

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 volkensii*, *Rubus steudneri*, *Rubus apetalus*, *Rubus pinnatus* and one cultivated cultivar *Rubus fruticosus* "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. volkensii* was second to the cultivated cultivar *Rubus fruticosus* 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 volkensii* 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 (Striket 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.



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 steudneri*, *Rubus apetalus*, *Rubus volkensii*, *Rubus pinnatus* *Rubus fruticosus* 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°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:

$$Y_{ij} = \mu + \alpha_i + \beta_j + \epsilon_{ij}$$

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

Where; Y_{ij} is the Blackberry species response, μ is the overall mean, i^{th} is the effect due to the i^{th} treatment, β_j is the effect due to the j^{th} block, ϵ_{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 (° C), precipitation (mm) and Humidity during Blackberry production over the two trials (Jan. to Dec. 2016 and Aug. 2016 to July 2017).

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. (°C)	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 (°C)	21.5	21.9	22.8	26.7	24.4	25.3	23.6						
	Humid.(%)	47	53	46	58	71	65	74						

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

95 3. RESULTS AND DISCUSSION

96 3.1 Cane height and diameter of different blackberry species

97 Canes of *R. apetalus* were significantly longer (34.07 cm) while *R. volkensii*, (29.91 cm) *R. steundneri*
98 (30.15 cm), *R. pinnatus* (26.93 cm) and *R. fruticosus* (28.17 cm) showed no significant variation in
99 cane height at week 4 (Table 2). At week 8 significant variation was observed among *R. apetalus* *R.*
100 *pinnatus* and *R. fruticosus*, however there was no significant variation between *R. pinnatus* and *R.*
101 *fruticosus*. At week 12 after planting no significant variation was observed among all the blackberry
102 species grown but at week 16 to week 32 a significant variation was observed with *R. apetalus* having
103 the highest cane height (71.75 to 137.58 cm). at week 36 significant variation was observed among *R.*
104 *apetalus* *R. volkensii* and *R. fruticosus* and significant variation among *R. volkensii* *R. steundneri*, *R.*
105 *pinnatus* and *R. fruticosus*. Significant differences were also not observed among *R. apetalus*, *R.*
106 *steundneri* and *R. pinnatus* at week 36 after planting. The growth of different blackberry species
107 showed differences in vigour with wild species *R. apetalus* being the most vigorous in terms of cane
108 height. These observations maybe attributed to the fact that *R. apetalus* is highly adapted to the Njoro
109 environment since it was originally collected from that environment. Adaptation has been shown to
110 positively affect performance of germplasm if other factors are held constant Facke et al. (8). It is
111 also assumed that difference among pomological traits is due to the effect of genotype and
112 environmental variations (Eyduran et al. (10). Plant height in blackberries is very important, as it
113 affects flowering (Eyduran et al. (11). The height of the different blackberry grown varied from one
114 species to the other indicating varied genetic potentials.

115 Cane diameter for all blackberry species did not vary significantly from week 4 to week 24 after
116 planting though *R. apetalus* had a numerically larger cane diameter compared to all other blackberry
117 species. At week 28 significant variation was observed among *R. apetalus*, *R. volkensii*, *R. pinnatus*
118 and *R. fruticosus*, however there was no significant variation between *R. apetalus* and *R. steundneri*
119 and also no significant differences among *R. volkensii*, *R. steundneri* *R. pinnatus* and *R. fruticosus*.
120 At week 36 significant variation was observed with *R. apetalus* having the thickest diameter of cane
121 (19.37 mm) while all the other blackberry species did not show any significant difference in in cane
122 diameter at week 36 (Table 2). Cane diameter is an important indicator of plants ability to withstand
123 unfavourable environmental conditions that affect yield such as wind (Eyduran et al. (11). In a
124 previous study by Cangi and Islam (12), cane diameter ranges for blackberries ranged between 3.49-
125 7.99 mm among different cultivars of blackberry with the lowest performance being *R. fruticosus* cv
126 Jumbo. Eyduran et al. (11) reported cane diameter range of 6.60 to 15.20 mm for eight cultivars, the
127 same findings were reported in the present study.

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

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

<i>R. steundneri</i>	3.33a	4.57a	5.53a	7.08a	8.00a	9.35a	10.92ab	13.32ab	15.58b
<i>R. pinnatus</i>	3.25a	4.45a	5.62a	7.08a	8.06a	9.05a	10.37b	13.06b	15.67b
<i>R. fruiticosus</i>	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. volkensii*, 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 (Waister *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 (Table 3). 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); Gundersheim 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. volkensii* 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.

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
<i>R. apetalus</i>	69.73b	22.87ab	9.85a	6.70bc	58.15a
<i>R. volkensii</i>	54.55c	21.50abc	3.67d	6.12bc	18.38c
<i>R. steudneri</i>	58.45c	19.62bc	4.75c	7.88ab	26.08b
<i>R. pinnatus</i>	80.02a	18.38c	6.00b	8.47a	25.97b
<i>R. fruticosus</i>	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 of 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. fruticosus* with (18) fruits per lateral. *R. fruticosus* had a significantly higher fresh fruit weight (5.38 g). Wild blackberry species *R. volkensii* 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. steudneri* 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. fruticosus* recording the highest dry weight of (2.42 g), *R. volkensii* had (1.56 g) and *R. apetalus* had the least dry weight of (0.76 g). While the other two wild species *R. steudneri* 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 Eydurán 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), Gercelcioğlu 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. fruticosus* recorded the largest fruit width of (21.10 mm), while *R. volkensii* 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. fruticosus* having the longest fruit length (22.84 mm), *R. volkensii* 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.

229 **Table 4: Number of flowers per cane, number of fruits per lateral, fruit weight (g) and fruit size**
230 **(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)
<i>R. apetalus</i>	581.60a	56.25	1.24c	0.76c	11.53c	11.87b
<i>R. volkensii</i>	63.33c	14.42c	3.68b	1.56b	16.23b	15.87b
<i>R. steudneri</i>	100.47b	0.00d	0.00d	0.00d	0.00d	0.00d
<i>R. pinnatus</i>	89.43bc	0.00d	0.00d	0.00d	0.00d	0.00d
<i>R. fruticosus</i>	100.50b	18.42a	5.38a	2.42a	22.84a	21.10a

231
232 Means followed by the same letter(s) within a column are not significantly different at $P=0.05$
233 according to HSD Turkey's test

234 235 4. CONCLUSION

236
237 In the present study blackberry germplasm exhibited varying growth and yield potential with the wild
238 species *Rubus apetalus*, being the most vigorous in terms of height, cane diameter, length of laterals,
239 number of canes, number of flowers per lateral and number of fruits per lateral. While *Rubus*
240 *volkensii* had larger fruit size and fresh fruit weight. Wild blackberry can be adopted for cultivation and
241 or introgressed in commercial cultivars with low vigour. A wider study to explore potential in the vast
242 wild blackberry germplasm in the country is recommended.

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