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Research Application Summary

Morphological response of selected passion fruit varieties to limiting water status

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Abstract

Passion fruit (*Passiflora* spp.) is the third most common fruit in Kenya. It belongs to the Passifloraceae family with three species under production in Kenya. The Kenya Agricultural and Livestock Research Organization (KARLO) released three varieties (KPF4, KPF11 and KPF 12) of sweet yellow passion fruit of which KPF 4 is the most widely adopted. The other varieties under production are the purple variety and the Brazillian type popular in the coastal region. Despite the crops' potential as an income earner, the expansion and productivity of the crop is hindered by drought stress coupled with poorly adapted varieties. This study aimed to analyze the morphological traits that confer drought tolerance to *Passiflora* spp. The study was carried out in two sites at Karurumo in Embu County and at the Kenyatta University farm in Kiambu County. The study was carried out on-farm and on-station and laid out in a randomized complete block design (RCBD) with split plot arrangement where the three irrigation schedules (5, 10 and 15 days interval) constituted the main plots while the five varieties of Passiflora species (KPF 4, Purple, purple grafted on the yellow variety and Brazillian variety) formed the sub plots. The data collected included the plant height, number of vines regrowth and the number of leaves. A one - way analysis of variance (ANOVA) with blocking, was carried out between the genotypes and irrigation schedule using SAS 2002; Version 16.0. Plant height was shown to be the most affected morphological trait in passion fruit. The five day watering interval to field capacity resulted in the lowest disruption in morphological growth patterns. The Brazillian variety showed the highest tolerance at all watering intervals with the purple being the worst performer. The results will contribute towards improving the breeding of more adapted varieties and increasing the adoption and production of passion fruit especially in the drought prone areas.

Key words: Climate change, drought, Kenya, *Passiflora* spp., water use efficiency

Résumé

Le fruit de la passion (Passiflora spp.) Est le troisième fruit le plus commun au Kenya. Il appartient à la famille des Passifloracées avec trois espèces en production au Kenya. L'Organisation de recherche agricole et d'élevage du Kenya (KARLO) a publié trois variétés (KPF4, KPF11 et KPF 12) de fruit de la passion jaune doux dont KPF 4 est le plus largement adopté. Les autres variétés en production sont la variété violette et le type brésilien populaire dans la région côtière. Malgré le potentiel des cultures comme pourvoyeur de revenus, l'expansion et la productivité de la culture sont entravées par le stress de la sécheresse associé à des variétés mal adaptées. Cette étude visait à analyser les caractéristiques morphologiques qui confèrent une tolérance à la sécheresse à la Passiflora spp. L'étude a été conduite dans deux sites; notamment à Karurumo dans le comté d'Embu et à la ferme de l'Université Kenyatta dans le comté de Kiambu. L'étude a été réalisée à la ferme et en station et disposée dans un dispositif de bloc complet randomisé (RCBD) avec un arrangement de parcelles divisées où les trois programmes d'irrigation (intervalle de 5, 10 et 15 jours) constituaient les parcelles principales tandis que les cinq variétés des espèces de Passiflora (KPF 4, Violet, violet greffé sur la variété jaune et la variété brazillienne) formaient les sous-parcelles. Les données collectées comprenaient la hauteur de la plante, le nombre de repousses de vignes et le nombre de feuilles. Une analyse de la variance à sens unique (ANOVA) avec blocage, a été réalisée entre les génotypes et le programme d'irrigation à l'aide de SAS 2002; Version 16.0. La hauteur de la plante s'est avérée être la caractéristique morphologique la plus affectée chez le fruit de la passion. L'intervalle d'arrosage de cinq jours pour la capacité du champ a entraîné la plus faible perturbation des schémas de croissance morphologique. La variété brazillienne a montré la tolérance la plus élevée à tous les intervalles d'arrosage, le violet étant le moins performant. Les résultats contribueront à améliorer la sélection de variétés plus adaptées et à accroître l'adoption et la production de fruits de la passion, particulièrement dans les zones sujettes à la sécheresse.

Mots clés: Changement climatique, sécheresse, Kenya, Passiflora spp, efficacité d'utilisation de l'eau

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Introduction

Passion fruit (*Passiflora* spp.) is a vigorous, climbing vine plant that belongs to the Passifloraceae family (Lipmann, 1978). The plant is believed to have originated from South America and has a life-span of between 2-5 years depending on the variety and the level of orchard management. In Kenya, five varieties comprising purple type, sweet yellow type (KPF4, KPF 11 and KPF 12) and the Brazilian type dominate production. It was first introduced in Kenya in the 1920s for commercial juice processing but has gained large market for fresh consumption (Kibet *et al.,* 2011). The passion fruit enterprise has high financial returns, with the gross value of an acre averaging 600,000 Kenya shillings (approximately $5770.89) , equivalent to 12 times that of maize (KARI, 2010). The fruit is a rich source of antioxidants, Vitamins A and C, essential mineral elements and phenolic compounds (Talcott, 2003).

Despite rapid initial adoption, the production has been decreasing due to drought, pests and diseases (Gesimba, 2008). Furthermore, increased irrigation presents the risk of nutrient losses through leaching which reduces crop performance. Establishment of drought tolerance level and plant allocation would enable production of crops that have higher resource use efficiency.

Drought stress limits production areas, fruit quality and quantity, and determines the varieties grown in different areas and the resources demanded, specifically higher irrigation in dry areas, which increases the cost of production (Lekeu, 2001; Munene, 2003). The identification of morphological traits will enable breeding for drought tolerant varieties. The establishment of a low cost, effective irrigation pattern with specified water amount and schedule of irrigation will enable farmers to effectively utilize water resources in an economical manner. These will reduce the major cost of production in passion fruit which is irrigation thus encouraging higher productivity, increase in economic use of the water resources, increasing the cash flow to farmers and thus promoting wealth creation and poverty reduction (HCDA, 2013).

Methodology

The experiment was conducted in two sites: Karurumo location in Embu County lying at latitude 0°31'52"S and longitude 37°27'02'E and at Kenyatta University field station that lies on the coordinates 1°10'50.0"S and 36°55'41.0"E for one season of the year 2016.

The study was done in-field and under screen house. The study was laid out in a Randomized Complete Block Design (RCBD) with a split plot arrangement with three replications. The irrigation schedules at 5 days, 10 days and 15 days interval constituted the main plot while the passion fruit accessions (KPF4, Brazilian, purple and the purple grafted on yellow) were the subplots. Three plants of each accession replicated three times were used in each plot. The planting materials were acquired from KALRO Thika center (for the KPF 4); the grafted purple variety and the Brazilian variety from KALRO Mtwapa centre; while the purple variety was self-raised at the Kenyatta University farm station.

The planting holes were dug at the recommended 45 by 45 by 45cm and mixture of top soil, sub soil, manure and DAP were used to fill the holes. The screen house set was planted in 30x30x45 cm plastic pots. After transplanting, uniform watering was done for the first two months to facilitate proper crop establishment and acclimatization. The other agronomic practices were carried out without discrimination between treatments. Data collection for the field study commenced one month after the start of the treatments and relied on non-destructive harvesting techniques. The data collected included the number of days to flowering, plant height which was measured using a meter rule, number of vines regrowth and number of leaves. Data were subjected to one - way analysis of variance (ANOVA) with blocking, using SAS 2002; Version 16.0. The means were separated using Least Significant Difference (LSD) test and Standard Error of Difference (SED). All the statistical comparisons were done at 95% confidence level.

Results and Discussion

Plant heights. Significant differences ($P \leq 0.05$) were observed between the 15 day interval water regimes and the 5 and 10 day interval treatments while no significant differences were observed at the other two water regimes as shown in Table 1. The five days water regimes had the tallest plants (168.8 cm) as compared to the shorter plants (125 cm) of 15 days water regime.

Plant height was significantly influenced ($P \leq 0.05$) by the genotype as shown in Table 2. The maximum plant height was achieved by the Brazillian variety at 339 cm on the two sites while the purple variety was the most affected by drought stress with a plant height of 46 cm. The purple grafted on yellow root stock performed better at 193 cm.

Number of leaves . A significant variation (P≤0.05) in the number of leaves per plant was observed depending on water regime (Table 3). The maximum average number of leaves per plant (40.2) was recorded from KP4 variety. The minimum number of leaves per plant was recorded from the purple variety which was statistically different from the other varieties. The grafted purple had a significant difference from the non-grafted purple throughout the growing period. The number of leaves showed no discernible difference between the water regimes despite showing significance difference between the varieties. The negative impact of the water stress on the number of leaves and size as observed are indications of a hindrance of leaf formation processes and the mechanisms that control transpiration (Muthomi and Musyimi, 2009). The more adapted plants appear to maximize on the light absorption though increased leaf production.

Number of vines. The number of vines regrowth per plant differed significantly (P≤0.05) among the different varieties. The Brazillian variety had a higher vine regrowth as compared to the other varieties during the entire period of the study. There was no significant difference in the number of vines between the watering regimes and thus the difference was hypothesized to be based on the varietal differences.

Table 1. Effect of varying water regime on plant height (cm) of passion fruit

Water treatment	Weeks after start of treatments					
	4	8	12	16	20	24
5 days watering interval	27.6^{a}	53.2^{a}	85.2^{a}	123.7^{a}	138.3^{a}	168.8^{a}
10 days watering interval	31.5^{a}	50.2^{a}	77.2^{a}	107.3^{a}	127.8^{a}	155.9^{a}
15 days watering interval	17.6^{b}	29^{b}	46.6^{b}	77.8^{b}	99.5^{b}	125.3^{a}
P Value	0.002	0.008	0.002	0.011	0.113	0.118
LSD (0.05)	7.4	15.72	20.61	28.87	37.88	42.56

Means followed by the same letter within columns are not significantly different at P ≤ 0.05.

Table 2. Effect of water stress on plant height (cm) of different varieties of passion fruit

Variety	Weeks after start of treatments					
	4	8	12	16	20	24
Grafted	39.6^{a}	63.7^{b}	96.3^{b}	123^{a}	139^{b}	193^{b}
Purple	25.1^{b}	39.6^{c}	63.1^{c}	54.3^{b}	66^{c}	46^{c}
KP4	43.7^{a}	83.7^{a}	126.3^{ab}	172.9^{a}	247^{a}	304^{a}
Brazillian	46.9^{a}	103.1^{a}	150.2^{a}	219.9^{a}	270^{a}	339^{a}
P Value	0.016	<.001	0.001	<.001	<.001	<.001
LSD (0.05)	13.6	27.55	39.62	56.9	70.1	90

Means followed by the same letter within columns are not significantly different at P ≤ 0.05.

Table 3. Effect of water stress on the number of leaves of different varieties of passion fruit

Variety	Weeks after start of treatments					
	4	8	12	16	20	24
Grafted	6.78^{b}	8.44^{b}	10.8^{b}	15.6^{b}	16.6^{b}	18.7^{b}
Purple	6.33^{b}	8.33^{b}	12.4^{b}	2^{c}	2.3^{c}	0^{c}
KP4	11^{a}	15.44^{a}	23.6^{a}	30.9^{a}	34.1^{a}	40.2^{a}
Brazillian	11.56^{a}	15.67^{a}	22^{a}	27.9^{a}	30.8^{a}	34.4^{a}
P Value	0.009	0.004	<.001	<.001	<.001	<.001
LSD (0.05)	3.614	4.979	6.79	9.97	11.43	11.77

Means followed by the same letter within columns are not significantly different at $P \leq 0.05$

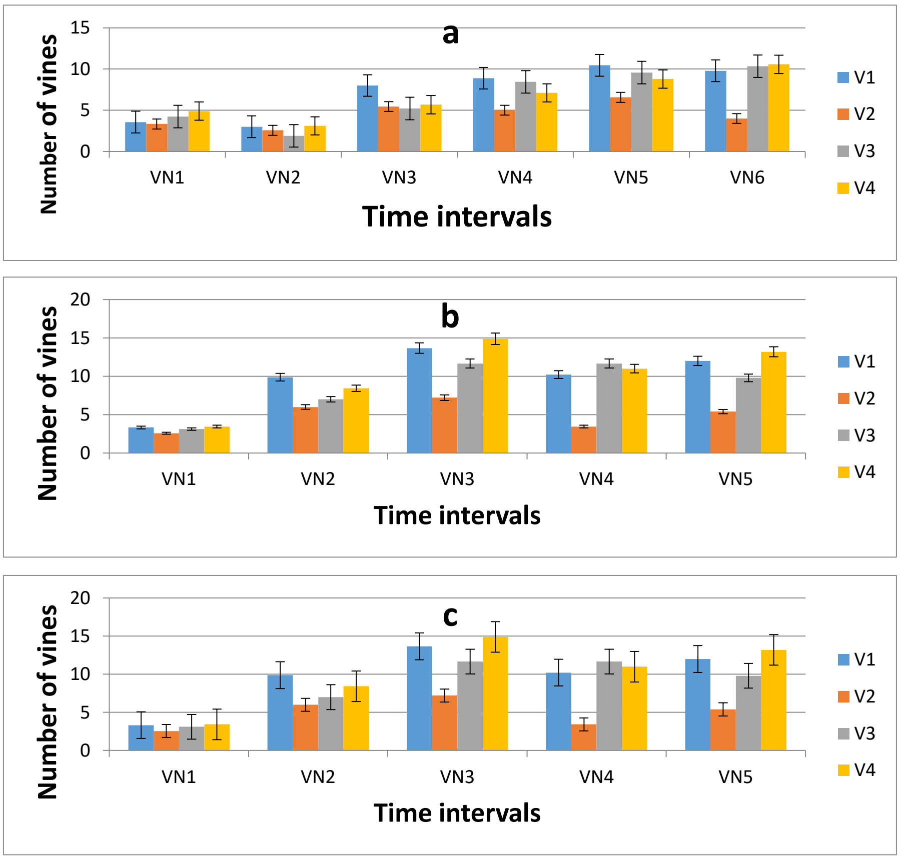

Figure 1. Number of vines of the different varieties for a (Embu), b (Kenyatta university field) and c (Kenyatta University screen house). VN is the harvesting intervals and V1 is the purple variety, V2 is the grafted, V3 is the KPF 4 and V4 is the Brazillian variety.

The morphological growth responses of different passion fruit varieties to varying water regimes indicate that watering at five days interval to field capacity is preferred for growth. The varieties showed significant difference in all the tested parameters including: the plant height, number of vines and number of leaves. The performance of the different varieties was greater at five days watering interval. At 15 days watering interval, the performance of all the varieties was low. This finding supports the recommendations of Solomon and Hamadina (2014) who reported that three days watering interval as sufficient for the passion fruit seedlings. The better performance of the grafted purple passion fruit variety against the non-grafted purple showed that the roots also play a key role in the drought tolerance in passion. This finding supports the study of Isutsa (2006) on the benefit of grafting purple passion fruit for drought tolerance. The high performance of the Brazillian variety in the coastal region which experiences high temperatures indicate the variety's ability to adapt to cooler regions (Szabados, 2011), contrary to the adaptability of the purple variety from the cooler to warm conditions. The impact of the climate change and its influence on the crop productivity is well reported. These results support the findings of Menzel *et al.* (1986) on the reduction of plant and other morphological traits by water stress attributed to poor nutrient absorbance and inability of the passion fruit stem to store water for longer periods beyond four days.

Conclusion

This study demonstrates that some passion fruit varieties have adapted to water stress and can be useful in the breeding programmes for drought tolerant genotypes. The importance of using the plant height as a morphological marker in passion fruit breeding for drought tolerance is also demonstrated. Through grafting, the importance of the root system as morphological marker is also clearly shown and future studies should examine the mechanisms by which the roots confer drought tolerance.

The Brazillian and the KPF 4 varieties were the most adapted varieties and are recommended for adoption in areas experiencing water stress. The effect of climate change in the cold highland areas resulting in temperature increase and reduction of rainfall can be curbed by use of purple grafted variety which has the advantage of drought adaptability without losing the desired attributes of the purple variety that is not adapted to drought stress.

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