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Effects of Drought and Salinity on Growth, Yield and Nutritional Contents of Cowpea Bean (*Vigna marina*)

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ABSTRACT

Background: The study was carried out to determine the duration of drought and salinity level on growth, green matter yield and nutrient content in cowpea bean plants.

Methods: The experiment was arranged in a 2-factor factorial style, including (A) three drought levels: (i) 07 days of watering, (ii) 14 days of irrigation and (iii) 21 days of watering cessation; factor (B) three salinity levels including (i) saline irrigation 2‰, (ii) saline irrigation 4‰ and (iii) saline irrigation 6‰. Each treatment has five replicates.

Result: Experimental results showed that stopping irrigation of cowpea bean plants for 14 and 21 days reduced height, SPAD index, stomatal opening, DM, CP and ash content, compared to stopping watering for seven days. It reduced the yield of green matter and the nitrogen content in the plant. Besides, increasing salinity irrigation concentration at four and 6‰ declined the height, SPAD index, stomatal opening, DM, EE and CP of cowpea bean. The green matter yield and nitrogen content in the plants also decreased when irrigated with salinity 6‰.

Key words: Drought, Goat feed, Nutritional content, Salinity, *Vigna marina* beans.

INTRODUCTION

According to Asadova (2021), significant areas are periodically susceptible to drought due to the warming trend in the climate in recent years. Therefore, expanding the area where drought-resistant leguminous crops are grown is necessary. Cowpea bean (*Vigna marina*) is a plant species in the legume family in the Vigna section of the subgenus cowpea bean that grows naturally throughout the tropics and ranks among the widely distributed flowering plants. Otherwise, cowpea is a multipurpose food legume of the tropics and a crucial nutrition source (Tripathi *et al*., 2019). It is occasionally grown as a cover crop and for improving soil fertilizing (Aiosa *et al*., 2019).

Several researchers have evaluated the impact of drought on growth indices and the quality of forage crops. Nohong and Nompo (2015) reported that prolonged drought reduced plant height and dry matter yield of elephant grass. Besides, Abid *et al.* (2016) indicated that alfalfa's leaves, shoots and roots were significantly reduced under severe stress. Cowpea bean is believed to have a strong tolerance to salt and drought. Hence it should be researched and grown in saline and drought-prone regions to supply fodder for animals. Therefore, the study was carried out to determine the duration of drought and the salinity level of growth, green matter yield and nutrient content in the *Vigna marina.*

MATERIALS AND METHODS

The study was conducted at the Experimental Farm of Can Tho University, Vietnam, from November 2021 to June 2022. Seeds of cowpea bean (*Vigna marina*) were kept in the Department Labortary. The characteristics of soil were pH_{H_2O} (5.44); pH_{KCl} (5.13); EC (4.2 mS/cm), CEC (11.84 meq.100 g^{-1}); NH_4^+ (29.52 mgNH_4^+ kg^{-1}); NO_3^- (11.86 mg NO_3^- kg^{-1}), available P (154.98 mg kg^{-1}). The plastic pot had dimensions of 32 × 27 cm.

The experiment was arranged in a 2-factor factorial style, including (A) three drought levels including (i) 07 days of watering, (ii) 14 days of irrigation and (iii) 21 days of watering cessation; factor (B) three levels of salinity including (i) saline irrigation 2‰, (ii) saline irrigation 4‰ and (iii) saline irrigation 6‰. Each treatment has five replicates.

The soil was dried in the air, removing weeds and straw, then weighted 10 kg of soil was for each pot. 02 seeds were sown in each pot. When the plant had grown then pruned to 01 plant. Cowpea beans were treated with drought by stopping freshwater irrigation at 30 days after sowing and extending it in turn with periods of (i) stopping freshwater irrigation for 07 days and after 07 days, starting irrigating saline water with concentrations of 2‰, 4‰, 6‰ lasting 07

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days; (ii) stop irrigation for 14 days, after 14 days of saline irrigation with concentrations of 2‰, 4, 6 lasting 07 days and (iii) stop irrigation for 21 days, after 21 days of saline irrigation with concentrations of 2‰, 4‰, 6‰ last 07 days. Each time irrigated with salt 100 ml, irrigated once a day. After the treatment period of drought, saline water irrigation was back to normal.

Data collection

Plant height (cm), SPAD index and stomatal opening (mmol/ m^2 /s) were collected 60 days after sowing. Green matter yield (g/pot) at 120 days after planting. Dry matter (D.M.) was determined by drying the sample at 105°C for 12 h, using the AOAC method (1990). Crude protein (C.P.) was the determination of crude protein by the Kjeldahl method (N*6.25). Neutral fiber (NDF) and acid fiber (ADF) were determined by the method of Van Soest and Robertson (1985). Crude fat (E.E.) was determined by the anhydrous ether extraction method (Thiex *et al*., 2003). Finally, the total mineral (ASH) was determined by heating the sample at 550°C for 3 hours.

Data analysis

Collected data were analyzed for variance using SPSS software version 13.0 to compare mean values by the Duncan test at a 5% significance level.

RESULTS AND DISCUSSION

Effect of drought, salinity on the height, SPAD index and stomatal opening

The height of cowpea beans 7, 14 and 21 days of treatments was statistically different at a 5% significance level (Table 1). Plant height was ranked in descending order when the time of stopping watering increased with a plant height of 166.40, respectively; 158.93 and 156.37 cm for the treatments of stopping watering 7, 14 and 21. Irrigation with salinity concentrations of 2, 4 and 6‰ had a statistically significant difference in plant height at 5% (Table 1). The salinity irrigation treatment at the concentration of 6‰ resulted in a plant height of 156.57 cm lower than the saline irrigation at the concentration of 4‰ (159.93 cm). The salinity irrigation at 2‰ had a plant height of 165.20 cm.

The SPAD index of cowpea leaves between treatments with salinity concentrations of 2, 4 and 6‰ was not statistically significant and ranged from 44.13 to 45.97 (Table 1). Research results of Septiana and Analuddin (2019) when treating 200 mM and 400 mM of NaCl salt did not affect the chlorophyll content of cowpea beans. Stopping irrigation for 21 days of treatment had a stomatal opening of 910.70 mmol m^{-2} s^{-1}, while stopping watering for 14 days and 7 days of treatments had a stomatal opening of 948,03 and 927.97 mmol $m^{-2}s^{-1}$, respectively and they were not statistically significant. Saline Irrigation at 6‰ had a stomatal opening of 911.48 mmol m^{-2} s^{-1} lower, but the difference was not statistically significant compared with saline irrigation at 4‰ and 2‰. According to Hura *et al.* (2007), the stomatal conductivity of plants was decreased in drought conditions. However, the longer time of stopping irrigation and increasing salinity irrigation in a short period did not reduced stomatal opening in cowpea beans. It may indicate that the cowpea pea plants recover quickly after regular watering.

Effect of drought and salinity on the nutritional content of *Vigna marina* bean leaves

Discontinuing irrigation for cowpea beans for 7, 14 and 21 days had a statistically significant difference in DM content at a 5% level (Table 2). The two treatments that stopped irrigation for 7 and 14 days had DM concentrations of 37.01 and 36.53%, respectively, higher than 21 days (33.3%). Saline irrigation 2‰ has a higher DM content of 45.88% and is statistically significant at 5% compared with saline irrigation 4‰ (32.27%) and saline irrigation 6 (28.7%). This result is consistent with the growth of plant length in Table 1. The effects of salinity and drought slow down plant growth.

The EE content in cowpea bean leaves at two periods of irrigated 7 days and 14 days, respectively, was 6.21 and 6.01%, but the difference was not statistically significant (Table 2). However, the two solutions were not statistically significant. This treatment has a statistically significant difference in EE content at 5% compared with the treatment

Table 1: Effect of drought and salinity on the height, SPAD index and stomatal opening of cowpea bean at 60 days after sowing.

Factor	Plant height (cm)	SPAD index	Stomatal opening	(mmol m^{-2} s^{-1})
Time to stop watering (A)	7 days	166.40[a]	44.67	927.97
	14 days	158.93[b]	44.39	948.03
	21 days	156.37[c]	46.22	910.70
Saline irrigation concentration (B)	2‰	165.20[a]	45.17	951.89
	4‰	159.93[b]	45.97	923.33
	6‰	156.57[c]	44.13	911.48
F (A)		*	ns	ns
F (B)		*	ns	ns
F (A*B)		*	ns	ns
CV		3.5	7.2	6.3

Note: In the same column, numbers followed by the same letter are not statistically different, ns: Not statistically significant difference, *: Statistical difference at 5% significance level.

with stopping irrigation for 21 days (5.22%). Saline irrigation 2, 4 and 6‰ had EE content in cowpea bean leaves of 6.46, respectively; 5.69 and 5.28% and the difference in EE content in cowpea bean leaves was statistically significant at the 5% level (Table 2).

The CP content in cowpea bean leaves reached the highest level of 24.44% in the treatment of stopping irrigation for 07 days. This value was more elevated and statistically significant at 5% compared to stopping watering for 14 days (20.34%) and stopped watering for 21 days, the CP content in cowpea bean leaves was 18.48% (Table 2). Increasing the concentration of saline irrigation for cowpea beans decreased the CP content in leaves from 22.21 in the 2‰ salinity treatments to 21.19% in the 4‰ and 19.86% in the 6‰ saline irrigation treatment (Table 2).

Stopping watering for 07 days, the content of NDF and ADF in cowpea bean leaves was 32.17 and 22.36%, respectively, which was not statistically significant compared with stopping watering for 14 days (33.67 and 22.53% according to the study method) and stopped irrigation for 21 days (34.50 and 21.82% in the same order). Irrigation concentrations of 2, 4 and 6‰ showed no statistically significant difference between NDF and ADF content in cowpea bean leaves (Table 2). The content of NDF in cowpea bean leaves between treatments with salinity concentrations of 2, 4 and 6‰ ranged from 32.54 to 34.08%, while saline irrigation 2, 4 and 6‰ had ADF content in cowpea bean leaves ranged from 21.85 to 22.51%. The results were also consistent with Abid *et al.* (2016), which indicated that alfalfa's ADF value decreased under severe water deprivation.

With holding watering for 14 and 21 days, the ash content in cowpea bean leaves was 5.88 and 6.20%, respectively. The difference was not statistically significant. However, these two treatments were statistically different at a significant level of 5% compared with the 7-day stop irrigation treatment (6.76%) (Table 2). The ash content in cowpea bean leaves in the 4 and 6 saline irrigation treatments was 6.79 and 6.46% higher and statistically different at the 5% than the 2 salinity irrigation treatments (5.60%).

The hemicellulose content in the two treatments with 14 and 21 days of watering cessation was 10.47 and 10.42% higher and statistically different at the 5% compared to the treatment with a 7-day stop watering time. value is 8.94% (Table 2). The hemicellulose content in the saline irrigation treatments of 2, 4 and 6‰ was not statistically significant and ranged from 9.72 to 10.07% (Table 2).

The results of Table 3 show that the DM content in the stem of the treatment with a 07-day watering stoppage time is 71.38% higher and statistically different at the 5% level of significance compared with the DM content in the stem of the treatment with the cessation of irrigation. Irrigated for 14 days (66.97%) and the treatment stopped watering for 21 days (61.86%). Among the saline irrigation treatments with concentrations of 2, 4 and 6‰, there was a statistically significant difference in DM content in the stem at the 5%

Table 2: Effect of drought and salinity on the nutritional content of cowpea bean leaves.

Factor		Dry material	Crude fat (%)	Crude protein (%)	Neutral fiber (%)	Acid fiber (%)	Ash (%)	Organic matter (%)	Hemicellulose (%)
		DM full	EE	CP	NDF	ADF	Ash	OM	Hemicellulose
Time to stop watering (A)	7 days	37.01^{a}	6.21^{a}	24.44^{a}	32.17	22.36	6.76^{a}	92.85	8.94^{b}
	14 days	36.53^{a}	6.01^{a}	20.34^{b}	33.67	22.53	5.88^{b}	93.19	10.47^{a}
	21 days	33.30^{b}	5.22^{b}	18.48^{c}	34.50	21.82	6.20^{b}	92.52	10.42^{a}
Saline irrigation concentration (B)	2‰	45.88^{a}	6.46^{a}	22.21^{a}	32.54	21.85	5.60^{b}	92.89	9.72
	4‰	32.27^{b}	5.69^{b}	21.19^{b}	33.72	22.35	6.79^{a}	93.04	10.04
	6‰	28.70^{c}	5.28^{c}	19.86^{c}	34.08	22.51	6.46a	92.63	10.07
F (A)		*	*	*	ns	ns	*	ns	*
F (B)		*	*	*	ns	ns	*	ns	ns
F (A*B)		*	*	*	ns	*	*	ns	ns
CV		9.64	9.34	5.78	8.93	4.15	8.53	1.62	10.69

Note: In the same column, numbers followed by the same letter are not statistically different, ns: Not statistically significant difference, *: Statistical difference at 5% significance level. DM: Dry matter, EE: Ether extract, CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, OM: Organic matter.

(Table 3). Saline irrigation 2 had a higher DM content in the stem of 45.88% than 4 (32.27%) and saline 6 had a 28.70% D.M. content.

The three treatments that stopped irrigation for 7, 14 and 21 days had EE content in cowpea bean stems ranging from 1.65 to 1.74% and was not statistically significant (Table 3). Irrigation with 2‰ and 4‰ salinity had different E.E. content in cowpea bean stem that was not statistically significant and had values of 1.77 and 1.89%, respectively. However, these two treatments had higher EE concentrations than the saline irrigation 6‰ treatment.

Table 3 showing the CP and ADF concentrations in the two treatments of stopping irrigation for 7 and 14 days had higher values. However, they were statistically different at the 5% significance level compared with the treatment with stopping irrigation for 21 days. Specifically, the concentrations of CP and ADF in the 7-day watering cessation treatment were 10.02 and 34.99, while the 21-day watering cessation treatment values were 9.06 and 32.24%. Saline irrigation 2‰ had a CP content of 11.43% higher in cowpea stalks and a statistically significant difference of 5% compared with saline irrigation 4 and 6‰. In contrast, the ADF content between saline irrigation treatments 2, 4 and 6‰ differences were not statistically significant. The content of NDF, OM and hemicellulose between the treatments of stopping irrigation 7, 14 and 21 days and the levels of saline irrigation at 2, 4 and 6‰ were not statistically significant. The NDF content ranges from 52.18 to 53.29%, the OM from 93.95 to 94.83% and the hemicellulose from 15.67 to 17.34%.

The ash content between the time of stopping irrigation 7, 14 and 21 days has a value of 5.71, 4.69 and 4.19%, respectively and the difference between treatments was statistically significant at the 5% level (Table 3). In saline irrigation treatments with concentrations of 2, 4 and 6‰, there was no statistically significant difference in ash content in stems. The ash content ranged from 4.8 in the saline irrigation treatments and had no significance. The ash content in cowpea stems and leaves decreased during the 14- and 21-day cessation treatments. It may be due to reduced soil nutrient availability and uptake as soil water content falls or too low soil nutrient availability (Khalil *et al.*, 2015).

Effect of drought and salinity on nitrogen in leaf and green matter yield

The nitrogen content in the two treatments that stopped watering for 7 and 14 days was 13.52 and 12.64% higher and statistically different at the 5% significance level compared to the 21days treatment; the value is 10.46% (Fig 1a). The nitrogen content in saline irrigation treatments 2, 4 and 6‰ was statistically different at the 5%. The 2 and 4‰ saline irrigation treatments had a higher nitrogen content of 13.44 and 11.83%, respectively than the 6‰ saline irrigation with 11.35% nitrogen content (Fig 1b). However, when stopping irrigation for 21 days or watering with saline at a concentration of 6‰, the nitrogen content in the plants

Table 3: Effect of drought and salinity on the nutritional content of cowpea bean.

Factor		Dry material	Crude fat (%)	Crude protein (%)	Neutral fiber (%)	Acid fiber (%)	Ash (%)	Organic matter (%)	Hemicellulose (%)
		DM full	EE	CP	NDF	ADF	Ash	OM	Hemicellulose
Time to stop watering (A)	7 days	71.38^{a}	1.74	10.02^{a}	52.90	34.99^{a}	5.71^{a}	94.35	16.58
	14 days	66.97^{b}	1.65	10.31^{a}	52.53	34.69^{a}	4.69^{b}	94.78	16.78
	21 days	61.86^{c}	1.71	9.06^{b}	52.81	32.24^{b}	4.19^{c}	93.79	16.53
Saline irrigation concentration (B)	2‰	79.08^{a}	1.77^{a}	11.43^{a}	52.78	33.78	4.89	94.83	16.88
	4‰	64.06^{b}	1.89^{a}	9.01^{b}	53.29	34.26	4.86	94.14	17.34
	6‰	57.08^{c}	1.45^{b}	8.94^{b}	52.18	33.88	4.84	93.95	15.67
F(A)		*	ns	*	ns	*	*	*	ns
F(B)		*	*	*	ns	ns	ns	*	ns
F(A*B)		*	*	*	*	*	*	*	ns
CV		7.63	10.95	8.33	2.59	5.17	7.51	2.26	11.89

Note: In the same column, numbers followed by the same letter are not statistically different, ns: Not statistically significant difference, *: Statistical difference at 5% significance level.
DM: Dry matter; EE: Ether extract, CP: Crude protein; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; OM: organic matter.

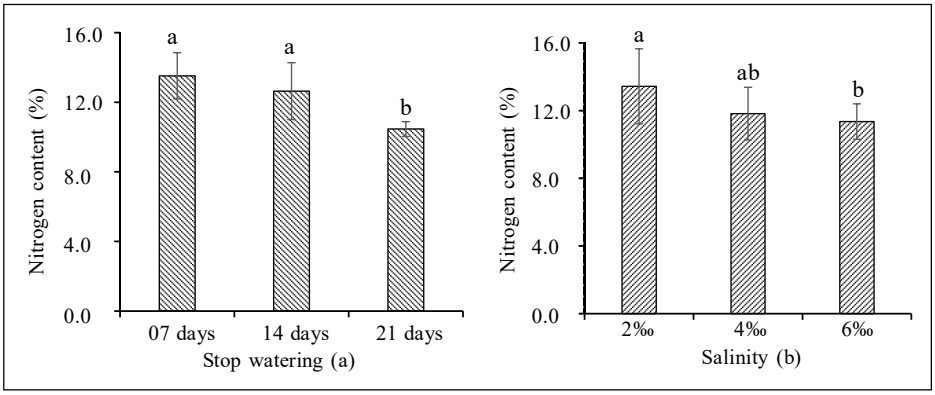

Fig 1: Effect of drought (a) and salinity (b) on N content of cowpea bean leaves.

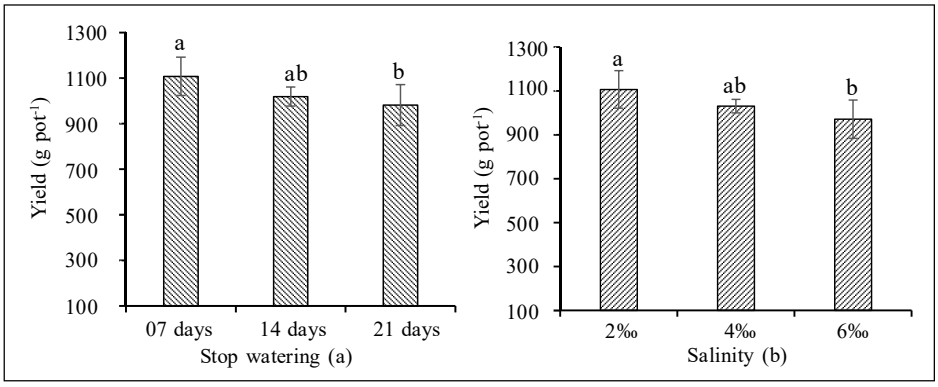

Fig 2: Effects of drought (a) and salinity (b) on green matter yield of cowpea bean.

was reduced (Fig 1a,b). According to Khare *et al.* (2020), salinity can directly inhibit N transport and assimilation. The N content was positively correlated with the chlorophyll index. However, the results in Table 1, the chlorophyll index in all treatments were not different.

Fig 2a shows that the green matter yield of cowpea at two periods of irrigation of 7 days and 14 days was 1,107.7 and 1,018.7 g pot^{-1}, respectively. The difference was not statistically significant. However, these two treatments had a statistically significant difference in green matter yield of cowpea at 5% compared with the treatment that stopped watering for 21 days (971,27 $g.pot^{-1}$). Saline irrigation 2, 4 and 6‰ yielded green matter of cowpea 1,106.1, respectively; 1,030.3 and 971.3 g pot^{-1} and the difference in green matter yield of cowpea was statistically significant at a 5% level (Fig 2b). Prolonged drought and high salinity irrigation reduced the green matter yield of cowpea (Fig 2a, b). According to Tetteh *et al.* (2020), water stress reduces the dry plant mass of cowpea.

CONCLUSION

Watering cowpea bean plants for 14 and 21 days reduced the height, SPAD index, stomatal opening, DM, CP and ash content compared to the 7-day stop watering period, reducing yield and green yield matter yield and nitrogen content in plants. Increasing salinity irrigation concentration at 4 and 6‰ reduced cowpea bean's height, SPAD index, stomatal opening, DM, EE and CP. At the same time, the green matter yield and nitrogen content in the plants also decreased when irrigated with salinity 6‰.

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