Theme 2: Options for Adapting to Salinity

Saving water with Chameleons

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Introduction

Rising sea levels contribute to increasing inland saline intrusion in low-lying areas of the Mekong River Delta (MRD) and fluctuating river volumes increase concerns for drought and water scarcity (Kaveney et al 2023). Without irrigation water, farmers in coastal areas do not cultivate rice causing fallow areas. To deal with the issues, potential dry season crops that can tolerate the conditions of low rainfall and saline irrigation need to be identified. Alternative crops like maize, quinoa, and beetroot were explored as potential crop options to replace rice during the dry season in VMD (FOCUS project, 2021).

In addition to finding alternative crop options, irrigation water-saving technologies are being created to contribute to water use efficiency in the context of water scarcity. Although many water management methods and models have been applied in the VMD with benefits, their adoption remains limited (Myeni et al., 2019; Wang et al., 2015). The Chameleon soil moisture sensor (via.farm) (the sensor) was designed as a monitoring tool to help farmers decide when and how much to irrigate (Moyo et al., 2020a). The sensors can measure soil tension indirectly without the need for calibration (Stirzaker et al., 2017) and indicate the soil moisture status with three coloured lights with blue as wet soil (0 to -22 kPa), green as moist (-22 to -50 kPa), and red as dry (more than -50 kPa). The colours determine when irrigation should occur with red indicating irrigation is required, whilst blue indicates no need for irrigation. The Chameleon's have enabled farmers to save the frequency and amount of water applied which helps improve the awareness of local farmers in adjusting irrigation schedules (Bjornlund et al., 2018; Mdemu et al., 2017; Moyo et al., 2020b).

This study aimed to test the effect of the sensor on decreasing irrigating water and reducing the impacts of saline water without yield compromise as well as investigating the ability of growing beetroot under saline irrigation and the limitation of irrigation water.

Methodology

The trials were implemented in both the greenhouse and field. The greenhouse trials were conducted in a randomized complete design with 3 replications using free-draining pots. Soil samples (0-20 cm) of a silty clay were collected with the homogenous area from Long Phu, Soc Trang Province, Vietnam. The trial consisted of two irrigation treatments (conventional and based on sensor signal) and three salinity treatments (non-saline, 0.5 g L^{-1}, and 1 g L^{-1}) applied to beetroot (Bohan F1) in 2022. The temperatures were maintained at 38/25 Degrees Celsius (day/night). All pots were maintained at 90% field capacity for the first two weeks post-sowing with non-saline water before salinity treatments were applied for conventional irrigation and irrigating based on the sensor. The field trials were implemented in Long Phu site where greenhouse soil samples were collected. The trials were conducted in a randomized complete block design with 4 replications including two irrigation treatments (conventional and based on sensor signal) applied to beetroot (Bohan F1).

The volume of water applied was recorded daily. Soil data were collected for chemical and physical analysis at crucial stages of plant growth, i.e., 7 days after the first fertilizing, 7 days after the last fertilizing, and at the time of harvest. Plant data was collected at the harvest time. Plant growth targets includes plant height, leaf length, leaf diameter, fresh biomass, SPAD index, Brix index, tuber diameter, and yield. Statistical analysis was performed using Minitab 21.0 software. All treatment means were compared for any significant differences by the Turkey tests at the P = 0.05 significance level.

Results

Greenhouse trial

Soil electrical conductivity (EC) (Figure 1) increased over the growth duration of beetroot. In the saline irrigation (1 g L^{-1}), the soil EC value of conventional irrigation (No-1) was significantly higher compared to treatment of irrigating based on the sensor (Cham-1) after 20 days aft er sowing (DAS).

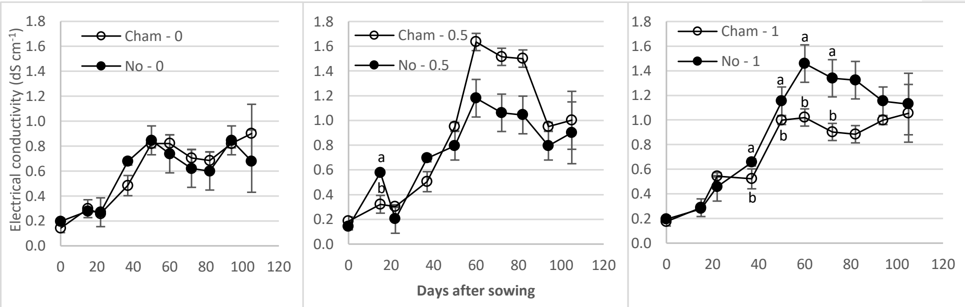

Figure 1. Effect of the irrigation and salinity treatments on the soil (1:5) electrical conductivity (dSm^{-1}) recorded over the growth duration of beetroot. The irrigation based on Chameleon and salinity concentration (0.5 g L-1 and 1 g L-1) of the salinity treatments commenced 20 days after sowing. The error bars indicate standard deviation. Treatment means with the same letter are not significantly different at P≤0.05.

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All treatments irrigated based on the Chameleon saved the amount of water applied by nearly 50% compared to continuous irrigation treatments, without yield loss (Table 1). Agricultural parameters were not significantly different between all treatments except for the SPAD index, it was higher with the increase of salinity. The maximum SPAD index was 62.1 in the non-saline irrigation based on Chameleon, which was significantly higher than treatment of saline water irrigation with salinity of 1 g L^{-1} based on Chameleon, at 48.8 as follows Table 1

Table 1. Salinity or irrigation treatment main effects on the amount of water use, agricultural parameters, and yield (g) of beetroot. Within a column, numbers followed by the same letter do not differ significantly at p< 0.05.

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Treatment	Total water use (L pot^{-1})	Yield (gram pot^{-1})	Plant height (cm)	Leaf length (cm)	Leaf diameter (cm)	Tuber diameter (cm)	SPAD index
Cham 0	11.9b	66.4	27.5	23.7	8.8	4.7	62.1a
Cham 0.5	10.5c	60.5	22.8	20.7	6.9	4.4	56.1ab
Cham 1	10.0d	53.5	24.0	20.5	8.1	4.3	48.8b
No 0	21.7a	59.9	25.7	21.8	8.3	4.5	55.3ab
No 0.5	21.7a	58.0	24.0	20.3	8.3	4.2	53.8ab
No 1	21.7a	55.8	25.7	21.5	7.8	4.6	51.3ab

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Field trial

Soil EC value (figure 2a) was not significant different except for 56 DAS where the soil EC value of irrigating based on the sensor was higher than conventional irrigation. Soluble sodium was not significantly different, while exchangeable sodium value of convetional irrigation treatment was 0.32 meq 100g^{-1}, which was significantly higher than that of treatment of irrigating based on the sensor at the harvest time (83 DAS) (figure 2b). Similarly, the ESP value of irrigating based on the sensor treatment was also lowe r signific antly compared to the conventional ir rigation.

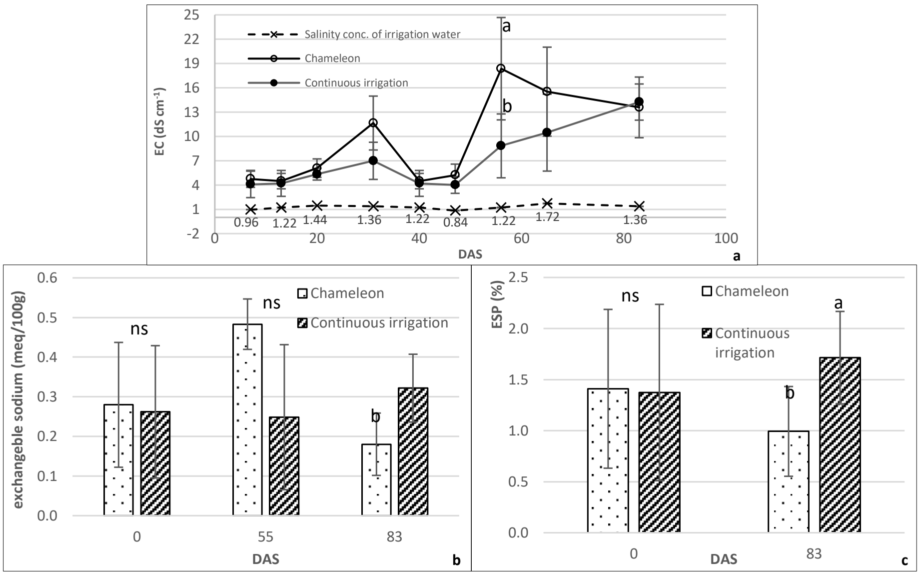

Figure 2. Effect of the irrigation treatments on soil EC (dS cm^{-1}) (a), exchangeable sodium (meq 100g^{-1}) (b) and Exchangeable sodium percentage (%) (c) recorded over the growth duration of beetroot. Treatment means with the same letter are not significantly different at P≤0.05.

Table 2 shows the amount of water applied when based on the sensor was significantly lower than that of continuous irrigation treatment, while all agricultural parameters and beetroot yield were not significantly different.

Table 2. Irrigation treatment main effects on the amount of water use, agricultural parameters, and yield (g) of beetroot. Within a column, numbers followed by the same letter do not differ significantly at p< 0.05.

Treatment	Total water use (m^3 ha^{-1})	Yield (tons ha $^{-1}$)	Plant height (cm)	Leaf length (cm)	Leaf diameter (cm)	Tuber diameter (cm)
Chameleon	1000b	36.2	30.0	24.5	7.83	6.83
Continuous irrigation	1750a	38.8	31.3	26.0	7.93	7.13

Discussion

Beetroot has never been grown in the VMD but showing the potential cultivation under continuous saline irrigation. In three levels of salinity, the yield of beetroot was not significantly different from 55.8 – 59.9-gram pot^{-1} (p<0.05). Besides, beetroot also showed drought tolerance as all treatments based on the sensor with non-saline and saline water applied help to save amounts of water without yield loss.

Both greenhouse and field trials showed a significant decrease in water use (Table 1 and 2) compared to continuous (conventional) irrigation of farmers in the VMD without yield loss. Likely, the Mkoba and Silalatshani farmers in the 2016/17 season reduced 37% and 34% of the amount of irrigation water with the Chameleon compared to the last season (Moyo et al., 2020b). For reducing salt accumulation in soil, treatments irrigated based on the sensor experienced the significant lower exchangeable sodium and ESP value compared to that of continuous irrigation treatments in the field trial.

Conclusion

Beetroot could grow well under the conditions of lack of irrigation water and saline affected at salinity of 1 g L-1. With the high economic value ($2) compared to rice ($0.4), beetroot is a potential upland crop option for the VMD farmers. However, their saline tolerance needs to be tested with higher levels of salinity.

Irrigation based on Chameleon with and without saline water on cultivating beetroot help to save the amount of irrigation water and reduce the salt accumulation in soil. The use of the Chameleon worked effectively to establish the irrigation schedule and farmers following the schedule can have more free time for different job or spend time with their families. The combination of beetroot and the Chameleon can provide more options for local farmers to earn profit instead of fallow.

Acknowledgments

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Links

References

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