https://dx.doi.org/10.22161/ijhaf.3.4.12 *ISSN: 2456-8635*

Effect of altitude and fruit bearing position on physical quality attributes of mandarin (*Citrus reticulata* Blanco) in Kavre, Nepal

Kiran Timilsina[1], Kalyani Mishra Tripathi[2]

[1]Agriculture and Forestry University, Rampur, Chitwan, Nepal
Email: kiran_freedom@live.com
[2]Department of Horticulture, Agriculture and Forestry University, Rampur, Chitwan, Nepal
Email: kmishra@afu.edu.np

***Abstract*— *Mandarin occupies a prominent position in the total fruit sector of Nepal. A study was conducted to assess the physical quality of mandarin in Kavre district of Nepal during February, 2018. Three altitudes (1410, 1540 and 1670 m.asl) and four bearing positions (East, West, North and South) in each tree were taken, from southern facing slope of local mandarin orchard under normal farmer managed practices. Fruits from each sector were scored for total weight, peel weight, peel thickness, length, diameter, juice content, rag and seed content and firmness. The result showed that the peel thickness (4.26 mm), length (51.62mm), firmness (6.04 lb/cm^2) were recorded higher in the mandarin harvested from an altitude of 1410 m.asl. Weight (78.37 g), percentage composition of peel (34.91%) and diameter (58.85 mm) were recorded highest in mandarin at an altitude 1540 m.asl. Percentage composition of juice (45.11%), percentage composition of rag and seed (27.62%) was recorded highest in mandarin fruit harvested in 1670 m.asl altitude. Similarly, weight (83.40 g), percentage composition of rag and seed (29.13%), length (49.16 mm) and diameter (59.08 mm) were recorded higher in mandarin on eastern canopy of tree. Percentage composition of juice (47.36%) was recorded higher in mandarin fruit harvested from western canopy. Peel thickness (3.74 mm) and firmness (4.41 lb/cm^2) were recorded highest in mandarin harvested from northern canopy of tree. The percentage composition of peel (33.81%) was highest in mandarin of southern canopy. The combined effect of altitude and fruit bearing position had significant effect on percentage composition of juice ($P<0.01$), percentage composition of rag and seed ($P=0.08$), length ($P=0.016$) and firmness ($P=0.021$). Mandarins at southern bearing position located at 1540 m.asl and lower altitude were comparatively of good quality than of the upper altitude*

Keywords*— *Canopy Position, Altitude, Physical, Quality Parameters

I. INTRODUCTION

The main citrus type grown in Nepal is Mandarin with approximately 64.8% acreage of the total citrus area (40,554 ha). The total area under mandarin in Nepal is 26,282 ha with the productive area of 16,248 ha and production of 146,690Mt (MOAD, 2016). Cultivation of mandarin orange (*Citrus reticulata* Blanco) is one of the major economic activities in the mid-hills (550-1300 m) of Nepal (Lohar, 1995). The mid-hill region of Nepal lying between 26^o 45'' to 29^o 40'' north latitude and 80^o 15'' to 88^o 12'' east longitude is quite suitable for mandarin cultivation (Shrestha & Verma, 1999).

Kavre, the mid-hill district of Province no. 3 of Federal Democratic Republic of Nepal is the one of the important mandarin orange growing area of Nepal. The total area and productive area in Kavre district were respectively 1,365 ha and 914 ha. The production of Mandarin was 10,962 Mt (MOAD, 2015/16). It is the most important income generating fruit of Kavre. District earned 450 to 500 million rupees by selling 90-92% of their total production outside the district in 2015/16 (DADO, 2015/16). Mandarin orange cultivation provides nutrition, employment to the people, acts as source of income and maintains environmental harmony (Tomiyashu, Verma, & Thapa, 1998).

https://dx.doi.org/10.22161/ijhaf.3.4.12 *ISSN: 2456-8635*

The production of better quality fruit is of paramount significance to attract the consumer preference. The position of the fruit and aspect of the fruit on a particular tree has considerable influence on the quantity and quality of fruit. The quality traits of fruits are affected by number of factors. Among this orientation of the fruit on the tree play a marvelous role in influencing the quality of the fruit (Gosh & Mitra, 1990; Underhill & Chadha, 1990; Mitchell, McLauchtan, Issacs, William, & Nottingham, 1992; Baidiyala, 1993; Rehman, Ahmad, Ghaffor, & Baloch, 1982; Rehman, Baloch, & Ghaffor, 1984 and Ray & Munshi, 1990). Mandarin orange grown at higher altitudes of Kavre district is not as good in terms of quality as they are in lower altitudes (Shrestha & Shrestha, 1999). Fruit quality is mainly determined by fruit color, fruit size, juice content (%), total soluble solids (TSS), titrable acidity (TA) and the TSS:TA ratio (Verreynne, Rabe, & Theron, 2004).

Differences in physical properties are associated with positional differences in canopy microclimate and exposure to light and temperature individual fruit (Sites & Reitz, 1949). All quality is influenced by factors such as fruit size, harvest date, position in the tree, rootstocks and climatic conditions. Each of these factors contributes to the variation in quality among fruit from same tree. Fruit from the southern side (northern hemisphere) of the tree had lower juice content (%) than from the northern side of the tree (Cohen, 1998).

The aim of this study was to determine fruit quality differences between the fruit from different bearing positions of tree canopy of local mandarins grown at different elevations of Kavre, Nepal.

II. MATERIAL AND METHODS

The study on the effect of elevation and fruit bearing positions on fruit quality attributes was conducted at Sharadhabatashe, Eklekhent and Sankhu, Kavre district during 2018. Three locations based on elevations (around 1410 m.asl, around 1540 m.asl and around 1670 m.asl) with four fruit bearing positions (viz. east, west, north and south) was taken for evaluation. Southern facing local mandarin tree with uniform size, age, vigor and under common farmer management were selected by GPS and were marked. Forty eight fruits representing the single tree (12 from each bearing positions (4 fruits at 50 cm interval height from inner canopy to outer canopy)) were collected and a replica containing 4 mandarins of each bearing positions were packed in sealed plastic bags and collected for physical analysis. Fruits were harvested in first week of February.

Different physical parameters i.e. fruit weight, length, diameters, firmness, peel weight, peel thickness, juice content and rag content (pulp + seed) were taken. The weight of fruit, peel and rag was recorded with the help of top balance. The diameter of fruit, peel thickness was measured with Vernier caliper, firmness was measured with penetrometer. The juice content was measured with squeezing by lemon squeezer and measured by top balance. The data were recorded, tabulated and statistically analyzed as mentioned by Gomez & Gomez (1984).

III. RESULTS AND DISCUSSION

1 Effects on physical properties of mandarin

1.1 Weight

The altitude had highly significant effects (P = 0.001) on fruit weight (Fig.1). The maximum weight (78.37 g) was observed in the mandarin at an altitude of 1540 m.asl followed by mandarin at an altitude of 1410 m.asl (76.64 g). The lowest weight (67.53 g) of mandarin was recorded in mandarin of highest altitude (1670 m.asl) considered.

https://dx.doi.org/10.22161/ijhaf.3.4.12 *ISSN: 2456-8635*

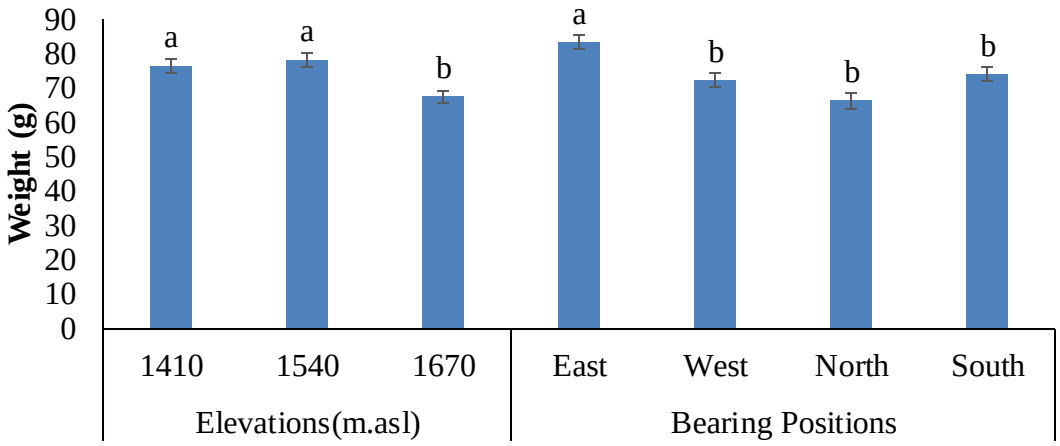

Fig.1: Effect of altitude and bearing position on weight of mandarin in Dhulikhel, Kavre, 2018

The fruit bearing position had very highly significant effects ($P \leq 0.001$) on fruit weight. The maximum weight (83.40 g) was observed in mandarin in the eastern canopy of the tree. The least weight (66.43 g) was observed in mandarin in the northern canopy of fruit bearing position within tree followed by mandarin in western bearing position of tree canopy (72.44 g) and mandarin in southern bearing position (74.20 g).

The higher weight at lower altitude is mainly due to cell division and dry matter accumulation resulted due to higher temperature (Rokaya, Baral, Gautam, Shrestha, & Paudyal, 2016). The accumulated juice inside the juice sacs contribute for the weight of mandarin. Summing these observations, mandarin weight decreased with the increase of altitude and lower altitude is best for its cultivation. Orchard altitude has a profound influence on light, temperature, humidity and other factors which have a direct influence on the fruit bearing, growth and maturity of fruits as well as on the physiochemical properties of mandarin. The inferior quality in high altitude might be due to the low light intensity resulting in low rate of starch synthesis and less starch content (Dhanraj, Krishnaprakash, & Arvindaprasad, 1985). The catabolic activities in the cell and loss of dry matters in the fruit sacs contribute for the loss of weight in mandarin (Rokaya, 2017).

1.2 Peel percent

The altitude had very high significance effects ($P \leq 0.001$) on percentage composition of peel (Fig.2). The highest peel percentage (34.91%) was observed in mandarin fruit at an altitude of 1540 m.asl followed by mandarin fruit at an altitude of 1410 m.asl (34.71%). The least peel percentage (27.29%) was observed in mandarin fruit at an uppermost altitude (1670 m.asl).

The fruit bearing position had significant effects ($P = 0.018$) on percentage composition of mandarin peel. The highest percentage (33.81%) of peel content was observed in mandarin fruit at southern bearing position of tree canopy. The least percentage (30.47%) of peel content was found in mandarin in western bearing position of tree canopy.

Intra- tree investigation showed that quality of mandarin is influenced by position of the fruit in the canopy. Sun exposed sectors of the canopy yield more fruit of higher quality than shaded inside canopy sectors (Trad, Galliche, Renard, & Mars, 2013). The content of peel by percentage was higher than compared to other mandarin hubs of Nepal. The rinds (peel) obtained from the pericarp of citrus is the primary waste and is available in large quantities during the citrus season thereby constituting environmental hazard and pollution to the environment. It would be beneficial if these wastes be put into productive use (Olabinjo, Ogunlowo, Ajayi, & Olalusi, 2017).

https://dx.doi.org/10.22161/ijhaf.3.4.12 *ISSN: 2456-8635*

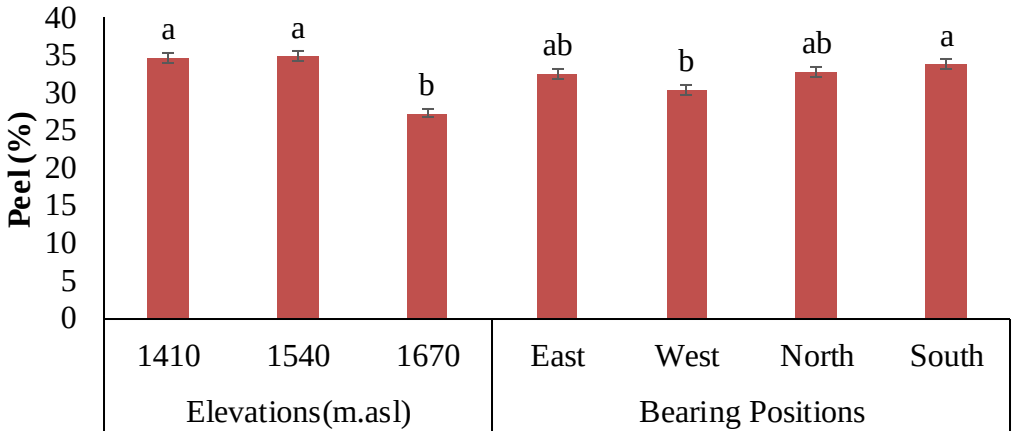

Fig.2: Effect of altitude and bearing position on peel (%) of mandarin in Dhulikhel, Kavre, 2018

1.3 Juice percent

The altitude had very high significance effects ($P \leq 0.001$) on percentage composition of juice of mandarin (Fig.3). The highest percentage (45.11%) of juice content was observed in mandarin at an altitude of 1670 m.asl. The least percentage (39.57%) of juice content was observed in mandarin fruit at an altitude 1410 m.asl followed by mandarin fruit at an altitude of 1540 m.asl (43.03%). The percentage composition of juice was found increasing with the increase in altitude.

Similarly, the bearing position of fruit in tree canopy had very high significant effects ($P \leq 0.001$) on percentage composition of juice of mandarin. The highest juice content (47.36%) was observed in mandarin fruit in western bearing position followed by mandarin in southern bearing position (45.68%). The lowest percentage (38.43%) composition of juice was observed in mandarin harvested from northern side of tree canopy followed by mandarin harvested from eastern bearing position (38.82%).

The warmer exterior part of tree canopies might have lower juice content due to lower availability of water in the trees and therefore that higher rates of photosynthetae translocation are found in these fruit due to active osmoregulation to maintain cell turgour (Yakushiji, Moringa, & Nonami, 1998). The better retention of juiciness qualities in fruits might be due to metabolic differences in the ripening rates of fruits from different altitudes (Dhanraj *et al.*, 1985).

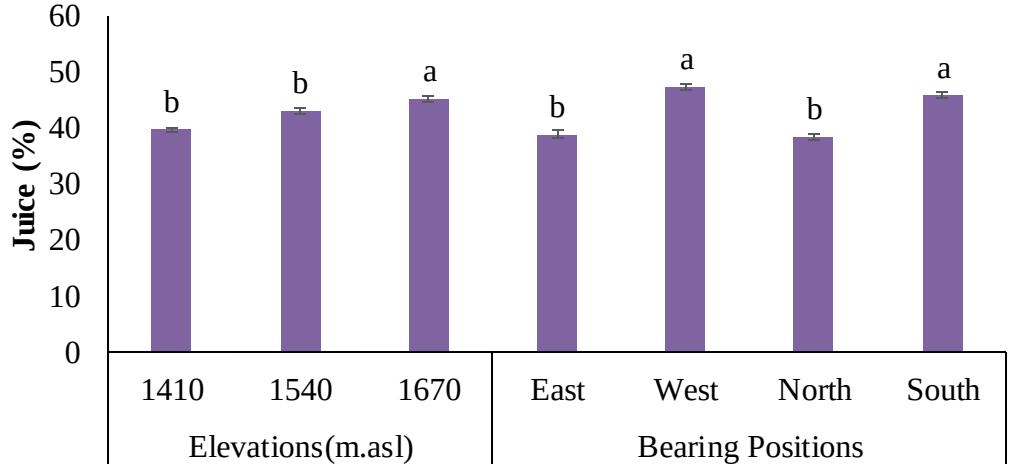

Fig.3: Effect of altitude and bearing position on Juice (%) of mandarin in Dhulikhel, Kavre, 2018

In findings from Reitz & Sites (1949); the direction of exposure of the leaf canopy to the light also had little if any relation to the amount of juice in the fruit with numerous exceptions. The juice content was found higher in the

https://dx.doi.org/10.22161/ijhaf.3.4.12 *ISSN: 2456-8635*

mandarin fruit at western canopy at each altitude judged. The different juice content observed between different altitudes between different farms under experiment is attributed to farm location as well as management of orchard system at each location and influenced by light interception and distribution.

1.3.1 Interaction effect of altitude and bearing position on juice percentage

The interaction effect of altitude and fruit bearing position on percentage juice content of mandarin was significantly high (F pr. 0.002) as shown in (Fig.4). The percentage of juice content was recorded highest in mandarin fruit of western canopy of tree at 1670 m.asl (51.27%) followed by mandarin fruit of southern canopy at same altitude (49.13%). The minimum juice percentage (37.19%) was observed in mandarin fruit of northern canopy at 1540 m.asl followed by mandarin fruit of eastern bearing position at 1410 m.asl (37.25%).

1.4 Rag and seed percent

The altitude had very high significant effects ($P \leq 0.001$) on percentage composition of rag and seed of mandarin (Fig.5). The highest percentage (27.62%) of rag and seed was observed in mandarin fruit at an altitude of 1670 m.asl. The least percentage (22.08%) was observed in mandarin at an altitude of 1540 m.asl.

Similarly, the bearing position of fruit within tree canopy had very high significant effects ($P \leq 0.001$) on percentage composition of rag and seed. The highest percentage (29.13%) of rag and seed was recorded in fruit at the eastern bearing position within tree canopy followed by mandarin at northern bearing position of tree canopy (28.74%). The lowest percentage (20.52%) was observed in mandarin located at southern bearing position followed by mandarin at western side of tree canopy (22.20%).

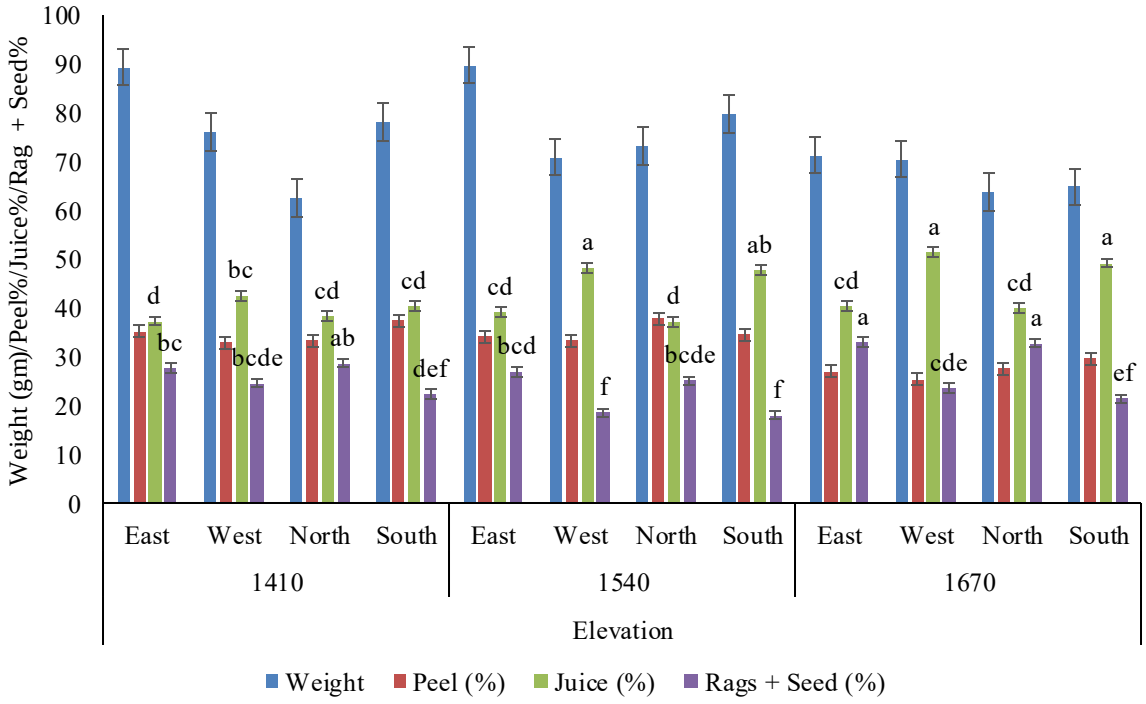

Fig.4: Interaction effect of altitude and bearing position on weight, peel (%), juice (%) and rag and seed (%) of mandarin in Dhulikhel, Kavre, 2018

https://dx.doi.org/10.22161/ijhaf.3.4.12 *ISSN: 2456-8635*

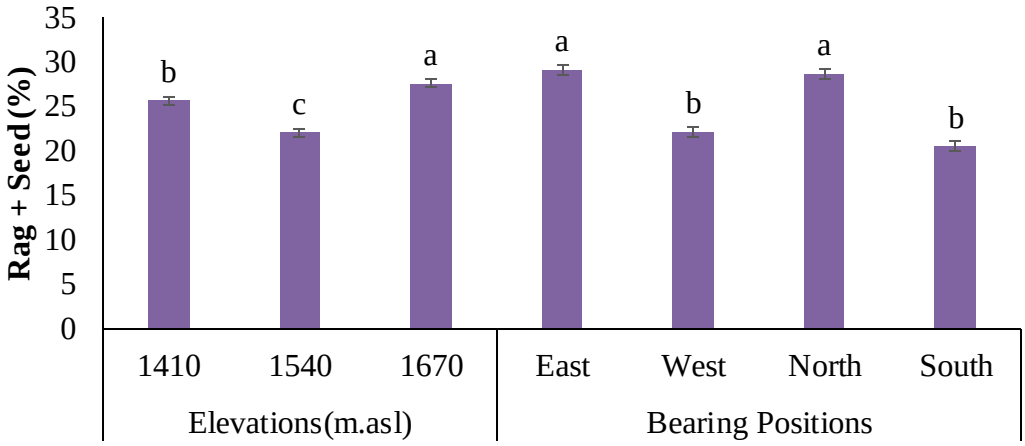

Fig.5: Effect of altitude and bearing position on rag and seed (%) of mandarin in Dhulikhel, Kavre, 2018

1.4.1 Interaction effect of altitude and bearing position on percentage composition of rag and seed

The interaction effect of altitude and fruit bearing position on percentage rag and seed content of mandarin was found significant highly (Fig.4). The lowest percentage (17.93%) of rag and seed content in individual fruit was recorded in mandarin fruit of southern canopy at 1540 m.asl followed by mandarin fruit at western canopy in the same altitude (18.53%). The highest percentage of rag and seed (32.95%) was found in mandarin fruit of eastern canopy at 1670 m.asl followed by mandarin fruit of northern canopy at same altitude (32.64%). Comparatively the middle altitude of the test contained lower percentage of peel and rag.

1.5 Peel thickness

The altitude had very high significance effects ($P \leq 0.001$) on peel thickness of mandarin (Fig.6). Peel of mandarin located at an altitude of 1410 m.asl was thickest (4.26 mm). Thin peel (3.01 mm) was observed in mandarin at an altitude of 1670 m.asl followed by mandarin at an altitude of 1540 m.asl (3.57 mm). In general trend peel thickness decreased with the advancement of altitude.

The non-significant effects were observed in between the mandarin bearing position within tree canopy and peel thickness. Several parameters are considered to be influenced by solar radiation, including fruit size, flesh firmness, soluble solids, anthicyaninin and starch content, acidity, pH and dry matter (Erez & Flore, 1986).

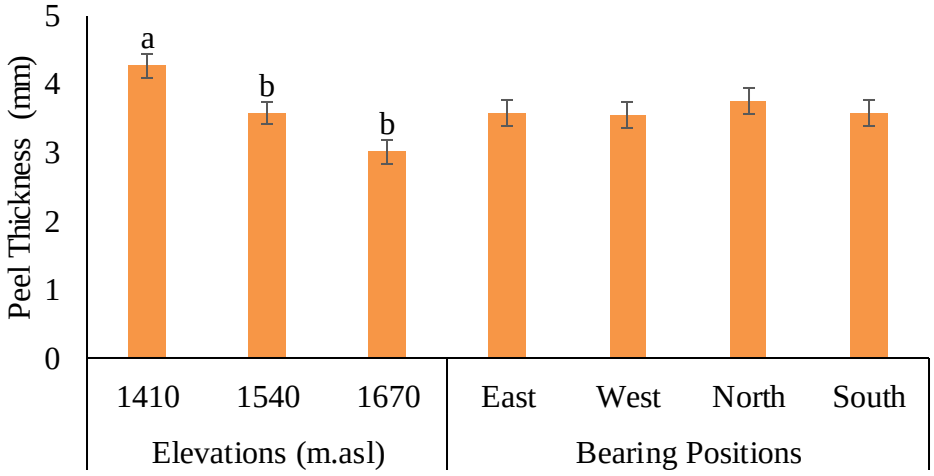

Fig.6: Effect of altitude and bearing position on peel thickness of mandarin in Dhulikhel, Kavre, 2018

https://dx.doi.org/10.22161/ijhaf.3.4.12 *ISSN: 2456-8635*

1.6 Length

Fig.7). The largest length (51.62mm) of mandarin fruit was observed in mandarin fruit at an altitude of 1410 m.asl. The shortest length (43.43 mm) of mandarin was observed in mandarin fruit at an altitude of 1610 m.asl. The length of mandarin fruit was found decreasing with the advancement of altitude.

The non-significant effects were observed in between the mandarin bearing position and length of mandarin fruit. The sensory quality attributes from high altitude compared to low altitude reveal climatogical factors affect on length and diameter of mandarin.

The altitude had very high significance effects ($P \leq 0.001$) on length of mandarin fruit (

1.6.1 Interaction effect of altitude and bearing position on length of mandarin

Altitude and bearing position had significant effect on length of mandarin fruit. As shown in Fig.8; the highest length (53.35 mm) was found in mandarin of eastern canopy at 1410 m.asl followed by mandarin at western canopy (53.13 mm). The lowest axial diameter (42.07 mm) was recorded in mandarin fruit of southern canopy at highest altitude of test followed by mandarin in northern canopy at the same altitude (43.38 mm).

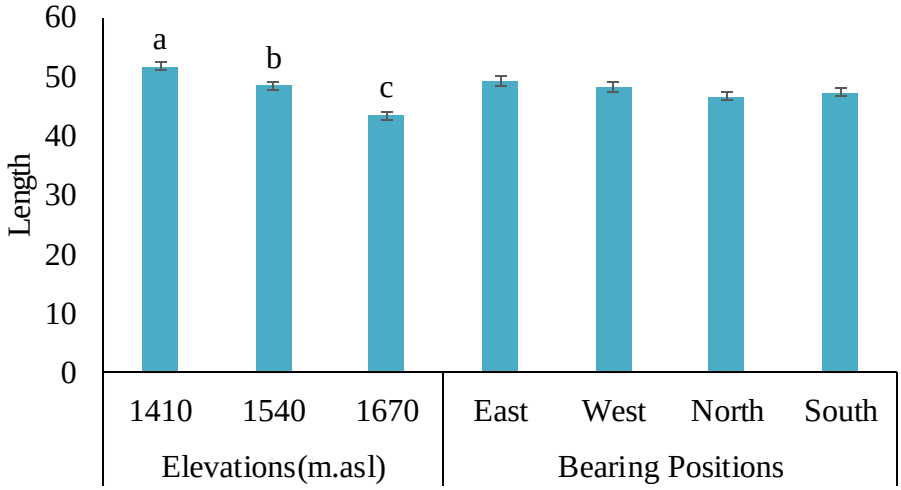

Fig.7: Effect of altitude and bearing position on length of mandarin in Dhulikhel, Kavre, 2018

1.7 Diameter

The altitude had very high significance effects ($P \leq 0.001$) on diameter of mandarin (Fig.9). The longest diameter (58.85 mm) was observed in mandarin harvested from an altitude of 1540 m.asl. The shortest diameter (53.58 mm) was observed in mandarin fruit from an altitude of 1670 m.asl.

The fruit bearing position had high significance effects ($P = 0.001$) on diameter of mandarin fruit. The longest diameter (59.08 mm) was observed in mandarin fruit in the eastern bearing position of tree canopy. The shortest diameter (54.20 mm) was observed in mandarin at northern bearing position followed by mandarin at western bearing position (55.26 mm) and mandarin fruit at southern bearing position (55.98 mm) on the tree canopy.

Light is a contributing factor for fruit size and linear relationship between fruit size and light exposure has been established (Robinson, Seeley, & Barrit, 1983). Altitude in altitude causes a net decline in variance between day and night temperatures are characteristic of inland growing areas. This modifies the global climate surrounding citrus tree in the hills during maturity. Claims have been made that fluctuations in temperature range have marked effect on physiological processes (De Wilt, Nel, Osthoff, & Labuschagne, 2010) because of which these effect might have been seen on this experiment. The lowest diameter in the fruit at upper altitude might be due to the fruit being attaining maturity.

https://dx.doi.org/10.22161/ijhaf.3.4.12 *ISSN: 2456-8635*

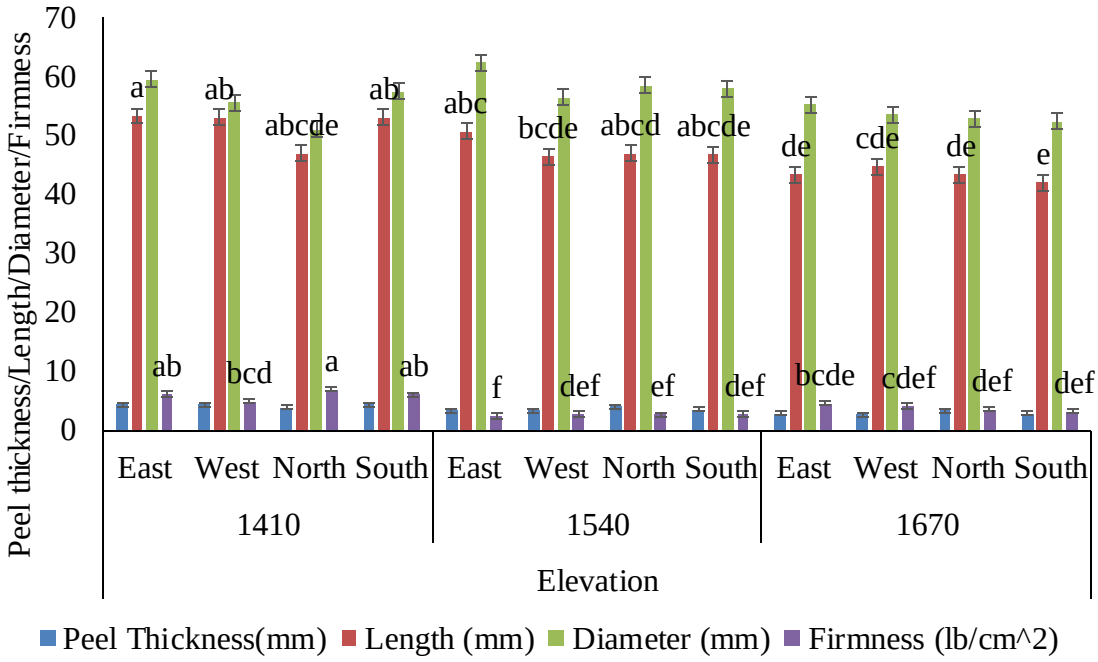

Fig.8: Interaction effect of altitude and bearing position on peel thickness, length, diameter and firmness of mandarin in Dhulikhel, Kavre, 2018

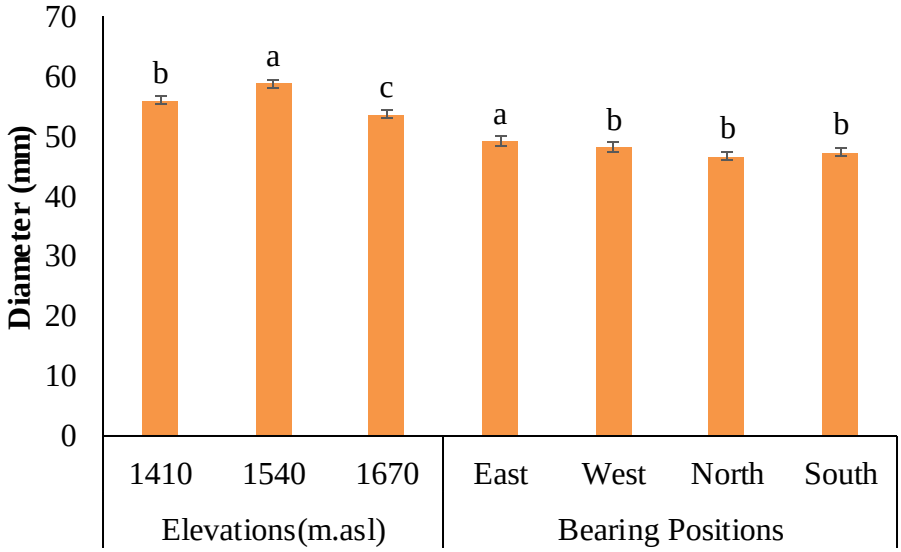

Fig.9: Effect of altitude and bearing position on diameter of mandarin in Dhulikhel, Kavre, 2018

1.8 Firmness

The altitude had very high significance effects ($P \leq 0.001$) on firmness of mandarin (Fig.10). The hardest fruit firmness (6.04 lb/cm^2) was observed in mandarin fruit harvested from an altitude of 1410 m.asl. The softest fruit (2.68 lb/cm^2) firmness was observed in mandarin fruit at an altitude of 1540 m.asl. Mandarin fruit at middle altitude were found comparatively softer.

https://dx.doi.org/10.22161/ijhaf.3.4.12 *ISSN: 2456-8635*

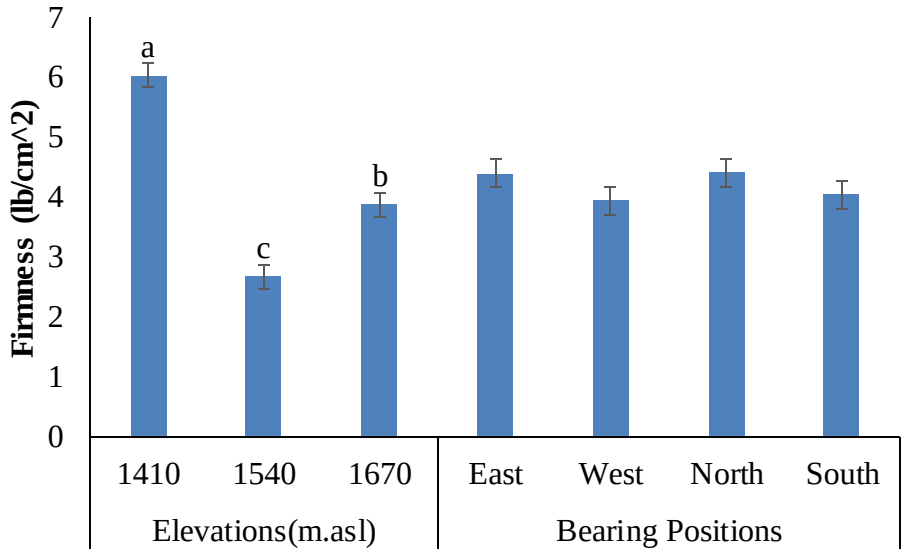

Fig.10: Effect of altitude and bearing position on firmness of mandarin in Dhulikhel, Kavre, 2018

The fruit bearing position had no significant effects on firmness of mandarin. The hardest fruit firmness (4.41 lb/cm^2) was observed in mandarin located northern bearing position followed by mandarin fruit at eastern bearing position (4.40 lb/cm^2) The softer fruit firmness (3.94 lb/cm^2) was observed in mandarin at western bearing position that were insignificantly different.

The decrease in firmness with altitude does not corroborate with the findings of Rokaya *et al*. (2016) where firmness increased with increasing altitude. This might be due to difference in location and applied fruit production inputs. Yen & Lin (1966) reported that shaded fruits tended to be more attractive in color and had thinner rind thickness. The dissolution of cell wall components contributes for fruit softening. In the lower altitude fruit matures faster than at the higher altitude due to higher temperature and early ripening physiological processes in fruit. The firmness of ripening might be due to largely influenced by cell turgor and composition of cell wall (Rokaya *et al*., 2016).

The variation in firmness according to bearing position and altitude might be due to cell turgor and composition attributed by varying microclimatic condtitons.Fruits that develop sunburn have higher firmness (Schrader, Zhang, & Sun, 2003) than fruit without disorder. The relationship between flesh firmness and canopy position was found inconsistent (Lewallen & Marini, 2003) in peach. The inverse relation was found between the irradiance and firmness in apples (Robinson, Seeley, & Barrit, 1983), so that it could be concluded that light indirectly influenced firmness due to its effect on maturity and fruit size.

1.8.1 Interaction effects of altitude and fruit bearing position on firmness of mandarin

The perusal from the data shown in Fig.8, the significant effect of altitude and bearing position of fruit was found on firmness of mandarin fruit. The maximum firmness (7.0 lb/cm^2) was observed in mandarin fruit of northern bearing position at an altitude of 1410 m.asl followed by mandarin fruit along eastern canopy at the same altitude (6.2 lb/cm^2). The least firmness (2.4 lb/cm^2) was recorded to be in fruit of eastern canopy at 1540 m.asl followed by mandarin fruit along northern canopy at same altitude (2.7 lb/cm^2).

IV. CONCLUSION

The microclimatic differences may affect the composition of fruits as different biochemical pathways are responsive to light and temperatures. Fruits sampled from various canopy positions and elevations confirmed the findings of Reitz & Sites (1949) and Cohen (1988) in that pronounced differences in fruit quality are related to their positions on the tree. The difference in physical properties of mandarin is probably related to microclimatic condition such as amount of light and higher temperatures to which different bearing positions are exposed at each elevation The influence of fruit position seemed to have major impact on percentage of rag and seed, percentage of juice, weight and firmness and less impact on peel thickness, axial and radial diameter of mandarin. Similarly different elevations seemed

to have major impact on firmness, peel thickness, percentage composition of peel, juice, seed and rag and weight. Considering the main physical attributes for maintaining physiochemical properties of mandarin, mandarin located at an elevation of 1540 m.asl followed by mandarin located at 1410 m.asl were promising than mandarin of higher elevation.

No parallel studies of elevation and bearing position have been accompanied earlier. Studies in this regard will be insightful.

ACKNOWLEDGEMENT

The authors are thankful to Food Research Division of NARC for providing lab facility during this experiment, Prime Minister Agriculture Modernization Project (PMAMP), Agriculture and Forestry University (AFU), Debraj Adhikari and Durga Prasad Paudel for the support provided for carrying out this research and for their co-operation.

REFERENCES

[1] Baidiyala, S. D. (1993). Maturity standard for Muzaffarpur litchi fruits. *South Indian Horticulture*, 223-224.

[2] Cohen, E. (1998). The chemical composition and sensory flavour quality of 'Minneola' tangerines I. Effects of fruit size and within tree position. *Journal of Horticulture Science, 63*, 175-178.

[3] DADO, K. (2015/16). *Yearly Agriculture development Programme and Statistics*. Kavre: District Agriculture development Office.

[4] De Wilt, M., Nel, P., Osthoff, G., & Labuschagne, M. T. (2010). The effect of variety and loca-tion on Cactus Pear (*Opuntia ficus-indica*) fruit quality. *Plants Food for Human Nutrition*(65), 136-145.

[5] Dhanraj, S., Krishnaprakash, M. S., & Arvindaprasad, B. (1985). Effect of orchard elevation on maturity and quality of apples. *Journal of Food Quality*, 129-142.

[6] Erez, A., & Flore, J. A. (1986). The qualitative effect of solar radiation on 'Redhaven' peachfruit skin color. *HortScience*, 1424-1426.

[7] Gosh, B., & Mitra, S. K. (1990). Effects of varying level of nitrogen, phosphorous and potassium on yield and quality of litchi(Litchi chinensis Sonn. I cv. Bombai. *Haryana J. Hort. Sci*, 19:1-2.

[8] Lewallen, K. S., & Marini, R. P. (2003). Relationship between flesh firmness and ground colour in peach as influenced by light and canopy position. *Journal of American Society of Horticulture*, 163-170.

[9] Lohar, D. P. (1995). *Orchard soil moisture conservation and fruit drop studies in mandarin orange*. Pokhara, Kaski, Nepal: Lumle Agriculture Research Centre.

[10] Mitchell, G. E., McLauchtan, R. L., Issacs, A. R., William, D., & Nottingham, S. M. (1992). Effect of low dose [irradiation on composition of tropical fruits and vegetables. *Journal of Food Composition and Analysis*, 291-311.

[11] MOAD. (2015/16). *Statistical Information on Nepalese Agriculture*. Kathmandu, Nepal: Government of Nepal, Ministry of Agriculture Development, Agribusiness Promotion and Statistics Division.

[12] MOAD. (2016). *Stastical Information on Nepalese Agriculture*. Kathmandu: Ministry of Agriculture D Development.

[13] Olabinjo, O. O., Ogunlowo, A. S., Ajayi, O. O., & Olalusi, A. P. (2017, July). Analysis of physical and chemical composition of sweet orange (Citrus sinensis) peels. *International Journal of Environment, Agriculture and Biotechnology, 2*(4), 2201-2206.

[14] Ray, D. P., & Munshi, P. S. (1990). A note on qualitative parameters and its association with leaf and soil nutrients litchi (Litchi chinensis Sonn. I). *Orissa Journal of Horticulture Science*, 1-2.

[15] Rehman, S., Ahmad, I., Ghaffor, A., & Baloch, A. K. (1982). Quality of sweet oranges (Citrus sinensis) as influenced by the fruit orientation on the tree. *Pakistan Journal Science*, 65-70.

[16] Rehman, S., Baloch, A. K., & Ghaffor A. (1984). The quality of sweet oranges (Citrus sinsensis) as influenced by exposure of sunlight. *Journal of Pure Applied Science*, 1-5.

[17] Robinson, T. L., Seeley, E. J., & Barrit, B. H. (1983). Effect of light environment and spur age on 'Delicious' apple fruit size and quality. *Journal of American Society of Horticulture, 108*, 850-854.

[18] Rokaya, P. R. (2017). *Effect of altitude and various and postharvest factors on quality and shelf life of mandarin (Citrus reticulata Blanco)*. Rampur, Chitwan, Nepal: Agriculture and Forestry University.

[19] Rokaya, P. R., Baral, D. R., Gautam, D. M., Shrestha, A. K., & Paudyal, K. P. (2016). Effect of altitude and maturity stages on quality attributes of mandarin (Citrus reticulata Blanco). *American Journal of Plant Sciences*, 958-966.

[20] Schrader, L. E., Zhang, J., & Sun, J. (2003). Environmental stress that cause sunburn of apple. *Acta Horticulture, 618*, 397-405.

[21] Shrestha, G. P., & Shrestha, G. K. (1999). An Overview of Fruit Growing in Nepal. *Nepalese Horticulture*, 36-40.

[22] Shrestha, P. P., & Verma, S. K. (1999). Development and Outlook of Citrus Industry in Nepal. *Proceedings of national Horticulture workshop* . Kathmandu, Nepal: Nepal Horticulture Society.

[23] Sites, J. W., & Reitz, H. J. (1949). The variation in individual Valencia oranges from different locations of the tree as a guide to sampling methods and spot packing for quality. *Proceedings for the American Society of Horticultural Science*, 1-10.

https://dx.doi.org/10.22161/ijhaf.3.4.12 *ISSN: 2456-8635*

[24] Tomiyashu, Y., Verma, S. K., & Thapa, D. B. (1998). *Citrus Cultivation in Nepal.* Kirtipur Nepal: Horticulture development Phase-II, HMG/JICA.

[25] Trad, M., Galliche, B., Renard, C. M., & Mars, M. (2013). Inter- and intra-tree variability in quality of figs. Influence of altitude,leaf area and fruit position in the canopy. *Scientia Hoericulturae*(162), 49-54.

[26] Underhill, S., & Chadha, K. (1990). A maturity standard for lychee(Litchi chinensis sonn. I. *Acta-Horticulturae*, 181-187.

[27] Verreynne, J. S., Rabe, E., & Theron, K. I. (2004). Effect of bearing position on fruit quality of mandarin types. *South African Journal of Plant and soil*, 1-7.

[28] Yakushiji, H., Moringa, K., & Nonami, H. (1998). Sugar accumulation and partitioning in satsuma mandarin tree tissues and fruit in response to drought stress . *Journal of American Society of Horticulture Science*, 719-726.

[29] Yen, M. Y., & Lin, C. H. (1966). Effect of shading on tonkan orange (Citrus tankan Hayata). I. The effect of shading on wind injury, fruit quality, size, and rate of fruit growth. *Agriculture Research*(15), 26-25.