UNDER PEER REVIEW

# Growth and Yield Potential of Wild Blackberry (*Rubus.* spp) under conventional production practices in Kenya


## ABSTRACT

Wild Blackberry (*Rubus* L. sub-genus *Rubus* Watson) species were evaluated for their growth and yield potentials under conventional production practices. At the Horticulture Research and Teaching Field, Egerton University, Kenya between January 2016 and July 2017. A randomized complete block design (RCBD) with three replicates and five treatments (species) were used. they comprised four wild blackberry species *Rubus volkensis, Rubus steundneri*, *Rubus apetalus, Rubus pinnatus* and one cultivated cultivar *Rubus fruiticosus "*Ruben*"*. Growth and yield potential were determined by their respective components i.e. cane height, cane diameter, number of canes per plant emerging from ground, number of laterals per cane, lateral length, internode length number of flowers per lateral and cane, fruit number per laterals, fruit size (length and width), fresh and dry fruit weight. Analysis of the data showed that wild species *Rubus apetalus* had the highest growth in terms of cane height 143.53 cm, cane diameter 19.37 mm, number of canes emerging from the ground 9 canes, number of flowers per lateral 58 and cane 581 and number of fruits per lateral 56, while. *Rubus pinnatus* had the longest internode length of 8.47 cm and lateral length of 80.02 cm however, *R. volkensis* was second to the cultivated cultivar *Rubus fruiticosus* in terms of, fruit size (length 22.84 mm and width 21.10 mm) and fruit fresh and dry weight of 3.7 vs 5.4 and 1.6 vs 2.4 g respectively. It was concluded that wild blackberry had growth and yield potential under conventional production practices. Adoption of *Rubus volkensis* under conventional production and the incorporation of growth vigour characteristics of wild species in breeding programs of the already cultivated species was recommended.


*Keywords: Wild blackberry*; *growth; yield potential;* conventional production.

## 1. INTRODUCTION

Blackberry belongs to the genus *Rubus*, that comprise a high diversity of species and are among the soft and aggregate fruits that are highly nutritious and therefore can form part of the human diet (Pamfil *et al.,* (1). They are rich sources of carbohydrates, dietary fibers, vitamins, minerals and other bioactive compounds (Wang (2). According to Ferreira *et al*. (3), blackberry cultivation has increased in recent years because of increased demand. Blackberry fruit has a high concentration of phenolics, carotenoids and flavonoids compounds, which can help protect against degenerative diseases. This compounds are anti-carcinogens and have anti-neurodegenerative and anti-inflammatory effect, therefore, blackberry berries are used in medicine (Wang (2). It also has other natural pigments, mainly anthocyanin used in dairy products, jams and preserves (Antunes, (4).

Blackberry is widely cultivated on over 20,000 ha, mainly in Europe and North America (Strik *et al.* (5). Blackberry is now a common fruit in marketing outlets, particularly in North America and the European Union and it has enjoyed expansion due to a combination of factors including a few improved cultivars, expanded marketing efforts and fruit availability (Strik*et al.,* (5). According to Chittaranjan (6), there are 84 wild blackberries species in Kenya that are not cultivated and therefore their growth characteristics and yield potential is not known when cultivated conventionally.

Blackberry production in Kenya relies on introduced cultivars yet numerous wild blackberry germplasm with the potential of being adapted. Their production is unexploited because of a knowledge gap that exists about their growth and yield potential under conventional production. The aim of this study was to evaluate the growth and fruit yield potential of wild blackberry species, in order to identify species that have comparative advantage over presently commercialized cultivar and may provide new options for further improvement through plant breeding and cultivation.

UNDER PEER REVIEW

## 2. MATERIAL AND METHODS

The study was conducted at the Horticulture Research and Demonstration Field, of Egerton University Njoro Kenya. The farm lies at a latitude of 0˚23`S longitude 35˚35`E and an altitude of ≈2238m above sea level. The area receives a total annual rainfall ranging from 1200 to 1400mm while average maximum and minimum temperatures range from 19˚C to 22˚C and 5˚C to 8˚C, respectively. The soils are well-drained dark reddish clays classified as *Mollic andosols* (Jaetzold and Schmidt (7).

Plant materials comprised rooted splits collected from the wild and confirmed by a botanist. The seedlings of the wild blackberry species *Rubus steundneri, Rubus apetalus, Rubus volkensis, Rubus pinnatus Rubus fruiticosus* were then planted in the field in December of 2015 at a spacing of 1.0×1.0m (a stand of 10,000 plants per hectare). The experiment was conducted in randomized blocks containing 5 treatments (species) with three blocks and 16 plants per experimental unit. The trees were cultivated according to the recommendation of Campagnolo and Pio (8).

Four plants from each experimental unit were selected randomly and tagged for data collection for plant growth and yield potential variables. In this study, the plant growth variables measured were cane height, cane diameter, number of laterals per cane lateral length, number of canes and internode length. Plant growth data, was collected after every four weeks, beginning 28 days after planting. Cane diameter, number of laterals per cane and lateral length was measured until the first day of flower set. During each data collection date, cane diameter of the four tagged blackberry species plants was measured at ≈ 15 cm from the ground level using a digital Vernier calliper (model 599-577-USA) and data obtained used to compute the average cane diameter of plants for the different species in millimeters.

Cane height of each tagged plants were determined using a tape measure until the plants attained a height of 150cm after which they were tipped to encourage lateral growth.

Number and length of laterals were counted and measured in centimeters' respectively at the beginning of flowering. number of primary laterals on each tagged cane were counted at three different times: at flowering, mid harvest and at the last harvest date to ensure late developing laterals were counted.

Lateral length was measured from the base of the lateral to the tip of the terminal fruit or terminal leaf bud for vegetative lateral.

Total number of canes that emerged from the ground were counted every four weeks after planting.

Yield potential variables were number of flowers per lateral and cane, number of fruits per lateral, fruit weight and fruit size.

Number of open flowers were counted every three days on each lateral of the tagged cane. After which the flowers on each lateral were summed up to give number of flowers per cane per plant. Double counting was avoided by subtracting the initial number of flowers counted from the current number of flowers counted.

Number of ripe harvestable fruits were counted on each lateral of the tagged canes prior to harvesting.

Weight of 20 sampled fruits on each lateral of the tagged cane were weighed using an electric weighing balance (Model: Tanita KD 200-510) from each plot and averaged. The fruit dry weight was determined by oven drying 20 sampled fruits from each plot at 80$^{o}$C for 24 hours to determine the dry matter content. The dried fruit were weighed using an electric weighing balance (Model: Tanita KD 200-510) Fruit size of was determined by measuring, its two linear dimensions, length (L) and Width (W) using a vernier caliper (Model 599-577-1/USA) at every harvest of sampled fruits.

The Proc univariate procedure of SAS (Version 9.1; SAS Institute, Cary, NC) was used to check for normality of the data before statistical RCBD analysis. Data were then subjected to analysis of variance (ANOVA) using the GLM procedure of SAS at P=0.05. Data were analysed using the model:

$Y_{ij} = \mu + \alpha i + \beta_j + \varepsilon ij$

i=1,2,3,4,5, j=1,2,3

Where; $Y_{ij}$ is the Blackberry species response, μ is the overall mean, $i^{th}$ is the effect due to the ith treatment, βj is the effect due to the $j^{th}$ block, $\varepsilon_{ij}$ the random error term. Means for significant treatments at the F test were separated using Tukey's honestly significant difference (THSD) test at P=0.05.

Monthly mean temperatures, relative humidity and total precipitation under Egerton ecological conditions during the experimental year 2016 January to 2017 July, is shown (Table1).

**Table 1. Average monthly air temperature ($^{o}$ C), precipitation (mm) and Humidity during Blackberry production over the two trials (Jan. to Dec. 2016 and Aug. 2016 to July 2017).**

UNDER PEER REVIEW

| Year | | Month | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | |
| 2016 | Precip. (mm) | 86.6 | 23.4 | 42.8 | 207.9 | 132.7 | 100.8 | 167.0 | 109.2 | 101.0 | 70.2 | 64.4 | 3.6 | 1109.6 |
| | Temp. ($^oC$) | 20.6 | 22 | 23.4 | 20.9 | 20.5 | 19.4 | 18.5 | 19 | 20.8 | 21.2 | 19.5 | 20.4 | 246.2 |
| | Humid. (%) | 42 | 47 | 46 | 66 | 76 | 75 | 65 | 65 | 59 | 59 | 70 | 66 | 736 |
| 2017 | Precip.(mm) | 3.7 | 31.3 | 37.1 | 45.4 | 109.9 | 29.8 | 152.5 | | | | | | |
| | Temp ($^oC$) | 21.5 | 21.9 | 22.8 | 26.7 | 24.4 | 25.3 | 23.6 | | | | | | |
| | Humid.(%) | 47 | 53 | 46 | 58 | 71 | 65 | 74 | | | | | | |

*Source: Egerton University Engineering Department (2016-2017)*

## 3. RESULTS AND DISCUSSION

### 3.1 Cane height and diameter of different blackberry species

Canes of *R. apetalus* were significantly longer (34.07 cm) while *R. volkensis,* (29.91 cm) *R. steundneri* (30.15 cm)*, R. pinnatus* (26.93 cm) and *R. fruiticosus* (28.17 cm) showed no significant variation in cane height at week 4 (Table 2). At week 8 significant variation was observed among *R. apetalus R. pinnatus* and *R. fruiticosus* however there was no significant variation between *R. pinnatus* and *R. fruiticosus*. At week 12 after planting no significant variation was observed among all the blackberry species grown but at week 16 to week 32 a significant variation was observed with *R. apetalus* having the highest cane height (71.75 to 137.58 cm). at week 36 significant variation was observed among *R. apetalus R. volkensis* and *R. fruiticosus* and significant variation among *R. volkensis R. steundneri, R. pinnatus* and *R. fruiticosus.* Significant differences were also not observed among *R. apetalus, R. steundneri* and *R. pinnatus* at week 36 after planting. The growth of different blackberry species showed differences in vigour with wild species *R. apetalus* being the most vigorous in terms of cane height. These observations maybe attributed to the fact that *R. apetalus* is highly adapted to the Njoro environment since it was originally collected from that environment. Adaptation has been shown to positively affect performance of germplasm if other factors are held constant Facteau *et al*. (8). It is also assumed that difference among pomological traits is due to the effect of genotype and environmental variations (Eyduran *et al*. (10). Plant height in blackberries is very important, as it affects flowering (Eyduran *et al.* (11). The height of the different blackberry grown varied from one species to the other indicating varied genetic potentials.

Cane diameter for all blackberry species did not vary significantly from week 4 to week 24 after planting though *R. apetalus* had a numerically larger cane diameter compared to all other blackberry species. At week 28 significant variation was observed among *R. apetalus, R. volkensis, R. pinnatus* and *R. fruiticosus*, however there was no significant variation between *R. apetalus* and *R. steundneri* and also no significant differences among *R. volkensis, R. steundneri R. pinnatus* and *R. fruiticosus.* At week 36 significant variation was observed with *R. apetalus* having the thickest diameter of cane (19.37 mm) while all the other blackberry species did not show any significant difference in in cane diameter at week 36 (Table 2). Cane diameter is an important indicator of plants ability to withstand unfavourable environmental conditions that affect yield such as wind (Eyduran *et al.* (11). In a previous study by Cangi and Islam (12), cane diameter ranges for blackberries ranged between 3.49-7.99 mm among different cultivars of blackberry with the lowest performance being *R. fruiticosus* cv Jumbo. Eyduran *et al.* (11) reported cane diameter range of 6.60 to 15.20 mm for eight cultivars, the same findings were reported in the present study.

**Table 2: Cane height and Cane diameter of different blackberry species**

| | Weeks after planting | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| eatment | 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 |
| Cane height (cm) | | | | | | | | | |
| *R. apetalus* | 34.07a | 44.50a | 55.90a | 71.75a | 89.40a | 109.10a | 130.58a | 137.23a | 143.53a |
| *R. volkensis* | 29.91b | 41.53ab | 50.38a | 65.35b | 80.53b | 93.38bc | 104.96b | 120.56b | 132.57b |
| *R.steundneri* | 30.15b | 41.55ab | 51.90a | 64.43b | 80.53b | 96.65b | 108.73b | 122.93b | 138.38ab |
| *R. pinnatus* | 26.93b | 38.37b | 48.75a | 61.85b | 75.43b | 90.83c | 103.41b | 119.00b | 136.00ab |
| *R.fruiticosus* | 28.17b | 37.43b | 49.18a | 61.93b | 75.73b | 89.52c | 102.81b | 117.52b | 133.42b |
| Cane diameter (mm) | | | | | | | | | |
| *R. apetalus* | 4.62a | 6.72a | 7.94a | 9.80a | 10.98a | 12.67a | 14.22a | 16.53a | 19.37a |
| *R. volkensis* | 3.78a | 5.12a | 6.42a | 8.28a | 8.90a | 10.18a | 9.98b | 13.20ab | 16.18b |

UNDER PEER REVIEW

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *R.steundneri* | 3.33a | 4.57a | 5.53a | 7.08a | 8.00a | 9.35a | 10.92ab | 13.32ab | 15.58b |
| *R. pinnatus* | 3.25a | 4.45a | 5.62a | 7.08a | 8.06a | 9.05a | 10.37b | 13.06b | 15.67b |
| *R.fruiticosus* | 3.23a | 4.82a | 5.98a | 7.43a | 8.05a | 9.23a | 10.70b | 12.32b | 15.35b |

*Means followed by the same letter(s) within a column are not significantly different at P= 0.05 according to HSD Turkey's test*

**3.2 Lateral length, number of laterals, number of canes emerging from the ground and number of flowers per lateral of different blackberry species**

*R. pinnatus* had significantly longer laterals (80.02 cm) than all the other blackberry species; *R. fruiticosus* had the shortest lateral length (26.98 cm). There were no significant differences in lateral length between *R. steundneri* and *R. volkensis,* lateral length differed from one species to another, difference in the pattern of lateral length growth on the cane is attributed to genotype and environment (Eyduran *et al.* (10). Lateral length is among the many pomological trait of different blackberry species/cultivar that were grown in this present and other studies. Dale (13) associated long lateral length with high fruit number per lateral in some raspberry, this is because long laterals have the ability to intercept light better than shorter ones (Waistser *et al.* (14).

The number of laterals showed a significant variation among the different blackberries, with *R. fruiticosus* (24.52) the highest and *R. pinnatus* (18.38) the lowest (Table 3). Number of laterals of a plant varies at different stages of plant growth, this variation is due to how well a plant species is adapted to certain environmental conditions and the genotype of that particular plant (Eyduran *et al.* (11). On a study by Strik (15) on two cultivars Prime jam and Prime jim total branches per cane was reported as (3.9 and 4.1) respectively, which varied significantly from the present study. According to Jennings (16) the number and extend of laterals development in blackberry is a major yield component. When a plant shows more number of laterals at the varying stage of its growth it is an indication that the plant is well adapted to that particular location and it has a genetic makeup suitable for that particular location therefore the prolific number of laterals it has.

The number of canes emerging from ground was significantly higher in *R. apetalus* (9.85)., compared to the rest (Table3). Number of canes emerging from the ground varied in this study, this variation in the number of canes is largely due to the effect of phenotype and genotype (Eyduran *et.al.* (11); Dale, (13). Gundershein and Pritts (17), also demonstrated that optimum cane number varies with cultivar due to cultivar difference and many interacting factors. In a research carried out by Eyduran *et al.* (11) among eight cultivars the average number of canes varied from (6.70 to 10.00) in a 2002 study period which was slightly higher than the current study. The highest number of canes recorded was (10.00) on cultivar "Nahavo" and "Chester" thornless respectively and a minimum number of canes recorded was (6.70) Dirksen thornless The difference in the number of canes that emerged from the ground in this study is also attributed to the genotypic difference in vigour and stature, with the wild type being the most vigorous in number of canes per plant in this study.

The number of flowers per lateral (Table 3) was significant with *R apetalus* having the highest number of flowers (58.15) flowers per lateral, the number of flowers per lateral was not significant between *R. steundneri* and *R. pinnatus* and between *R. apetalus* and *R. fruiticosus, R. volkensis* had the lowest number of flowers per lateral. The significant difference in the number of flowers shown by different blackberry species is due the genetic makeup of the different blackberry species and environmental adaptability of a specific blackberry species (Eyduran *et al.* (11).

The length of internode differed significantly from one species to another *R. pinnatus* had the longest internode length of (8.47 cm) while cultivated cultivar had the shortest internode length of (6.00 cm). length of internode is associated with the height of the plant however in this current research the length did not show any relationship with cane height. In a similar study on six genotype by Salvador *et al.* (18) cultivar "Obsidian" had the shortest internode of (4.45 cm), while cultivar "Onyx had the longest internode length of (7.31 cm). Those result by the former author differed from this current study. The difference in the length of internode is attributed to the different genotype of each species that respond differently in a given environmental condition.

UNDER PEER REVIEW

**Table 3: Lateral length, number of laterals, number of canes, internode length and number of flowers per lateral of different blackberry species**

| Treatment | Lateral length | Number of laterals | Number of canes | Internode length | Flowers per lateral |
|---|---|---|---|---|---|
| *R. apetalus* | 69.73b | 22.87ab | 9.85a | 6.70bc | 58.15a |
| *R. volkensis* | 54.55c | 21.50abc | 3.67d | 6.12bc | 18.38c |
| *R. steundneri* | 58.45c | 19.62bc | 4.75c | 7.88ab | 26.08b |
| *R. pinnatus* | 80.02a | 18.38c | 6.00b | 8.47a | 25.97b |
| *R. fruiticosus* | 26.98d | 24.52a | 4.00cd | 6.00c | 30.52a |

*Means followed by the same letter(s) within a column are not significantly different at P= 0.05 according to HSD Turkey's test*

### 3.3 Number of flowers per cane, number of fruits per laterals, fruit weight, fruit size (length and width) of different blackberry species

The number of flowers per cane (Table 3) was significant with *R apetalus* having the highest number of flowers (58) per lateral. A significant difference was also observed in the number of flowers per cane with *R. apetalus* having the highest number flowers per cane (581) (Table 3). The number of fruits per lateral was significantly higher in *R. apetalus* (56) while the lowest number was recorded in. *R. fruiticosus* with (18) fruits per lateral. *R. fruiticosus* had a significantly higher fresh fruit weight (5.38 g) Wild blackberry species *R. volkensis* was the second highest in fresh fruit weight at (3.68 g) and. *R. apetalus* had the least fresh fruit weight (1.24 g), while two wild species *R. steundneri* and *R. pinnatus* did not set fruit (Table 4).The dry weight of blackberry fruits after oven drying recorded a significant difference in weight with *R. fruiticosus* recording the highest dry weight of (2.42 g), *R. volkensis* had (1.56 g) and *R. apetalus* had the least dry weight of (0.76 g). while the other two wild species *R. steundneri* and *R. pinnatus* however could not have dry and fresh weight as they did not set fruits (Table 4) A similar result by Wolukau (19) indicated that the largest raspberry fruits had the greatest percent fruit dry weight. The variation in fruit weight could be because of the different species/cultivar grown, environmental conditions and nutritional status of the plantation (Yilmaz *et al.* (20) According to Clark and Finn (21) berry weight has a direct effect on the marketability and acceptance of blackberries in both fresh and processing. This results are in agreement with a study carried out by Eyduran *et. al.* (11) where the weight of eight American blackberry cultivars was found to range from (1.00 to 5.50 g). Fruit weight of blackberry cultivars grown in a different regions of Turkey were previously reported between as (2.0-6.6 g) per fruit (Cangi and Islam, (12), Gercekcioglu *et al.* (22); Agaoglu *et al*. (23) while fruit weight of wild growing blackberries in Turkey were between (1.5-2.1 g) (Celik *et al.* (24). In the current study the berry weight from the different species were less than the ideal weight for fresh market which is recommended to have a berry weight that ranges from 8-10 g and should also not be more than (15 g) (Clark and Finn (21). Blackberry plants that look normal and healthy may sometimes flower profusely but fail to set fruit (Mohammad, (25). this failure may be complete, with no fruit set at all, but more often it may be partial, with the production of misshapen berries. The appearance of such berries may range from nearly normal to some with only a single drupelet. The condition may be the result of an infection by a virus or fungus, insect damage, hereditary abnormalities, or a combination of these causes (Mohammad, (25).

Fruit size of different blackberry species grown were significantly different in terms of fruit width and fruit length (Table 4). *R. fruiticosus* recorded the largest fruit width of (21.10 mm), while *R. volkensis* had a fruit width of (15.87 mm). *R apetalus* had the least fruit width of (11.08 mm). Fruit length was also significant with *R. fruiticosus* having the longest fruit length (22.84 mm), *R. volkensis* had a fruit length (15.87 mm) and *R. apetalus* had the shortest fruit length (11.08 mm) (Table 4). In a similar study by Campagnolo and Pio (8) on 11 berry cultivars, the average berry size range was length (16.6 to 27.3 mm) and diameter was (17.3mm to 25.1 mm). This results did not vary from the current study and the variation in fruit size is due to genetic and genotypic expression of different cultivars/species.

UNDER PEER REVIEW

**Table 4: Number of flowers per cane, number of fruits per lateral, fruit weight (g) and fruit size (length and width) of different black berry species**

| Treatment | Flowers per cane | Fruits per lateral | Fruit fresh weight (g) | Fruit dry weight (g) | Fruit length (mm) | Fruit width (mm) |
|---|---|---|---|---|---|---|
| *R. apetalus* | 581.60a | 56.25 | 1.24c | 0.76c | 11.53c | 11.87b |
| *R. volkensis* | 63.33c | 14.42c | 3.68b | 1.56b | 16.23b | 15.87b |
| *R. steundneri* | 100.47b | 0.00d | 0.00d | 0.00d | 0.00d | 0.00d |
| *R. pinnatus* | 89.43bc | 0.00d | 0.00d | 0.00d | 0.00d | 0.00d |
| *R. fruiticosus* | 100.50b | 18.42a | 5.38a | 2.42a | 22.84a | 21.10a |

*Means followed by the same letter(s) within a column are not significantly different at P= 0.05 according to HSD Turkey's test*

## 4. CONCLUSION

In the present study blackberry germplasm exhibited varying growth and yield potential with the wild species *Rubus apetalus,* being the most vigorous in terms of height, cane diameter, length of laterals, number of canes, number of flowers per lateral and number of fruits per lateral. While *Rubus volkensis* had larger fruit size and fresh fruit weight. Wild blackberry can be adopted for cultivation and or introgressed in commercial cultivars with low vigour. A wider study to explore potential in the vast wild blackberry germplasm in the country is recommended.

## REFERENCES


1. Pamfil, D., Swartz, H., Ness, C. Zimmerman, R.H. Identifying Rubus species using random amplified polymorphic DNA, Proc. of XXII *Congress of American Society for Horticultural Sciences, Lexington*. 1996, 783-789.
2. Wang S.Y: Antioxidant capacity and phenolic content of berry fruits as affected by genotype, preharvest conditions, maturity, and handling. In: Zhao Y. (ed.): Berry Fruit: Value-added Products for Health Promotion. Taylor and Francis Group, Boca Raton. 2007,147–186.
3. Ferreira, D. S., Rosso, V. V. Mercadante, A. Z. Compostos bioativos presents emamora-preta (*Rubus* spp.). *Revista Brasileira de Fruticultura*. 2010, v. 32, n. 3, p. 664-674,
4. Antunes, L.E.C. Blackberry: a new crop option to Brazil. Cienc. *Rural*. 2002,32,151–158.
5. Strik, B.C., Clark, J.R., Finn, C.E. Banados, M. P. Worldwide Blackberry Production. *Horticultural Technology*. 2007,17(2): 205-213.
6. Chittarajan, T.W. Blackberry blueberry pests and diseases. *Indian Journal of fruit science.* 2011,*25: 54-68*.
7. Jaetzold, R.and Schmidt, H. *Farm Management Handbook of Kenya.* Vol I IV, Nairobi Kenya, 2012.
8. Campagnolo, M. A. Pio R. Phenological and yield performance of black and redberry cultivars in western parana state. Acta scientiarum. Agronomy. 2012, vol 34i 4 15528n 4 p439-444.
9. Facteau, T.J., Rowe, K.E. Chestnut, N.E. Firmness of sweet cherry fruit following multiple applications of gibberellic acid, *Horticultural science.* 1986, 56 (5): 327.
10. Eyduran, S.P, Agaoglu, Y.S, Eyduran, E. Özdemir, T. Examination of Pomological Features of Different Ten Raspberry Cultivars by the Methods of Various Statistics. *Research Journal. Agriculture and Biological. Science*. 2006, 2 (6): 307-313.
11. Eyduran S.P., Eyduran E. Agaoglu Y.S. Estimation of fruit weight by cane traits for eight American blackberries (*Rubus fruticosus* L.) cultivars. *Journal of Biotechnology*. 2008, 7: 3031–3038.
12. Cangi, R. Islam, A. Adaptation of some blackberry cultivars in Ordu province (2000-2002 results). I. National Kiwifruit and Small Fruits Symposium, Ordu, Turkey. 2003, pp. 348-352.
13. Dale, A. Productivity in Red raspberry. *Horticultural Review.* 1990, 11:185-218.
14. Waister, P. D., Wright, C. J. Cormack, M. R. Potential yield in red raspberry as influenced by interaction between genotype and cultural methods. *Acta Horticulturae.* 1980, 112: 273-283.
15. Strik, B. C., Clark, J. R., Finn, C. E. Buller, G. Management of primocane fruiting Blackberry impact on yield fruiting season and cane architecture. *Hortscience.* 2012, 47:593-598.

UNDER PEER REVIEW

16. Jennings, D. L. *Raspberries and blackberries their breeding, diseases and growth*. *Fruit Breeding*. Academic Press, London, UK. Feb,11,1988.
17. Gundershein, N. A. Pritt, M. P. Pruning practices affect yield, yield components and their distribution in “Royalty” purple raspberry. *Journal of American Society,* 1991, *116*(3): 390-395.
18. Salvador, J. F., Strik, B. C., Zhao, Y. Finn, C. E. Trailing blackberry genotype differ in yield and post-harvest fruit quality during establishment in an organic production system. *HortScience.* 2015, 50 (2):240-246.
19. Wolukau, N. J Effect of nitrogen and cane density on cane architecture, fruit and fruit yield components in primocane bearing red raspberry Retrieved from *https;//mspace.lib.imanitoba.ca>bitstream*,1992.
20. Yilmaz, K. U., Zengin, Y., Ercisli, S., Gunduz, K. Asma, B. M. Some selected pysico-chemical characterestics of wild and cultivated blackberry fruit (*Rubus fruiticosus* L) from Turkey. *Romanian biotechnological letters.* 2009, 14: 4152-4163
21. Clark J.R. Finn C.E. Blackberry breeding and genetics. Fruit, Vegetable and Cereal Science and Biotechnology. 2011, 5: 27–43.
22. Gercekcioglu, R., Esmek, I., Gunes, M. Edizer, Y. A study on adaptation of some blackberry (*R. Fructicosus* L.) cultivars in Tokat province. I. National Kiwifruit and Small Fruits Symposium. 2003, pp. 337- 343, Ordu.
23. Agaoglu, Y.S., Eyduran, S. P. Eyduran, E. Comparison of some pomological characteristics of blackberry cultivars growth in Ayas conditions. *Journal of Agricultural Science.* 2007,13(1):69-74.
24. Celik, S., Bahar, E., and Korkutal, I. Selection of superior-productive individuals from blackberry population growing in Trakya as wild. Proceedings of 4th National Horticulture Congress, 8-12 September, 2003, Antalya, Turkey. 2003, p. 131-134.
25. Mohammad B. Report on Plant Disease. University of Illinois at URBANA Champaign RPD. 1996, 711.