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Potential of sweet sorghum (*Sorghum bicolor* L.) cultivars under different water regimes for some agronomic performances, juice yield and related traits

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Abstract

Continued evaluation for drought tolerance on crops with high potential is an important factor in mitigating the effects of climate change and in the long run secure enough food and alleviate world hunger. Sweet sorghum is one of the multifunctional crops which has shown potential as food, industrial and bioenergy source, thus it is important to study its potential under various conditions. A pot study was conducted in early rainy season (March-August 2020), the experiment was arranged 3 × 2 factorial in RCBD with four replications. Factor A was 3 water regimes (FC, 2/3AW and 1/3AW), factor B was two sweet sorghum cultivars [cv. Suwan Sweet Extra (Thai sweet sorghum) and SSV74 (imported from India)]. The results revealed that significant differences were not observed among water regimes in most traits i.e. plant height, stalk diameter, relative water content (RWC), stalk fresh weight and juice yield in harvesting day. This could suggest that sweet sorghum will perform well in any moisture condition, most importantly in lesser moisture environments. Significant differences were observed among sweet sorghum cultivars in several traits i.e. spad chlorophyll meter reading (SCMR), chlorophyll content, brix value, root dry weight, juice yield and R/S ration at harvesting day. Relationship among traits were also observed but the most interesting results was where we found juice yield having negative correlation to brix value (r=-0.736***) and another no correlation was observed between stalk weight and juice.

Keywords: water regimes, drought stress, relative water content, R/S ratio.
Abbreviations: FC_field capacity; AW_available soil water; PWP_permanent Wilting Point; SCMR_spad chlorophyll meter reading; OM_organic matter; EC_electrical conductivity; RCBD_randomized complete block design; DAP_days after planting; R/S ratio_root shoot ratio; SG_specific gravity; D_density; M_mass; V_volume;

Introduction

One of the major challenges that comes with climate change is the water scarcity that adversely affect plant growth and development. The major effect of climate change will come from the CO_2 emissions and rainfall which do have negative effect on crop production in both long and short periods (Arona 2019; Chandio et al., 2020). The unreliable and decreasing rainfalls has led to water scarcity resulting in drought which negatively impacts the plant growth metabolism thus having effect on crop productivity especially in rainfed production areas (Fracassoa et al., 2016; Shikwambana et al., 2021). Several strategies have been touted means to mitigate against effects of climate change with use of resilient varieties as a leading potential solution to climate change (Etten et al., 2019; Pareek et al., 2020; Diallo et al., 2020). Sweet sorghum (*Sorghum bicolor* L. Moench) is one of the promising crops belonging to Poaceae family, which is closely associated with sugarcane. It is a close relative to grain sorghum as it produces grain production (but not widely consumed due to palatability) and it is also associated with sugarcane for its sugar-rich stalk and high sugar accumulation (16 to 23 brix) (Rao Dayakar et al., 2004). The important trait of this crop as compared to other bioenergy crops is that it can be grown in semi-arid and arid conditions with good water use efficiency (WUE) and nitrogen use efficiency (NUE) (Rao et al., 2013; Pennington, 2020). Just like grain sorghum it can be cultivated for its grain which is then used as animal feed, but sweet sorghum is a dual-purpose crop as it has potential to accumulate a good amount of soluble sugar in its stem (Lopez-Sandin et al., 2021). Its adaptability to wide range of conditions coupled with its production of soluble sugars thus makes it a good candidate crop for bioenergy production (Marthur et al., 2017; Tang et al., 2018). The depletion of oil reserves, increasing greenhouse gases and very volatile prices of fuel has led to evaluation of potential bioenergy crops like the sweet sorghum (Almodares et al., 2013; Rao et al., 2019). Even though the crop has shown good potential as a dual crop, interested in mass production is still at its limited pace as compared to other cash crops like cotton and sunflower even though it has shown a better return to scale on investment compared to this crop (Liu et al., 2014). Although, sweet sorghum has shown more potential and it is widely cultivated in countries such as USA, China and India, in contrast, Thailand still produces the sweet sorghum as a miscellaneous crop. Thailand is still highly dependent of sugarcane as a bioenergy crop even though the crop is highly demanding as compared to sweet sorghum. With the bio-ethanol and bioenergy industry in Thailand expected grow significantly with promising prospects (Wattana, 2014; Wang et al., 2021), it is thus critical to consider sweet sorghum as a feed stock for the industry because of dual purpose and also the crops efficiency in water and nutrients. Several cultivars have been developed for planting in various specific environments of Thailand (Bunphan et al., 2014: Bunphan et al., 2015). The importance of evaluating these cultivars alongside foreign cultivars for performance under the Thailand environment is critical selecting suitable cultivars that will easily be adopted and cultivated by Thai farmers. Therefore, the aim of this research was to evaluate the effect of different water regimes on agronomic traits, juice yield and yield related traits of local and imported cultivar sweet sorghum.

Result and discussion

Plant height

The results of our study shows that plant height was not affected by water regimes at all growth stages except 90 DAP, where 1/3AW gave significantly shorter height than the two other water regimes (Fig. 1). This result was in line with Mwamahonje et al. (2021) who found that plant height was not influenced by water regime, whereas, Devnarain et al. (2016) reported that drought stress had no effect on plant height but different cultivars has affected on plant height in theirs research. However, our results were in contrast to Alhajturki et al. (2012) who observed that low moisture had an effect on plant height. Further, Upadhyaya et al. (2014); Almodares et al. (2013); Sher et al. (2015); Gano et al. (2021); Nazari et al. (2021) reported that plant height of sorghum was greatly influenced by water regime, where well-watered plants recorded higher plant height than less watered plants, with Widiyono et al. (2020) reporting that plant height of some sorghum accessions under water stress were reduced. In our study, the results further shows that there was no significant differences in plant height as influenced by cultivar at all growth stage except at 75 and 120 DAP (Fig. 2) and this was in contrary to Alhajturki et al. (2012) who reported that they observed significance differences on plant height when evaluating sweet sorghum cultivars, whereas Almodares et al. (2013) results were in agreement with ours as they did not find any interaction between water regime and cultivar influence on plant height.

Stalk diameter

No significant differences were observed on stalk diameter at all growth stages (30, 60, 90 and 120 DAP), similarly water regimes and cultivars did not show any significant difference on stalk diameter (data not shown) in this study, contrastingly Almodares et al. (2013); Alhajturki et al. (2012) reported that stalk diameter was affected by water regime. Whereas Nazari et al. (2021) found out that significant differences were observed between irrigation regimes for stalk diameter and other traits, normal irrigation showed highest stalk diameter than mild and severe deficit irrigation. However, we found an interaction between water regimes and cultivar at harvesting day (120 DAP) for the stalk diameter (Table 1).

***SCMR** (SPAD chlorophyll meter reading)*

Highly significant differences were observed at all data collection dates except for 45 DAP and 75 DAP where significant and non-significant differences were observed respectively. The 1/3AW showed the highest SCMR values at 30, 60, 90 and 105 DAP, however at 45 DAP, the FC recorded the highest SCMR values than other water regimes (Table 2), similar to Aranyanark et al. (2009) who observed the effect of water regimes on SCMR value in peanut at 20 and 40 DAE (days after emergence) where 1/3AW showed higher SCMR than FC and 2/3AW, but did not observe any differences in SCMR value at 60 DAE. In our recent study, we found that the SCMR at 75 DAP did not have any significant differences among water regimes (Table 2) in contrast, Upadhyaya et al. (2014) reported that SCMR was not affected by water stress or drought condition. Furthermore, Gowsiga et al. (2021) found that drought stress decreased SCMR value (9.5%) when compared to irrigated control. In case of sugarcane Jangpromma et al. (2010) reported that SCMR was affected by drought in at 100 DAT but was not affected on 90 and 110 DAT and drought stress gave a lower SCMR than FC, this result was different to ours. The SCMR values recorded high significant differences among sweet sorghum cultivars at all stages except 90 DAP. We found that cv. Suwan Sweet Extra recorded a higher SCMR values at all growth stages (Fig. 3). No interaction between water regime and sweet sorghum cultivar was found for SCMR in this research (data not shown), likewise Arunyanark et al. (2009) reported that no interaction between water regime and cultivar was found in peanut growth, however these results are in contrast to Jangpromma et al. (2010) who found the interaction between water regime and sugarcane varieties.

Chlorophyll content

Chlorophyll content had significant differences for both water regimes and sweet sorghum cultivars except at 30 and 90 DAP. We found the sweet sorghum grown under 1/3 available water (1/3AW) to have higher chlorophyll content as compared to other water regimes (2/3 AW and FC). Moreover, we found out that 1/3AW had the highest chlorophyll content at 75 DAP as compared to other growth stages (19.44 ug cm^{-2}), and FC had the lowest chlorophyll content at all stage except 30 and 90 DAP (Fig. 4), but our results differed with previous reports that found a significant reduction in chlorophyll content in sorghum grown under water stress (Reddy et al., 2014; Fracasso et al., 2016; Fadoul et al., 2018; Amoah and Antwi-Berko, 2020, Ayalew et al., 2018), Devnarain et al. (2016) found that drought stress has decreased total chlorophyll content when compared to well-watered, however the chlorophyll content recovered well after re-watering (well-watered), Takele (2010) found that chlorophyll content in pre-and post-flowering drought-tolerance sorghum were reduced during dehydration and chlorophyll content in water stress pre-flowering sorghum recovered following re-watering while no recovery was observed on post-flowering sorghum. Moreover, Mwamahonje et al. (2021) observed that water regime did not affect the chlorophyll content. The two sweet sorghum cultivars recorded varying chlorophyll content at all stages except at 90 DAP (Fig. 5). Sweet sorghum cv. Suwan Sweet Extra had higher chlorophyll content as compared to cv. SSV74 at all stage except at 90 DAP where there was no significant difference in chlorophyll content. It was observed that at 75 DAP the chlorophyll content was at its peak for both the cultivars under study. The chlorophyll content had an increasing trend from early growth stages until reached its peak at 75DAP and thereafter it showed a downward trend until the last stage of data collection (Fig. 5). In the current study there was no significant interaction observed between cultivar and water regime but contrarily Jangpromma et al. (2010) observed a strong interaction between water regime and sugarcane varieties for the chlorophyll content.

Relative water content (RWC)

Results of our study shows that water regimes did not have any effect on RWC for all the growth stages (Fig. 6), contrasting results were observed by Sher et al. (2015) who reported that RWC of sorghum under low water supply was lower than that of plants in high water supply, whereas Alayew et al. (2018) observed significant differences among the genotypes for leaf RWC under the two water regimes, all the genotypes showed a reduced RWC in low moisture crops. In our study, RWC did not record significant differences among cultivars except at 60 and 90 DAP (Fig. 7) closely similar to Sher et al. (2015) who reported that RWC did not differ among cultivars. There was no significant interaction on this trait in our current study, which was similar to previous study by Sher et al. (2015) whereas Devnarain et al. (2016) observed that leaf water content (LWC) of sorghum genotypes was not significantly different between control and drought stress, and LWC ranged between 85-88% during mild stress, 82-86% during severe stress.

Brix value

The result revealed that brix value at 75 DAP was not significantly different both in water regimes and among cultivars, whereas brix value recorded at harvesting day, showed significantly different results both in various water regimes and among cultivars. At harvesting day, 2/3AW had the highest brix value but it was not significantly different from FC (15.8 and 14.4 brix, respectively) and 1/3AW showed the lowest brix value which was significantly different from the other two water regimes (Fig. 8), this was in contrast to Upadhyaya et al. (2014) and Alhajturki et al. (2012) who found out that plants under lower water regimes recorded higher brix value than well-watered plants. Moreover, Vasilakoglou et al. (2011) and Miller and Ottman (2010) reported that the brix value was not affected by irrigation water supply, whereas, Tovignan et al. (2020) observed that total soluble sugars of sweet sorghum in maturity stage were not affected by drought in both years but sucrose was significantly affected by drought. Between the cultivars, the Thai sweet sorghum cultivar recorded a higher brix value than imported cultivar (17.2 and 11.1 brix, respectively) (Fig. 9), this is supported by Tovignan et al. (2020) who reported that various sweet sorghum cultivars had different on total soluble sugars. However, interaction between water regime and cultivar in this trait at 75 and harvesting day was not significant (data not show).

Stalk fresh weight

The result of a current study revealed that, stalk fresh weight had no significant differences both at 75 DAP and harvesting day, the water regimes and cultivars did not show any significant differences on stalk fresh weight (Fig. 10 and 11), and no significant interaction was found in recent study. In contrast to previous studies, a higher stalk yield was observed in well-watered crops than in lowly watered crops (Alhajturki et al., 2012; Almodares et al., 2013; Vasilakoglou et al., 2011; Ayalew et al., 2018; Nazari et al., 2021).

Stalk dry weigh

The result revealed that stalk dry weight was not influenced either by water regimes or cultivars at 75 DAP, this was in disagreement with Sher et al. (2015) who found that water regime had effect on total dry weight at 73 DAP. However, at harvesting day, we found that stalk dry weight had significant differences among water regimes, where FC and 2/3AW showed a higher stalk dry weight than 1/3AW (56.28, 53.14 and 41.85 g pl^{-1} respectively), similarly Vasilakoglou et al. (2011); Gano et al. (2021); Nazari et al. (2021) and Sher et al. (2015) reported that higher moisture resulted in higher stalk yield as compared to lower moisture. In the current report, cultivars did not have any influence on the stalk dry weight.

Root dry weight

The result revealed that the water regime and cultivar had effect on root dry weight at 75 DAP and harvesting day. Notably, a significant interaction between water regime and cultivar was also observed for this trait. At 75 DAP under FC, root dry weight had the highest weight as compared to other water regimes (13.82 g pl^{-1}) whereas 2/3 and 1/3AW root dry weight was not significantly different. At harvesting day, FC and 2/3AW recorded almost double the root dry weight as compared to 1/3AW (Fig. 12). At 75 DAP cv. SSV74 recorded a higher root dry weight compared to Thai sweet sorghum, but at harvesting day Thai sweet sorghum root weight surpassed that of the cv. SSV74 almost two times (75.74 and 39.72 g pl^{-1} respectively) (Fig. 13). Contrary to our results, Mwamahonje et al. (2021) reported that root biomass was not affected by water regime but cultivar had a more significant influence on root biomass. Interaction between water regime and cultivar was found on this trait as shown in Table 3. A combination of FC and cv. SSV74 showed the highest root dry weight both at 75 DAP and harvesting day (20.97 and 90.89 g pl^{-1} respectively) whereas, interesting result were observed at 75DAP for the cv. Suwan sweet extra where lower root weight was observed at FC as compared to the other two water regime, this could suggest that high moisture suppresses root growth in this cultivar and it strives much better in low moisture. This is interesting as this could be an important trait for drought tolerance in this cultivar.

Table 1. Stalk diameter at harvesting day of two sweet sorghum at vary water regimes.

Water regimes	Cultivar	Stalk diameter (mm)
FC	Suwan Sweet Extra	19.09b
	SSV74	24.97a
2/3AW	Suwan Sweet Extra	22.49ab
	SSV74	20.13b
1/3AW	Suwan Sweet Extra	21.72ab
	SSV74	21.80ab
F-test		*
LSD		4.27
CV (%)		13.07

*significant different at p≤0.05.

Table 2. SCMR value of sweet sorghum on different water regimes.

Water regimes	SCMR (unit)					
	30DAP	45DAP	60DAP	75DAP	90DAP	105DAP
FC	30.74b	39.34a	40.86b	42.55	40.81c	37.68b
2/3AW	28.60c	38.81a	41.39b	41.44	45.49b	46.75a
1/3AW	33.99a	36.50b	44.88a	40.85	49.71a	45.36a
F-test	**	*	**	ns	**	**
LSD	1.56	2.21	1.99	-	2.91	4.95
CV (%)	4.69	5.42	4.39	5.17	6.02	10.73

Ns: not significant, * and ** significant different at p ≤0.05 and ≤0.01, respectively.

Table 3. Root dry weight of sweet sorghum under different water regimes at 75 DAP and harvesting day

Water regimes	Cultivar	75DAP	at harvesting day
		g pl^{-1}	
FC	Suwan Sweet Extra	6.68d	43.45b
	SSV74	20.97a	90.89a
2/3AW	Suwan Sweet Extra	12.21b	42.40b
	SSV74	7.56cd	91.70a
1/3AW	Suwan Sweet Extra	10.85bc	33.32b
	SSV74	8.21cd	44.64b
F-test		**	*
LSD		3.89	19.44
CV (%)		23.28	22.34

* and ** significant different at p ≤0.05 and ≤0.01, respectively.

Table 4. Interaction between water regime and sweet sorghum cultivar of juice yield, juice weight and SG.

Water regimes	Cultivar	Juice yield	Juice weight	SG
		g pl-1		
FC	Suwan Sweet Extra	8.13c	8.31c	1.018cd
	SSV74	36.73b	37.64b	1.027bc
2/3AW	Suwan Sweet Extra	32.90b	34.31b	1.045ab
	SSV74	34.83b	34.70b	1.001cd
1/3AW	Suwan Sweet Extra	24.03b	25.27b	1.054a
	SSV74	64.73a	64.72a	0.999d
F-test		**	**	**
LSD		13.38	13.31	0.027
CV (%)		26.44	25.86	1.72

** significant different at p ≤0.01, respectively.

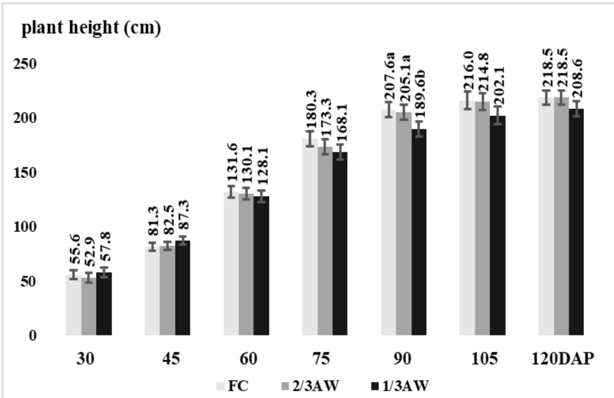

Fig 1. Plant height of sweet sorghum on the different water regimes.

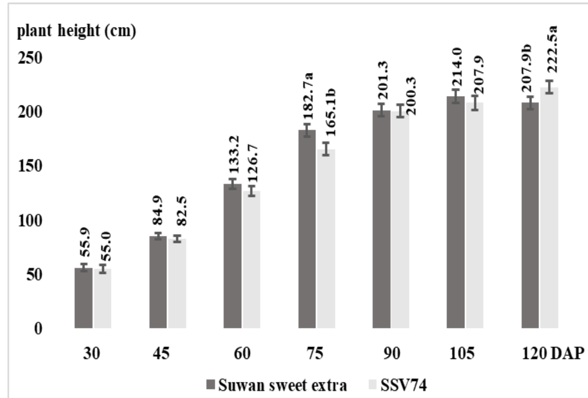

Fig 2. Plant height of two sweet sorghum cultivar at vary stages.

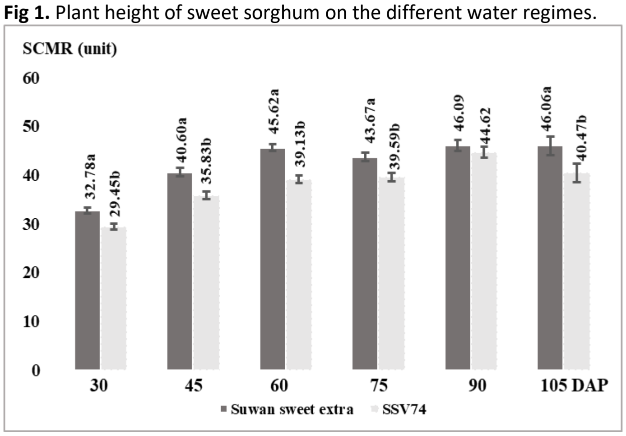

Fig 3. SCMR values of two sweet sorghum in different stages under three water regimes.

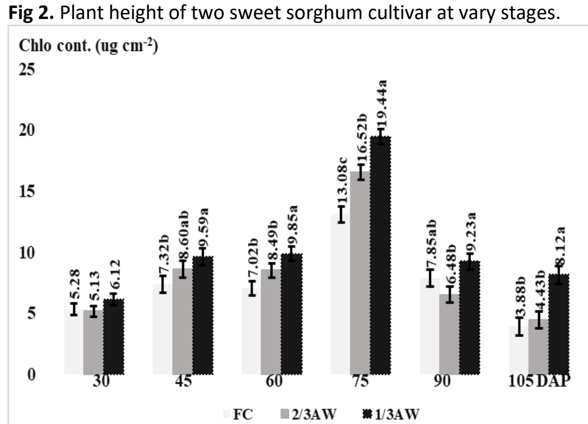

Fig 4. Chlorophyll content of sweet sorghum in different water regimes.

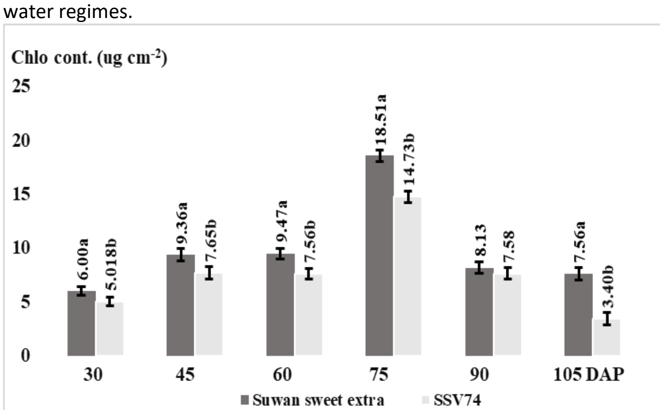

Fig 5. Chlorophyll content of two sweet sorghum in different stages.

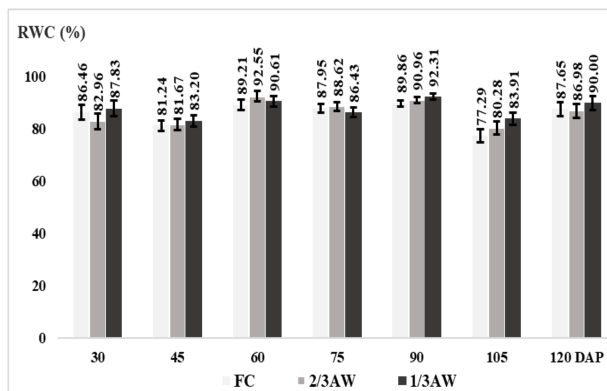

Fig 6. RWC of sweet sorghum in different water regimes at different stages.

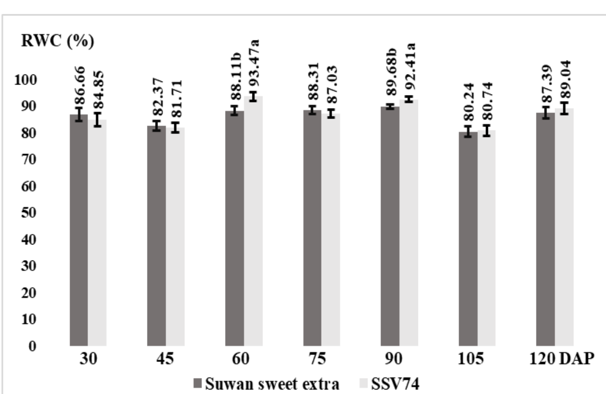

Fig 7. RWC of two sweet sorghum cultivars at different stages.

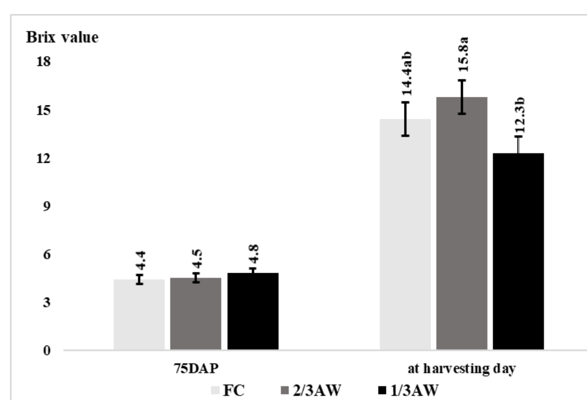

Fig 8. Brix value at 75 DAP and harvesting day under different water regimes.

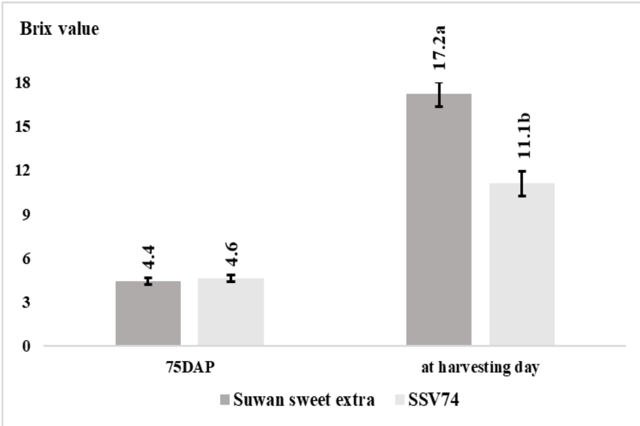

Fig 9. Brix value at 75 DAP and harvesting day of two sweet sorghum cultivars.

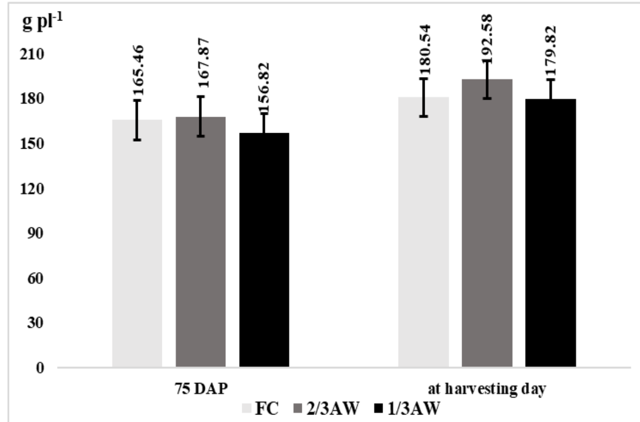

Fig 10. Stalk fresh weight of sweet sorghum under different water regimes.

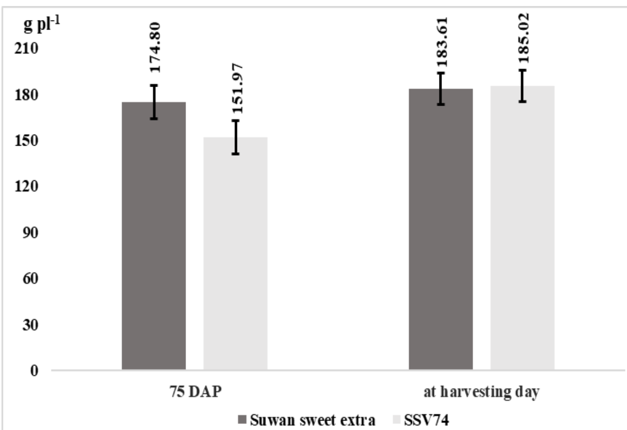

Fig 11. Stalk fresh weight of two sweet sorghum cultivars at 75 DAP and harvesting day.

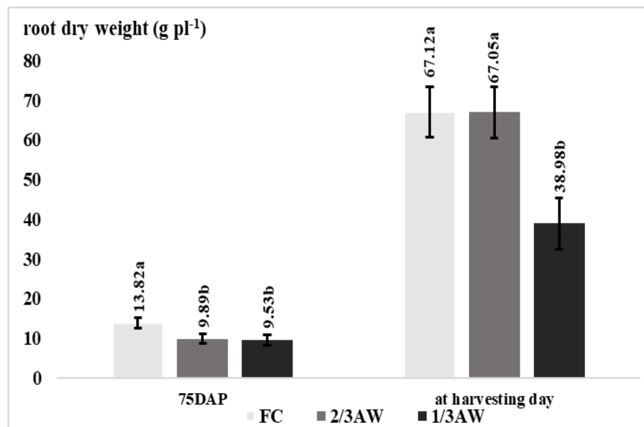

Fig 12. Root dry weight of sweet sorghum under various water regimes.

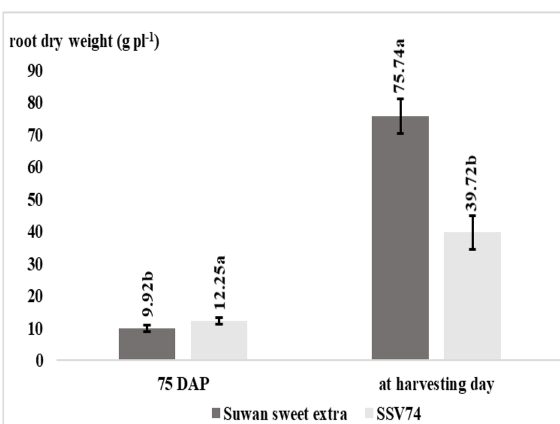

Fig 13. Root dry weight of sweet sorghum under various water regimes.

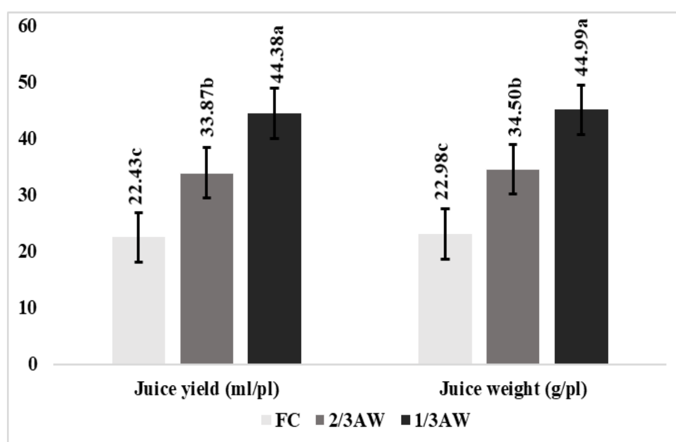

Fig 14. Juice yield and juice weight of sweet sorghum under vary water regimes.

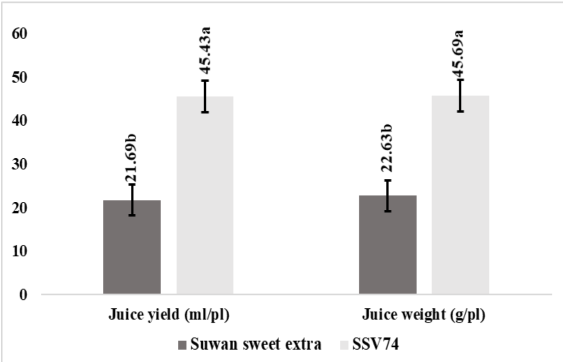

Fig 15. Juice yield and juice weight of two sweet sorghum.

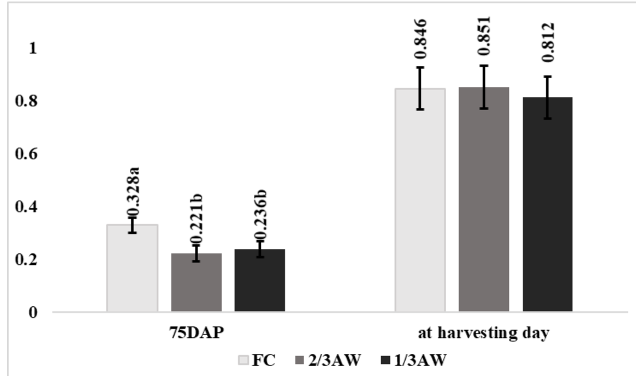

Fig 16. R/S ration of sweet sorghum under various water regimes.

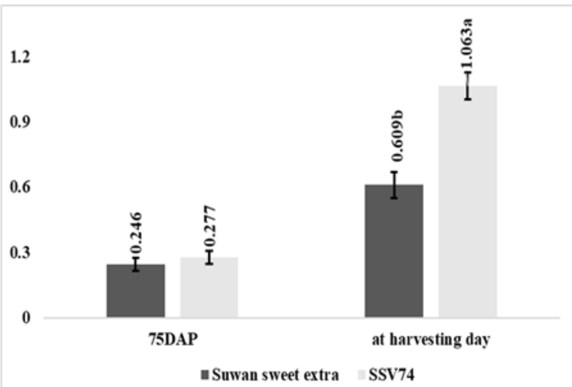

Fig 17. R/S ratio of two sweet sorghum cultivar at 75 DAP and harvesting day.

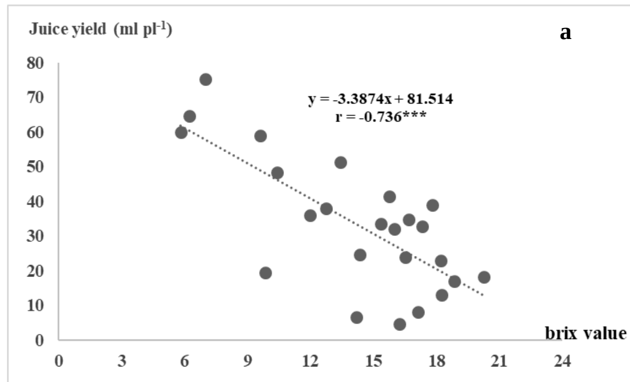

Fig 18. (a) Relationship between juice yield and brix value of sweet Sorghum.

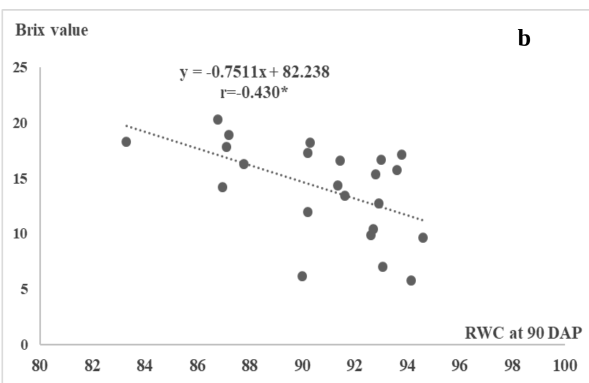

Fig 18. (b) Relationship between brix value and RWC at 90 DAP of sweet sorghum.

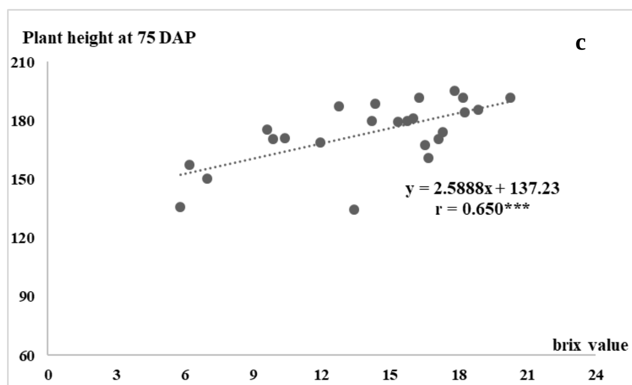

Fig 18. (c) Relationship between plant height and brix value of sweet sorghum.

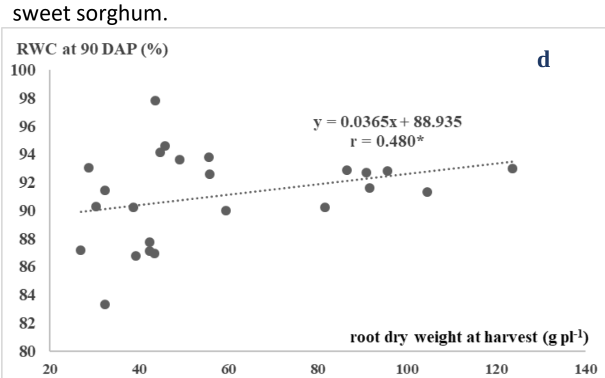

Fig 18. (d) Relationship between RWC and root dry weight of sweet sorghum.

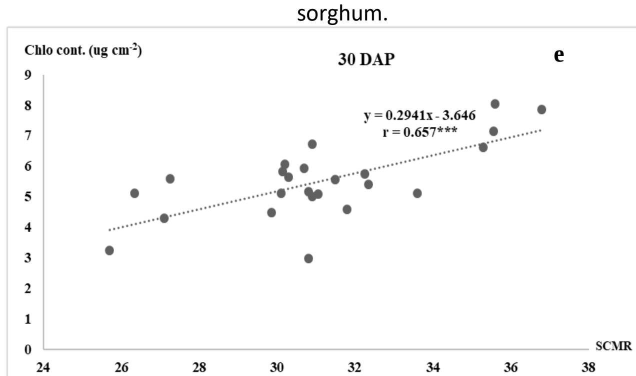

Fig 18. (e) Relationship between chlorophyll content and SCMR at 30 DAP of sweet sorghum.

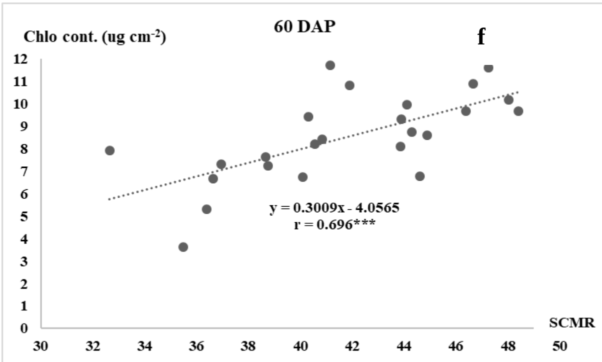

Fig 18. (f) Relationship between chlorophyll content and SCMR at 60 DAP of sweet sorghum.

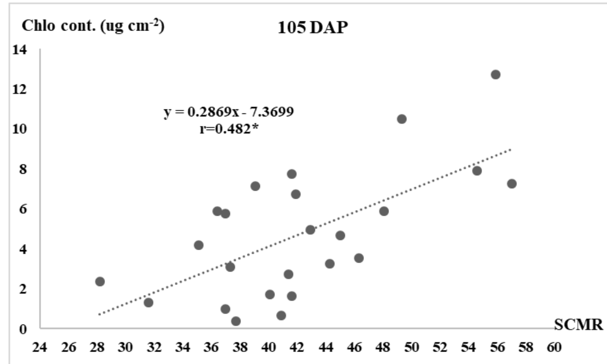

Fig 18. (g) Relationship between chlorophyll content and SCMR at 105 DAP of sweet sorghum.

Juice yield, Juice weight and SG (specific gravity)

Water regimes had an effect on both juice yield and weight of sweet sorghum, as 1/3AW gave the highest juice yield and weight (44.38 ml pl^{-1} and 44.99 g pl^{-1} respectively), whereas the lowest juice yield and weight were observed in FC (Fig. 14), our results disagreed with Vasilakoglou et at. (2011) and Alhajturki et al. (2012) who observed that juice yield was higher in high moisture regime as compared to lower moisture regime. Our results were in contrast with Tovignan et al. (2020) found that post-flowering drought has no effect on juice eight at maturity both in 2013 and 2014 as compared to well-watered. Considering cultivar effect, we found that cv. SSV74 recorded two times higher juice yield and weight than Thai sweet sorghum. Further Thai sweet sorghum had higher SG than cv. SSV74 (1.039 and 1.009 respectively) (data not shown), this result was supported by brix value (brix value of cv. Suwan Sweet Extra had higher than cv. SSV74), this is so because brix value is highly correlated to SG.

The interaction for juice yield and weight and SG was also analyzed (Table 4). The 1/3AW and cv. SSV74 showed the highest juice yield and weight (64.73 ml pl^{-1} and 64.72 g pl^{-1} respectively), whereas FC and cv. Suwan Sweet Extra had the lowest juice yield in our study (8.13 ml pl^{-1} and 8.31 g pl^{-1}). For SG, we found that 1/3AW and cv. Suwan Sweet Extra showed higher SG that other combinations but was not significantly different from 2/3AW and Suwan Sweet Extra. Our results showed that cv. SSV74 with all water regime gave a lower SG than Thai sweet sorghum cultivar.

Root shoot ration (R/S ratio)

The recent study revealed that water regime affected S/R ratio only at 75 DAP, whereas two sweet sorghum cultivar showed no significant differences in this trait at harvesting day (Fig. 16). Our results were in agreement with Wang et al. (2016) who reported that the R/S ratios were not significantly affected by moisture treatment. The cultivar effect showed no significant difference at 75 DAP but at harvesting day the cv. Suwan Sweet Extra had higher R/S ratio than cv. SSV74 (1.063 and 0.609 respectively) (Fig. 17).

Relationship between some agronomic traits of sweet sorghum related to yield and juice

In this study we found out brix value at harvesting day had strong negative correlation to juice yield (r=-0.736***) (Fig. 18 a) similar to Alhajturki et al. (2012) who reported that brix in low moisture stress had negatively correlated to juice yield (r=-0.54**), and also had negative correlation to RWC at 90 DAP (r=-0.430*) (Fig. 18b). However, brix value had a moderately positive correlation to plant height at 75 DAP (r=0.650***) (Fig. 18 c) but no correlation on plant height to brix value at harvesting day was observed, this was in agreement with Codesido et al. (2013), Alhajturki et al. (2012) and Tovignan et al. (2016) who reported that brix value had no correlation with plant height. We also found moderate association between root dry weight at harvest and RWC at 90 DAP (r=0.480*) (Fig. 18 d). The most surprising result that we found in this study, was the no association observed between stalk weight and juice yield. This was surprising because stalk weight is a factor of juice yield as observed in various studies (Calvaho and Rooney, 2017; Alhajturki et al., 2012). Correlations between SCMR and chlorophyll content were observed in this study (Fig. 18 e and f) as also observed in other previous studies (Jangpromma et al., 2010, Bunphan et al., 2018).

Materials and Methods

The experiment was conducted under pot condition in Udonthani province, Thailand. A study was done between March to August year 2020. The study was conducted under a rain-out shed so as to control moisture to the plants during rainy season.

Plant materials

Two pure lines of sweet sorghum were used in the experiment; cv. Suwan Sweet Extra which was kindly donated from National Corn and Sorghum Research Center, Nakhon Ratchasima Thailand and cv. SSV74 which was imported from India by Faculty of Agriculture, Khon Kaen University.

Experimental design and treatments

The experiment was arranged in 3 × 2 factorial in RCBD with four replications. Factor A was three water regimes (field capacity; FC, 2/3 available soil water and 1/3 available water); a1= FC, a2= 2/3AW and a3= 1/3AW) and two sweet sorghum cultivars were used as factor B (b1= Suwan Sweet Extra and b2= SSV74). The soil texture used was classified as sandy with low fertility (data not shown), with good drainage capacity.

The dimensions of the pot were 20 × 28 cm (D × H), each pot contained 10.0 kg of soil.

Water application

All the experimental units were watered consistency from first 15 days after planting (DAP), thereafter the water regimes were initiated as described above.

Soil properties analysis

The chemical content was analyzed on soil samples from the 0-20 cm layer from a field where the pot culture soil was collected. The soil pH was 6.4, the EC value was 0.04 ds/m. Organic matter (OM) was 0.41% (very low), total nitrogen (N) was very low (0.02%), phosphorus (P) was low (10 mg kg^{-1}), potassium (K) was very low (7 mg kg^{-1}). Soil moisture content at FC and permanent wilting point (PWP) were determined at 21.27 and 1.99% respectively (data not show).

Agricultural meteorology

Average temperature ranged between 25.3-35.2 ºC, average humidity was 75 %, total rainfall was 904.5 mm were recorded in the experimental months (data not show).

Agronomic practices

The sweet sorghum seeds were planted into the pot with basal fertilizer (formula 15-15-15) applied at a rate of 156.25 kg ha^{-1}. After 14-15 days after planting (DAP), the seedlings were thinned to one plant per pot, and at 30 DAP, the chemical fertilizer at the same rate and formula was applied. Irrigation was performed every two days from 0 to 15 DAP and weeds were removed manually by hands.

Data collection

Two plants from each experimental plot were selected for data collection. The plants growth parameters (plant height and stalk diameter) were collected interval 15 days at 30, 45, 60, 75, 90, 105, 120 DAP (at harvest day). Relative water content (%) (RWC) was recorded 15 days interval at 30, 45, 60, 75, 90, 105, 120 DAP, RWC was as follow (Turner, 1986):

$$\text{RWC (\%)} = \frac{leaf\ fresh\ weight - leaf\ dry\ weight}{\text{turgid weight} - leaf\ dry\ weight}$$

Stalk fresh weight (g pl^{-1}) were recorded at 75 DAP and harvesting day. Stalk dry weight and root dry weight (g pl^{-1}) were collected at 75 DAP and harvesting day, then oven dried at 60 ºC for 72 hr (or until constant dry weight) then the mass was collected and results used for root shoot ratio (R/S ratio). The brix value was recorded at harvesting day by using hand refractometer.

SCMR was measured interval 15 days at 30, 45, 60, 75, 90, 105 DAP using SPAD-502 meter (Minolta SPAD-502 meter, Tokyo, Japan) and the chlorophyll content in leaves was measured following Moran (1982) briefly, a small leaf disc was cut using 1 cm^2 cork border, then placed in a vial containing 5 ml DMF (N, N-dimethyl formamide) and incubated in 4 °C for 24 h in dark. The chlorophyll extract was measured at 647 and 664 nm by a spectrophotometer. The equations to calculate for total chlorophyll, chlorophyll a (Chl a) and b (Chl b) were as follows:

Total Chl = Chla + Chlb

Chla = 12.64(A664) – 2.99(A647)

Chlb = -5.6(A664) + 23.24(A647)

Data analysis

All data recorded was analyzed using Statistix 10. An ANOVA (analysis of variance) was exercised to verify the overall significance of data. The least significance difference (LSD) test was employed to compare the means at 5% probability level (Steel and Torrie, 1960). The association of some traits were also analyzed by using Statistix 10.

Conclusion

From our observed results we can conclude that moisture have no major effect on some agronomic traits of sweet sorghum i.e. plant height (except at 90 DAP), stalk diameter (except at 75 DAP and harvesting day) RWC and R/S ratio at harvesting day, stalk fresh weight of sweet sorghum as this did not show any significant difference under different water regimes. However, water regimes did affect SCMR, chlorophyll content, brix value at harvesting day, root dry weight, juice yield, juice weight and R/S ration at 75 DAP. The association of some traits was unexpected results i.e., brix value had negative relation to juice yield and also stalk weight was not associated with juice yield. Therefore, because of many contrasting results of the present study we suggest a further study or repeat to ascertain the current results of water regimes in sweet sorghum.

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