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Wild blackberry (*Rubus* spp.) differ in duration to reproductive phase under conventional production in Kenya

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The purpose of this study was to determine the duration from planting to reproductive phase, of wild blackberry (*Rubus* spp.) collected from the wild.It was carried out at the Horticulture Research and Teaching Farm, Egerton University, Njoro, Kenya. The experimental layout wasa randomized complete block design (RCBD) replicated three times; treatment was four wild blackberry species and one cultivated cultivar. The days to first flowering were significantly shorter in cultivated species *Rubus fruiticosus* at 126 days after planting while wild species *Rubus pinnatus, Rubus steundneri Rubus volkensis* and *Rubus apetalu s*took much longer time (341, 333, 332 and 227 days, respectively). Compared to other wild species *R. apetalus* took a significantly shorter time to flowering than all the other wild species. Analysis also showed that cultivated species*, R. fruiticusos* had significantly the longest harvesting duration compared to all wild species planted in the present study. It is concluded that wild blackberry species under conventional production practices have varying days to reproductive phase. However, more studies are necessary with a view to reducing the days to reproductive phase for the wild species to compare favourably with the cultivated types.

Key words: Wild blackberry, reproductive phase, conventional production.

INTRODUCTION

Blackberries were earlier considered as wild fruits and belong to the family of Rosaceae. Currently, gardening of this species is of great significant in a number of countries (Clark and Finn, 2014). With regards to nutritional benefits, blackberry has beenclassified second after Blue berry (*Vaccinium sp.)* among the berry fruit species in the world. They are rich in numerous nutrients such as vitamins, minerals, anti-oxidants and dietary fibers that are vital for health (Ding et al., 2006; Tulipani et al., 2008). They belong to the genus *Rubus* that comprises a high diversity of species like: *Rubus ursinus, Rubus fruiticosus* and *Rubus argutus,* besides they are among the soft and aggregate fruitsthat are healthy and nutritious to the human diet (Tulio et al., 2008; Hirsch, 2013). Blackberries are extensively cultivated on over 20,000 ha worldwide, mainly in Europe and North

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America (Strik et al., 2007).

Blackberry is a mild climate fruit crop that can acclimatizefast to diverse ecological conditions, such as woodlands, scrubs, sides of hills, a long hedge rows and can be invasive within a relatively short time across large areas. Moreover, blackberry tolerates drought and warmer conditions compared to raspberries, flowers and produces purple, black or red fruits (Crocker et al., 1998).

The health benefits are attributed to presence of high nutritional content of dietary fiber, vitamin C, K, folic acid, and manganese which is an essential mineral (Sariburun et al., 2010). They are also notable for their phytochemical content that is nutritious and antioxidant strength which is higher in ranking among fruits,that are known to destroy free radicals that harm cells and can lead to cancer, such compounds are ellagic acid, tannins, ellagitannins, quercetin, gallic acid, anthocyanins, and cyanidins (Hager et al., 2008; Overall et al., 2017). The phenolic compounds found in blackberries have also been linked to a reduced risk of cancer and cardiovascular diseases which are degenerative (Reyes-Carmona et al., 2005).

Production of blackberry has improved significantly in the United States of America (USA) (Siriwoharn et al., 2004). In Kenya, there are 84 species of wild blackberries (Chittaranjan, 2011). While the number of cultivated species and acreage in Kenya is unknown, however, in U.S.A, 15 species are in cultivation with production of 65,171 tonnes from 7,159 ha of land. North America and European Union in particular have become a common outlet market for blackberry fruits; this expansion have been enjoyed due to a combination of factors like improved cultivars, expanded marketing efforts and fruit availability (Strik et al., 2007).Generally increased berry consumption is due to its potential health benefit and in food market that are functional (Ding et al., 2006; Tulipaniet al., 2008; Kaumeet al.,2012). However, in Kenya there is little or no information on the performance in terms of reproductive phase, flowering and fruiting time after planting of wild blackberry species in comparison to the cultivated types that have been imported. The duration that wild blackberry takes to reach reproductive phase is unknown as they grow wild without keen interest.Theobjective of this study was to evaluate the duration it takes from planting to reproductive phase of four wild blackberry species and one cultivated cultivar when grown under conventional cultivation.

MATERIALS AND METHODS

Study site

The research was carried out at the Horticulture Research and Demonstration Field, of Egerton University Njoro Kenya. Geographically it lies at a latitude of 0°23`S longitude 35°35`E and an altitude of ≈2238m above sea level, receiving an annual rainfall that ranges from 1200 to 1400 mm, while the average maximum and minimum temperatures range from 19 to 22°C and 5 to 8°C, respectively. According to Jaetzold and Schmidt (2006) the soils are characterized as well-drained dark reddish clays classified as *Mollicandosols*.

Planting material, experimental design and treatment

Wild blackberry plant materials were collected from the wild in Nakuru County (36.0800 E,0.3031 S) and Baringo County (35.7412 E, 0.4897 N) in July 2015 and later taken to a botanist to identify the species after which they were propagated through splits cutting. The seedling of the different wild blackberry species *R. steundneri, R. apetalus, R. volkensis, R. pinnatus, R. 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 (2012).

Data collection

Days to first and 50% flowering

The number of days from transplanting to first day of flower appearance was determined, while days to 50% flowering were taken when the lateral in each tagged plant had at least 5 flowers.

Flowering duration

The duration of blooming was determined by counting the number from the day of first bloom to the last day of blooming.

Fruit set percentage

Percent fruit set was determined by the number of fruits expressed as a percent of the total number of flowers per cane.
Percent fruit set =(Number of mature fruits per cane *100)/Total number of flowers per cane.

Fruit maturity

The days to fruit maturity was determined by how long it takes the colourto change from red to black or purple or any other colour on the tagged fruits.

Harvesting duration

Harvesting duration was determined as the period from first harvest to the last day of harvesting, which was carried out everyday from the first day of fruit maturity from the grown blackberry.

Data analysis

The Procunivariate 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 $P \leq 0.05$. Data were analyzed using the model:

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

Where, Y_{ij} is the Blackberry species response, μ is the overall

Table 1. Days to first flowering, days to 50% flowering, fruit set %, days to fruit maturity and harvesting duration of different wild blackberry species.

Treatment	Days to first flowering	Days to 50% flowering	Fruit set %	Days to fruit maturity	Harvesting duration
R. apetalus	227.17[b]	267.33[b]	84.47[a]	34.37[ab]	175.83[b]
R. volkensis	332.67[a]	367.00[a]	39.52[c]	35.12[a]	87.17[c]
R. steundneri	333.67[a]	364.33[a]	0.00[d]	0.00[c]	0.00[d]
R. pinnatus	341.00[a]	374.33[a]	0.00[d]	0.00[c]	0.00[d]
R. fruiticosus	126.83[c]	154.17[c]	55.83[b]	33.18[b]	269.83[a]

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

mean, αi is the effect due to the ith treatment, βj is the effect due to the jth block, εijis 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.

RESULTS

Days to first flowering (Table 1) were significantly shorter in *R. fruiticosus* while there were no significant differences in the number of days to first flowering, among wild species *R. volkensis, R. pinnatus* and *R. steundneri,* which took longer days to first flowering. Wild species *R. apetalus* had the shortest days to flowering compared to the other wild species.A similar result was also observed for the days to 50% flowering, whereby *R. fruiticosus* had a significantly shorter daysto all the wild species grown while *R. apetalus* had also a significantly shorter days to 50% flowering in comparison to other wild species grown. Percent fruit set also varied significantly with the wild species *R. volkensis* having a lower percent fruit set followed by cultivated species *R. fruiticosus,* and wild species *R. apetalus* had the highest percent fruit set.Two wild species *R. steundneri* and *R. pinnatus* did not set any fruit during the study. Days to fruit maturity did not show significant variation between *R. apetalus* and *R. volkensis*, however cultivated species *R. fruiticosus* differed significantly from all the wild species. Harvesting duration varied significantly among all the species with cultivated species *R. fruiticosus* exhibiting the longest harvesting duration, while the shortest was observed in *R. volkensis*.

DISCUSSION

The number of days to first and 50% flowering of the blackberryspecies grown were significantly different. Duration to first and 50% flowering in fruit crop is important because it determines when fruit will be ready for harvesting. The change from vegetative to flowering stage in plants is controlled by environmental factors such as temperature and light (Guo et al., 1998; Mouradov et al., 2002). Many other environmental factors such as mineral nutrition and abiotic stress affect flowering time (Lae-Hyeon et al., 2017). The variation in the number of days to flowering is as a result of different chilling requirements (Dale et al., 2003), and it has been described as basic climatic factor for flowering and fruit set (Elloumi et al., 2013) that has a strong effect on phenological stages (Javanshah, 2010). Temperate fruit cultivars with set chilling requirements, show great variability in the flowering period from year to year under warm winter conditions (Petri et al., 2008). Cultivated species *R. fruiticosus* might have responded better to the climatic conditions in the present study thus the fewer days to first and 50% flowering compared to all the wild species.

Flowering time in plants can also be due to genetic factors (Mouradov et al., 2002; Simpson et al.,2003; Putterill et al., 2004) as there are specific genes responsible for early or late flowering in plants. The significant difference in flowering time could be due to the genetic make-up of the different blackberry species planted during this study. Cultivated species could have had genetic factors related to early flowering while the other species had genes which took a longer time to respond to early flowering.

Flower bud initiation in blackberry may be influenced by accumulation of carbohydrates (Crandall et al.,1974), even though there has been no systemic study to establish causal relationship or to examine the interacting effects of irradiance and cane carbohydrates reserves on blackberry flower bud differentiation (Takeda et al.,2003). For the current study, this could be the reason for the difference in time of flowering, therefore cultivated species *R. fruiticosus* accumulating enough carbohydrate for early flower bud initiation compared to the wild species that were grown during the same study.

According to Takeda et al.(2002), flower bud initiation is generally thought to respond to short day in biennial blackberry cultivars and the rate of flower bud initiation varies with the type of cultivar and prevailing winter temperatures. This study shows that cultivated blackberries that were planted together with the wild species have shorter chilling requirement hence the shorter duration to first and 50% flowering. Flowering time can also be manipulated by exogenous application of gibberellic acid (GA) as this has been shown to positively regulate the expression of flowering signal integrator genes such as *SOC1* and *LFY* (Blazquez and Weigel, 2000; Moon et al., 2003). Though in this study, there was no exogenous application of GAs, therefore this could not be the reason for the different flowering time.

Fruit set variation was observed in the different blackberry species; wild blackberry *R. apetalus*had the highest percent fruit set while cultivated *R. fruiticosus*and wild species *R. volkensis*had lower percent fruit set. Fruit set variation as proposed by MacDaniels (1922) suggested that all buds of brambles have the potential to develop into fruit buds at the same time. Carew et al.(2000) observed that full flowering potential is often inhibited by cultural conditions,more advanced buds that have completed differentiation may suppress some buds (Takeda et al., 2003). Internal shading on early senescence and abscission may also arrest some buds (Wright and Waister, 1984).Fruit set is determined by the adaptability of a species to a given location; it is affected by moisture content of the soil and nutrient availability. Reproductive bud development and differentiation rate in blackberry are reliant on climate and the time of floral bud differentiation and blooming (Moore and Caldwell, 1985). Wild species *R. apetalus* adapted well to the environmental conditions it was grown followed by cultivated species *R. fruiticosus* and wild species *R. volkensis.* Plants that look normal and healthy may at times produce a lot of flower but fail to set fruits completely, but more often it may be partial, with misshapen berries, whose appearance range from nearly normal to some with only a single drupelet (Mohammad, 1996). Such conditions may be due to virus or fungal infection, damage caused by insects, genetic abnormality or all those combined causes (Mohammad, 1996). In the present study, lack of fruit set in *R. steundneri* and *R. pinnatus* could be due to a combination of all those factors that leads no fruit set.

The number of days from flower opening to fruit maturity did not show any significant difference apart from the two species which did not set fruit. Variation of days from first bloom to fruit maturity depends on cultivar and climatic conditions (Salgado and Clark 2015). A comparable result was also reported by Hussain et al. (2016) where the duration between flower bud and ripe berry stages of blackberry cultivars ‘Tupy’ and ‘Xavante’ was quite similar, 29.6 and 31 days, respectively. Striket al.(2012) also found out that the number of days from first bloom to first fruit was unaffected by cultivar or treatment and average was 36 and 43 days in 2004 and 2005, respectively. This is an indication that the days from initial bloom to fruit maturity is not influenced by species for this study and in other studies citationtherein.

Harvesting duration for the different blackberry species was significant with *R. fruiticosus* having the longest harvesting duration, while the shortest in harvesting duration was *R. volkensis*. The longer harvesting duration is due to the ability of a plant species to utilize its carbohydrates or photosynthates efficiently therefore the longer duration of flowering. In some species, the harvesting duration was shorter and is due to lack of fruit set, diseases and environmental condition. Phenological characteristics especially flowering period,days to fruit maturity harvesting period vary due to cultivars and ecological conditions (Rosati et al., 1993). In another study by Campagnolo and Pio (2012) on 11 blackberry cultivars, the longest harvesting duration of cultivar “Amoravermelha” was 161 and 245 days, in 2009/2011 and 2010/2011 respectively, which was shorter than the results of the current study of the different blackberry species while the shortest harvest duration was for cultivar “Chactow” at 42 and 38 days in 2009/2011 and 2010/2011, respectively. Duration of harvest varies from one species to the other due to the adaptability of that species to a given environmental conditions.

Conclusion

This study shows that different blackberry species cultivated in Kenya differ in the days to reproductive phase, wild species *Rubus apetalus* had the shortest days flowering followed by *Rubus volkensis*in comparison to the cultivated species *Rubus fruiticosus.* Harvesting duration also was long in *R. apetalus* and *R. volkensis*but not longer than the cultivated species. This is an indication that the two wild species can be adopted for cultivation through further improvement under convectional production.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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