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Research Application Summary

Increasing yellow passion yields by managing water stress using hydrogel, polythene and grass mulches in Embu and Kiambu Counties, Kenya

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Abstract

Over the years, farmers in dry areas of Africa have depended on a narrow range of crops that tolerate water stress for nourishment and income generation. Yellow passion fruit production is a lucrative venture of much higher income compared to other crops such as cereals in drought prone areas. Agronomic management involves better use of available soil water conserving practices, especially in areas where rainfall is a major limiting factor, benefits farmers by enhancing both productivity and profitability. The present study was carried out to evaluate the potential of different soil water conserving practices to increase productivity of yellow passion fruit (*Passiflora* spp.). A researcher-farmer managed field experiment was conducted in Ugweri, Embu County, and a similar one at Kenyatta University research farm, Kiambu County (Researcher-managed), consisting of six treatments (Hydrogel_20g, Hydrogel_10g + Polythene Mulch, Hydrogel_10g + Grass Mulch, Plastic Mulch, Grass Mulch and a control), in a randomized complete block design (RCBD). A single variety of KPF4 was used. At 42 weeks after transplanting (WAT), yield significantly ($P<0.05$) varied from 5.10 t/ha in the control treatment to 10.53 t/ha (Hydrogel_10g + Polythene mulch treatment) in Ugweri. Similarly, at Kenyatta University initial yields varied from 3.11 t/ha in the control treatment to 9.73 t/ha in the Hydrogel_10g + Polythene mulch treatment. These results indicated that Hydrogel_10g + Polythene consistently provided the highest yields over the five harvests; 10.53 t/ha, 14.05 t/ha, 20.27 t/ha, 17.76 t/ha and 14.90 t/ha in Ugweri, and 9.73 t/ha, 12.05 t/ha, 17.88 t/ha, 13.99 t/ha and 11.40 t/ha at Kenyatta University. Based on these findings, Hydrogel_10g+Polythene Mulch could be a viable option for farmers to adopt for increasing fruit production in yellow passion.

Key words: Dry areas, grass mulch, hydrogel, Kenya, polythene mulch, water stress, yellow passion fruit

Résumé

Au fil des années, les agriculteurs des régions sèches d'Afrique ont comptés sur une gamme étroite de cultures qui tolèrent le stress hydrique pour se nourrir et générer des revenus. La production de fruits de la passion jaunes est une entreprise lucrative avec des revenus beaucoup plus élevés que d'autres cultures telles que les céréales dans les zones sujettes à la sécheresse. La gestion agronomique implique une meilleure utilisation des pratiques disponibles de conservation de l'eau et du sol, particulièrement dans les zones où les précipitations sont un facteur limitant majeur, profite aux agriculteurs en améliorant à la fois la productivité et la rentabilité. La présente étude a été menée pour évaluer le potentiel de différentes pratiques de conservation de l'eau du sol en vue d'augmenter la productivité des fruits de la passion jaunes (Passiflora spp.). Une expérience sur terrain gérée par des chercheurs et des agriculteurs a été menée à Ugweri, dans le comté d'Embu, et une expérience similaire à la ferme de recherche de l'Université Kenyatta, dans le comté de Kiambu (gérée par les chercheurs), consistant en six traitements (Hydrogel_20g, Hydrogel_10g + paillis de polyéthylène, Hydrogel_10g + paillis d'herbe, paillis de plastique, paillis d'herbe et un témoin), dans un dispositif de bloc complet randomisé (RCBD). Une seule variété de KPF4 a été utilisée. Quarante-deux semaines après la transplantation (WAT), le rendement variait significativement (P <0,05) de 5,10 t / ha dans le traitement témoin à 10,53 t / ha (traitement Hydrogel_10g + paillis de polyéthylène) à Ugweri. De même, à l'Université Kenyatta, les rendements initiaux variaient de 3,11 t / ha dans le traitement témoin à 9,73 t / ha dans le traitement Hydrogel_10g + paillis de polyéthylène. Ces résultats ont indiqué que Hydrogel_10g + Paillis de polyéthylène a toujours fourni les rendements les plus élevés au cours des cinq récoltes; 10,53 t / ha, 14,05 t / ha, 20,27 t / ha, 17,76 t / ha et 14,90 t / ha à Ugweri et 9,73 t / ha, 12,05 t / ha, 17,88 t / ha, 13,99 t / ha et 11,40 t / ha à l'Université Kenyatta. Sur la base de ces résultats, Hydrogel_10g + Paillis de polyéthylène pourrait être une option viable pour les agriculteurs à adopter pour augmenter la production des fruits de la passion jaunes.

Mots clés : Zones sèches, paillis d'herbe, hydrogel, Kenya, paillis de polyéthylène, stress hydrique, fruit de la passion jaune

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Background

Millions of Kenyans depend on horticulture for food, and income generated from sales in local and export markets. In the dry areas of Kenya, inadequate rainfall that is poorly distributed is a major factor limiting crop performance. This is in line with Srinivasarao *et al.* (2013) who reported that the amount of rainfall and its distribution are key to influencing crop productivity in rain-fed farming. Some of the staple food crops, such as maize that farmers grow in some parts of Embu and Kiambu counties in Kenya are highly vulnerable and often succumb to moisture stress. This poses a serious threat to the attainment of food security and better livelihoods for all, as envisaged in Kenya's vision 2030. Interventions emphasizing planting of drought resistant varieties especially in drier areas of Embu county have not been successful (AGRA, 2014).

Although some farmers irrigate their crops to manage water stress, the water application methods are inefficient and often result in irregular crop production because of nutrient losses through leaching. Farmers have mixed experience with a few crop choices they consider suited in the drought stressed areas of Kiambu and Embu County. Some of the crops have proved to be better insurance against total crop failure. However, even some initially preferred alternatives such as cereals have become unreliable due to inadequate rainfall exacerbated by climate change. There has been growing enthusiasm and adoption of sweet yellow passion fruit (especially KPF4 variety) by some farmers due to claimed adaptation to abiotic and biotic stress according to the Kenya Agricultural and Livestock

Research Organization (KALRO). However, farmers' experience has indicated that KPF4 yellow passion fruit variety has high water demands and requires supplemental irrigation for profitable production. Passion fruit if well managed has a prolonged production season, unlike annual crops such as maize. According to HCDA (2016), the contribution of passion fruit in Kenya increased for about Kshs 1.9 billion (approximately $11,402,700) in 2014 to over Kshs 2billion (approximately $19,236,300) in 2016.

Considering the economic importance of yellow passion especially to communities in semi-arid areas of Kenya, improved soil water conserving practices are urgently needed. One of the suggested ways to increase crop productivity is to build farmers' capacity to implement water conserving practices suited to dryland ecologies (Mwandalu and Mwangi, 2013). Use of polythene, grass mulch and hydrogel has been successfully applied in conserving soil moisture for increased agricultural crops yields in other regions (Jain *et al.,* 2017). These water conserving practices have different potential to enhance productivity of agricultural crops. Therefore, this study aimed to identify the best suited water conserving practice to increase yields of yellow passion fruit in dry environments in Kenya.

Study description

This study was conducted in Ugweri, Embu County (Eastern Kenya) and at Kenyatta University, Kiambu County (Central Kenya). The average annual rainfall in Embu county is about 1067.5mm with drier areas receiving as low as 640 mm. Temperatures ranges from 12°C (minimum experienced in July) to 30°C in March, with an average of 21°C annually. The soils are mainly Nitisols. Kenyatta University experiences average annual rainfall of approximately 989mm, with an annual average temperature of 18.7°C. The study adopted a randomized complete block design (RCBD) with six treatments, three replications and 18 plots (3 plants per plot). Each seedling of yellow passion fruit (KPF4 variety) was transplanted in a hole consisting of 20kg of manure and 125g DAP fertilizer mixed with soil.

Treatments were applied one month after transplanting. Ten litres of water was applied to each plant after every two weeks. Bi-weekly data collection commenced 1.5 months after the application of treatments.

Results

Yields (measured by total fruit weight per harvest) varied significantly ($P<0.05$) between treatments (Tables 1 and 2). The H10g+ PM treatment recorded the highest yields at both sites; H10g+GM, PM, GM, and H20g ranked second, third, fourth and fifth, respectively. The control consistently recorded lowest yields throughout the harvesting period and in all sites.

Discussion

Soil moisture is one of the factors that influence plant development, vigor and ultimately yield. In this study the hydrogel_10g+ polythene mulch treatment had the highest yields due to higher relative ability of the treatment to create a good soil microclimate characterized by more moisture storage and higher soil temperatures. The positive effect of polythene mulch was because it significantly contributed to reduced weed problems, evaporation, higher soil temperatures and reduced leaching of nutrients. The hydrogel applied to the soil contributed significantly to increasing the amount of water conserved under this treatment. Hydrogels have the ability to absorb water more than 200 times of their own weight. Adequate water significantly contributed to increased number of fruits that reached maturity and were harvested. Dry soil conditions shrivel fruits and increases premature fruit-fall (Morton, 1987). Similarly, the H10g + Grass mulch treatment was second best because of the cumulative positive effect provided by both hydrogel and grass mulch. Higher yields associated with combined soil application of hydrogel and polythene or organic mulch have been reported elsewhere (Yang *et al.,* 2012; Jain *et al.,* 2017).

The PM, GM and H20g produced higher yields compared to the control. This was due to the cumulative effect of better growth environment, water and nutrient absorption and mobilization, and partitioning to reproductive system.

Table 1. Fruit yields (t/ha) under different treatments in Ugweri site, Kenya

Treatments	42WAT	44WAT	46WAT	48WAT	50WAT
H10g + PM	10.53[a]	14.05[a]	20.27[a]	17.76[a]	14.90[a]
H10g + OM	8.97[b]	12.58[b]	18.68[b]	17.49[a]	14.52[a]
PM	8.00[bc]	9.92[c]	16.15[c]	12.97[b]	12.72[b]
OM	7.89[bc]	9.01[c]	15.94[c]	12.07[bc]	12.23[b]
H20g	7.03[c]	8.89[c]	15.27[c]	11.56[c]	11.28[b]
Control	5.10[c]	7.04d	13.33[d]	9.26[d]	9.63[c]
P-value	<.0001	<.0001	<.0001	<.0001	0.0003
LSD	1.1904	1.1907	1.5041	1.1909	1.5039

*Means not sharing a common letter in a column had significant effect at 5 % Probability level. H10g+PM-Hydrogel_10g+Polythene Mulch, H10g+GM-Hydrogel_10g+Grass mulch, PM-Polythene mulch, GM-Grass mulch, H20g-Hydrogel-20g, Control-No hydrogel, no mulch

Table 2. Fruit yields (t/ha) under different treatments in Kenyatta University site

Treatments	44WAT t ha^{-1}	46WAT t ha^{-1}	48WAT t ha^{-1}	50WAT t ha^{-1}	52WAT t ha^{-1}
H10g + PM	9.73[a]	12.05[a]	17.88[a]	13.99[a]	11.40[a]
H10g + OM	7.54[b]	9.86[b]	16.15[b]	11.69[b]	10.32[b]
PM	6.13[c]	9.10[bc]	15.86[b]	11.52[b]	10.30[b]
OM	5.26[cd]	8.60[c]	14.34[c]	10.08[c]	8.78[c]
H20g	4.46[d]	7.51[d]	13.16[d]	9.18[cd]	7.70[d]
Control	3.11[e]	5.89[e]	11.26[e]	8.39[d]	7.09[d]
P-value	<.0001	<.0001	<.0001	<.0001	0.0006
LSD	0.9421	0.9429	0.9438	0.9425	0.9444

*Means not sharing a common letter in a column had significant effect at 5 % Probability level.
H10g+PM-Hydrogel_10g+Polythene Mulch, H10g+GM-Hydrogel_10g+Grass mulch, PM-Polythene mulch, GM-Grass mulch, H20g-Hydrogel-20g, Control-No hydrogel, no mulch

Conclusion

Soil moisture conserving practices significantly increases yields of yellow passion fruit in dry areas. Different soil moisture conserving technologies exhibit different capabilities in mitigating effects of water stress on yields of crops in different areas. In Embu and Kiambu counties, H10g+PM and H10g+GM are feasible water conserving technologies that could be further explored and promoted among farmers to increase productivity and profitability of yellow passion fruit.

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