, and shell thickness. All relations in both cultivars were presented in Figure 3 with the number of branches.
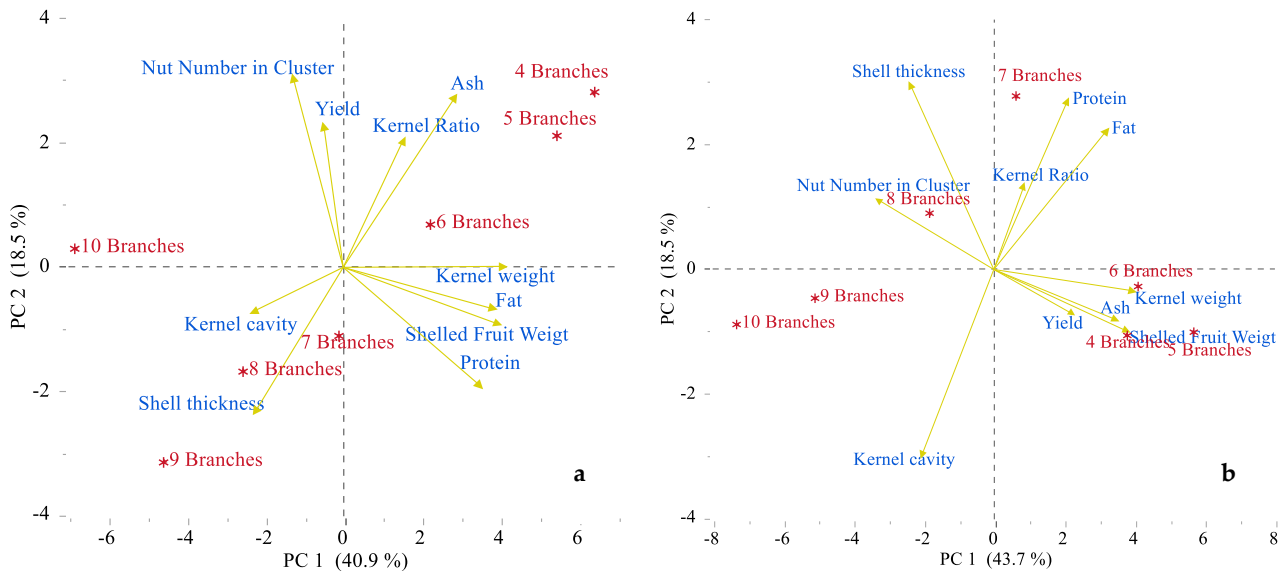

Figure 3. Relationships amongst fruit characteristics in 'Palaz '(**a**) and 'Tombul' (**b**) in terms of branch numbers.

4. Conclusions

This study was carried out with two prominent hazelnut cultivars in the world and interpreted the effects of the number of branches in the ocak that is the most used growing technique worldwide. The results of the study showed an increase in quality parameters with decreasing branch numbers. The highest quality fruits and yield were obtained from the ocaks that did not exceed six branches. Four–five branches had the best fruit quality, and to increase the yield, removal of branches from dense ocaks is needed in Ordu ecology. To obtain a high-quality product, the number of branches in the ocak can be limited to a maximum of 6, but the soil and the location of the orchard should be considered in determining the number of branches. Moreover, appropriate branch numbers for different regions need to be determined by carrying out similar studies. It clearly seems that excess branches will not mean more products.

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