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Response of three tossa jute (*Corchorus olitorius* L.) cultivars produced in Benin to salinity stress at germination and young plant stages

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ABSTRACT

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The response of three tossa jute cultivars *Ordinaire*, *5-Doigts* and *Acc : Sud 2* to salt stress was evaluated at germination and young plant stages. Five NaCl concentrations: 0; 30; 60; 90 and 120 mM NaCl were used. Seeds were submitted to NaCl in petri dishes and germination was checked every day during thirty days in a completely randomized design with four replicates. Four-week old plants were submitted in pots to the same five NaCl concentrations by irrigation every two days for two weeks in screen house. NaCl reduced seed germination rate in all cultivars from day 2 to day 30 and the germination index. At the end of the 30 days, salt stress reduced the final germination percentages with a significant difference among cultivars: cultivar *5-doigts* was the least affected than the two other cultivars. Salt effect caused a reduction of young plant growth whatever the growth parameter considered with a significant difference among cultivars. The growth of cultivar *Acc:Sud 2* was more affected by salt stress with the lowest salt tolerance index whereas that of cultivar *Ordinaire* was the least affected with the highest salt tolerance index. Thus, cultivar *5-Doigts* appeared as the most resistant to salt stress at germination stage among the three cultivars; whereas cultivar *Ordinaire* followed by *5-Doigts* was the most salt resistant at young plant stage.

Introduction

Salinity is one of the most important environmental constraints limiting the agricultural productivity around the world (Ashraf et al., 2004;

Hussain et al., 2004). On average, the world loses 10 hectares of cultivable land per minute, including 3 hectares due to salinization (Mermoud, 2006). In fact, the salinity covers more than 6% of the total surface of the planet, 3.8% of which is located in

Africa (Manchanda, 2008). In Benin, the extent of land affected by salinity is not precisely known. However, preliminary studies (unpublished) carried out by our research team with our partners have shown that certain vegetable production areas including non-coastal areas are at high salt risk. Indeed, the degree of plant response to salinity depends on salt concentration, plant species, variety and development stage (Bennaceur et al., 2001). Germination is considered as one of the most critical stages in the life cycle of plants (Almansouri et al., 2001; Hadas, 2004). In addition, under salt stress conditions, seed germination and the first phase of seedling growth are critical stages for plant establishment (Khan et al., 2003). The response of plants to increased NaCl concentration depends on the species (Lakra, 2006; Chukwu et al., 2006; Gandonou et al., 2012). In addition, within the same given species, a substantial variation in salt sensitivity may appear in cultivars or varieties as it has been reported in several species of vegetable crops including amaranth (Wouyou et al., 2016); chili (Kpinkoun et al., 2018), cabbage (Gouveitcha et al., 2020) and tomato (Kinsou et al., 2019; 2020).

Two species of jute *Corchorus capsularis* L. (Deshi jute) and *Corchorus olitorius* L. (Tossa jute) are grown in tropical and subtropical regions for trade purposes (Edmonds, 1990). In Benin, tossa jute (*Corchorus olitorius* L.), commonly known as "crincrin" holds an important position in people's diet and is one of the most widely practiced market gardening crops (Savi, 2009). Due to the richness of its tender leaves in nutritional substances (vitamin C, provitamin A, mineral salts, proteins), *Corchorus olitorius* also known as wild okra (Ahmadi et al., 2016) could be a "powerful weapon" to combat nutritional deficiencies, especially in developing countries (Kahane et al., 2005; Soro et al., 2012). Market gardeners in Southern Benin acknowledge the salinity of irrigation water and sea spray as a major problem for their activities (Orobiyi et al., 2013; Dégénénon, 2018 cited by Kpinkoun, 2019). Much of the jute production area in Benin is located in the coastal zone and irrigated lands in Southern Benin where soil and irrigation water salinity are real problems hampering crop production. The identification of salt resistant genotypes capable of minimizing the depressive effects of salinity on yields would certainly improve agricultural production in areas

affected by salinity. Some studies were focused on the effect of salt stress on jute seed germination and plant growth. Among them, we can quote Khandker et al. (1992), Islam et al. (2011), Ahmadi et al. (2015) and Ben Yakoub et al. (2019). However, except the works of Ghosh et al. (2013) and Naik et al. (2015), data on salinity tolerance of tossa jute cultivars/varieties are rare. Moreover, basically no research work has focused on salt resistance of tossa jute cultivars produced in Benin. The current study is designed to fill this gap. It mostly aims at evaluating the relative level of salt resistance of tossa jute cultivars available in Benin at both germination and young plant stages.

Materials and methods

Plant material

Three tossa jute cultivars including two local (*Ordinaire* and *5-Doigts*) and one introduced (*Acc :Sud 2*) were used. Seeds of cultivars *Ordinaire* and *5-Doigts* were provided by the National Institute of Agricultural Research of Benin (INRAB) whereas those of the introduced cultivar were provided by World Vegetable Center (WVC).

Experimental conditions

For germination stage study, the experiment was laid out as a Completely Randomized Design (CRD) with four replications. Seeds (40) of each cultivar were incubated in 10 cm Petri dishes on one layer of filter paper moistened with 15 ml distilled water (control) and the same volume of salt solutions of 0; 30; 60; 90 or 120 mM NaCl. Seeds were incubated in darkness at 26°C. The seed was considered as germinated when the radicle emerged from the seed coat and germination was checked every two days during thirty days incubation period.

For young plant stage study, the experiment was carried out in a screen house at Center of Agricultural Research of Agonkanmey (Abomey-Calavi, Republic of Benin) from June to August 2019. Plants were cultivated at a temperature of 26 °C/22 day/night with natural light and a relative humidity of 55%. Seeds underwent a dormancy break before germination in trays filled with potting soil for three weeks. Young seedlings were

then transferred to earthen small pots of 5.8 cm diameter and 6 cm height containing a mixture of potting soil and sandy loam soil 50:50 (one plant/pot) and cultivated for one week before stress application. Plants of the three cultivars were submitted to salt stress in earthen big pots of 11.3 cm diameter and 14 cm height filled with 3 kg of a same mixture. Treatments consisted of plant irrigation every two days with 100 ml/pot of salt solution of 0; 30; 60; 90 or 120 mM NaCl corresponding respectively to an electric conductivity of 0.221; 3.827; 6.47; 10.56 and 14.02 dS.m⁻¹ determined by a conductimeter (VWR; CO310). The experiment was laid out as a Completely Randomized Design (CRD) with two factors and four replications. The two considered factors were cultivars (with three levels) and salt concentrations (with five levels).

Experiment evaluation

Salt effect on seed germination was evaluated using germination kinetics, germination index and final germination percentage. The germination index was calculated according to Wouyou et al. (2016); Kpinkoun et al. (2018) and Gouveitcha et al. (2020) as Germination Index (GI) = $10 \times (n_{24} + n_{48} + n_{72}) / (n_{24} + 2n_{48} + 3n_{72})$ where n_{24} , n_{48} , n_{72} were respectively the number of germinated seeds on 24, 48, et 72 hours.

Plant height, leaf number, root length, shoot and root fresh and dry matters were measured before stress application (X_0); they were measured again after 2 weeks of treatment (X_1). For dry matter determination, fresh samples were transferred to an oven at 80 °C for 72 hours. Plants Relative Growth was calculated for each growth parameter as $(X_1 - X_0) / X_0$.

Cultivars were determined according to their salt resistance using the following parameters:

- the final germination percentage reduction under salt stress;
- the growth reduction under salt stress;
- the Salt Tolerance Index (STI) calculated according to Tabatabaei et al. (2012) either for seed germination (based on final germination percentage) or for plant growth as:

Salt Tolerance Index (STI) = $(Y_S \times Y_P) / (\bar{Y}_P)^2$
where,

Y_S = measure of one replicate under NaCl treatment.

Y_P = measure of one replicate of the control.

\bar{Y}_P = means of measures of all replicates of the control.

Statistical analysis

For all parameters, each value was presented in the form of mean ± standard error with a reading of four independent samples per treatment. The analysis of the main effects of stress intensity or cultivars was based on a one-way analysis of variance (ANOVA). Means were compared with Tukey-Kramer test. Data were statistically analyzed using the JMP Pro 12" software (SAS Institute, 2015).

Results

Effect of salt stress on seed germination

Figs. 1, 2, and 3 show the evolution of seed germination as a function of time from 2 to 30 days of germination in the presence of NaCl at 0; 30 ; 60; 90; and 120 mM respectively for the cultivars *Ordinaire*, *5-Doigts* and *Acc: Sud 2*. In the absence of stress, the responses of the three jute cultivars were different from the second (2nd) day until the thirtieth (30th) germination day. After two days, more than 70% of the seeds germinated for the cultivars *Ordinaire* (75.62%) and *5-Doigts* (74.37%) while less than 5% of the seeds germinated for the cultivar *Acc: Sud 2* (1.87%). Thus, seed germination began from day 2 in the absence of stress for all cultivars. By day 4, the percentage of germination increased in all cultivars and reached 78.75% for *Ordinaire*; 78.12% for *5-Doigts* and 4.37% for *Acc: Sud 2*. Thus, the percentage of seed germination was greater than 75% for all jute cultivars after 4 days except cultivar *Acc: Sud 2* (4.37%). After 4 days, no change was observed in the germination percentage of cultivar *5-Doigts* indicating that this cultivar reached its maximum germination capacity after 4 days. For the other two cultivars, the germination percentage increased slowly until the 30th day corresponding to the end of the experiment, reaching 83.75% for the cultivar *Ordinaire* and 55% for *Acc: Sud 2*. These results

revealed a significant variability in the germination capacity of cultivars in the absence of stress. Cultivar *Ordinaire* exhibited the greatest germination capacity while *Acc: Sud 2* showed the lowest. In the presence of NaCl, there was a slowdown in germination for all cultivars and all concentrations from the second (2nd) to the thirtieth (30th) day of germination with reactions that vary among cultivars (Fig. 1, 2 and 3): On the second (2nd) day, germination percentages decreased in *Ordinaire* with reductions of 3.12%; 4.37%; 37.5% and 71.25% relative to the control respectively at 30; 60; 90 and 120 mM NaCl. For *5-Doigts*, germination percentages decreased with reductions of 7.5%; 10%; 40% and 64.37% relative to the control respectively at 30; 60; 90 and 120 mM NaCl. For *Acc: Sud 2*, there was also a reduction corresponding to 0.62%; 1.87%; 1.87%; 1.87% respectively at 30; 60; 90 and 120 mM NaCl. At 60; 90 and 120 mM NaCl, no seed of cultivar *Acc: Sud 2* germinated. On the fourth day, germination percentages decreased in *Ordinaire* with reductions of 3.12%; 3.75%; 33.12% and 70.62% relative to the control; for *5-Doigts* the reduction rates were 5%; 9.37%; 38.75% and 63.12% compared to the control and for *Acc: Sud 2*, the reduction rates were 2.5%; 3.73% and 4.37% respectively at 30; 60; 90 and 120 mM NaCl. At 90 and 120 mM NaCl, no seeds germinated for *Acc: Sud 2*. Similar observations were made from the 6th to the 30th day except that for the cultivar *Ordinaire* from the 14th to the 30th day. There was a slight increase in the germination percentage at 120 mM NaCl versus 90 mM NaCl and from day 26 to day 28 this increase was observed at 60 mM versus 30 mM NaCl in *Ordinaire*. In *5-Doigts*, a slight increase was observed at 60 mM NaCl compared to 30 mM NaCl and even compared to the control (0 mM NaCl) from the 26th to the 30th day). For cultivar *Acc: Sud 2*, germination started for the high concentrations (60, 90 and 120) mM of NaCl respectively from only the 4th, 6th and 12th day. This result showed that stress delayed seed germination of all jute cultivars with varying reactions depending on the cultivar. The germination delay was more noted in cultivar *Acc: Sud 2* compared to the other two cultivars.

Table 1 shows the effect of NaCl on germination index of the three cultivars of horsehair. In the absence of stress, the Germination Indexes (GI) of the three cultivars were 8.78; 9.047 and 2.50

respectively for *Ordinaire*, *5-Doigts* and *Acc: Sud 2*. Cultivar *5-Doigts* had the highest germination index while *Acc: Sud 2* had the lowest. The effect of NaCl caused a reduction in the germination index in all cultivars tested. However, the three cultivars showed variable responses. Cultivar *Ordinaire* showed germination indexes of 8.96; 6.52; 4.96 and 4.29 respectively at 30; 60; 90 and 120 mM NaCl. The reduction in germination index in this cultivar was significant ($p \leq 0.001$) from 60 mM NaCl. In cultivar *5-Doigts*, the germination indexes were 8.14; 8.28; 5.91 and 4.68 respectively at 30; 60; 90 and 120 mM NaCl. The reduction in this cultivar was significant ($p \leq 0.001$) from 90 mM NaCl. The germination indexes of cultivar *Acc: Sud 2* were 2.50; 0.83; 0.00; 0.00 corresponding to a non-significant reduction compared to the control. However, no seed of this cultivar germinated above 60 mM NaCl during the first three days.

Fig. 4 shows the effect of different NaCl concentrations on the final germination percentage of the three jute cultivars. In the absence of stress, the final germination percentages were 83.75%; 78.12% and 55.00% respectively for cultivars *Ordinaire*, *5-Doigts* and *Acc: Sud 2*. *Ordinaire* showed the highest final germination percentage while *Acc: Sud 2* exhibited the lowest. The effect of NaCl caused a reduction in the final germination percentage in all cultivars studied. However, the three cultivars exhibited variable behaviors. Cultivar *Ordinaire* exhibited final germination percentages of 83.75%; 83.75%; 60.00% and 60.62% corresponding to significant reduction ($p \leq 0.001$) from 90 mM NaCl. In cultivar *5-Doigts*, the germination percentages were 75.62%; 79.37%; 58.75% and 33.75% corresponding to significant reduction ($p \leq 0.001$) only at 120 mM NaCl. The final germination percentages of *Acc: Sud 2* were 54.37%; 43.12%; 30.00 and 10.00% corresponding to significant reduction ($p \leq 0.001$) from 90 mM NaCl. Thus, the reduction of final germination percentage by salt stress was less accentuated in cultivar *5-Doigts* in comparison with the two other cultivars.

Salt Tolerance Index of cultivars

The salt tolerance indexes (STI) varied from 0.623 in the cultivar *Acc: Sud 2* to 0.859 in the cultivar *Ordinaire* (Table 2). However, the difference among these indexes is not significant. However,

this index remains higher for cultivar *Ordinaire* and lower for cultivar *Acc: Sud 2*.

Effect of salinity on young plant growth

Salinity symptoms were characterized by leaf chlorosis associated to necrosis (Fig. 5).

Plant height

Fig. 6 reveals the reduction of plant growth under salt stress. Salt stress effect resulted in a decrease in plant height growth in the three cultivars but this decrease was significant ($p \leq 0.05$) only for cultivar *Acc: Sud 2* (Fig. 7). Thus, plant height of cultivar *Acc: Sud 2* was more affected by salt stress than that of the two other cultivars which reacted the same way.

Leaf number

Salt stress effect resulted in a decrease in plant height growth in the three cultivars but this decrease was significant ($p \leq 0.05$) for cultivar *Acc: Sud 2* from 90 mM NaCl and only at 120 mM NaCl for cultivar *5-Doigts* (Fig. 8). Thus, leaf number of cultivars *Acc: Sud 2* was the most affected by salt stress whereas that of cultivar *Ordinaire* was the least affected; cultivar *5-Doigts* showed an intermediary behavior.

Shoot fresh mass

Salt stress effect resulted in a decrease in fresh

mass growth in the three cultivars but this decrease was significant ($p \leq 0.05$) for cultivar *Acc: Sud 2* from 90 mM NaCl and only at 120 mM NaCl for cultivar *5-Doigts* (Fig. 9). Thus, shoot fresh mass of cultivars *Acc: Sud 2* was the most affected by salt stress whereas that of cultivar *Ordinaire* was the least affected; cultivar *5-Doigts* showed an intermediary reaction.

Shoot dry mass

Salt stress effect resulted in a decrease in dry mass growth in the three jute cultivars but this decrease was not significant for any of the three cultivars (Fig. 10). Thus, shoot dry mass of the three cultivars was affected in the same way.

Roots

Salt stress induced a non-significant reduction in root growth whatever the growth parameter considered (Table 3). Thus, no root growth parameter was affected by salinity for any of the three jute cultivars.

Salt Tolerance Index (STI) of cultivars

Results revealed that the difference among STI of the three cultivars was significant only for the parameters CRMFPA and CRMSPR (Table 4). For these two parameters, cultivar *Ordinaire* exhibited the highest STIs while *Acc: Sud 2* cultivar presented the lowest.

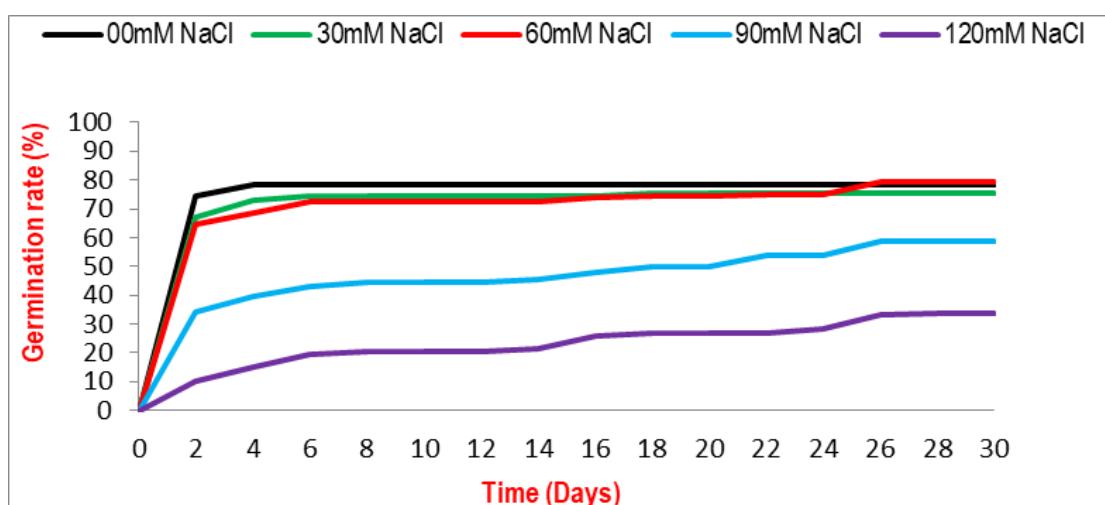


Fig. 1: Rate of germination of tossa jute seeds under saline conditions for cultivar *Ordinaire*.

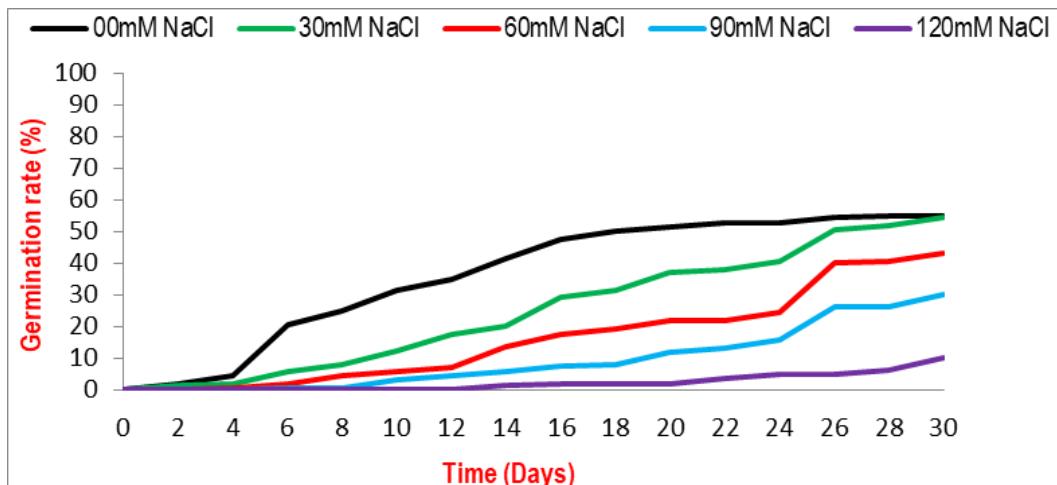


Fig. 2: Rate of germination of tossa jute seeds under saline conditions for cultivar 5-Doigts.

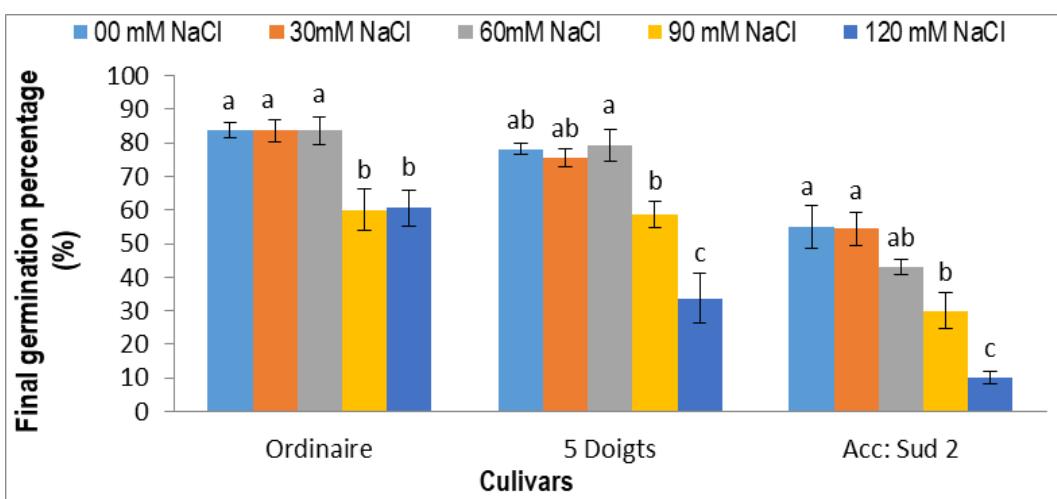


Fig. 3: Rate of germination of tossa jute seeds under saline conditions for cultivar Acc:Sud 2.

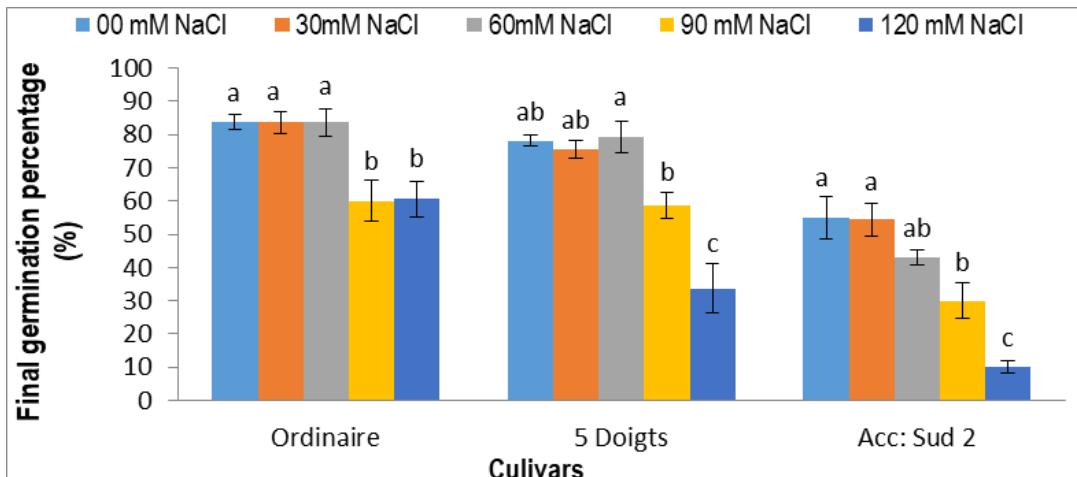


Fig. 4: Effect of different concentrations of NaCl salinity on final germination percentage of three tossa jute cultivars. Vertical bars are standard error of means of four replications. Means with different letters were significantly different ($p < 0.05$ or 0.001).

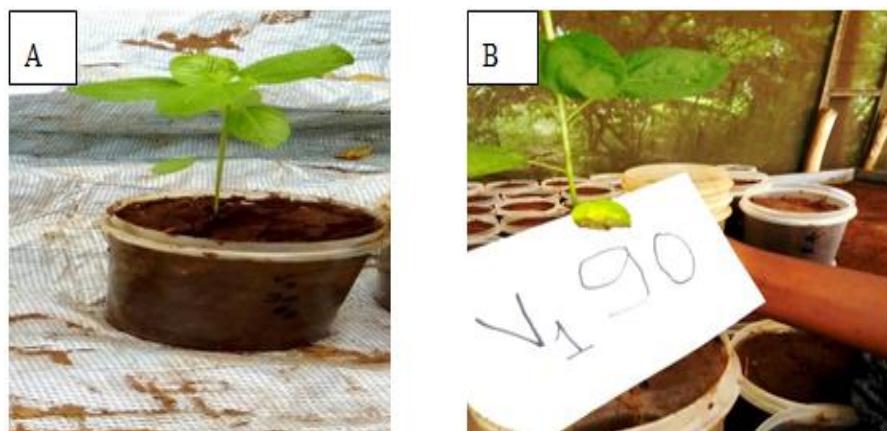


Fig. 5: Salinity symptoms in tossa jute plants (A: Control plants; B: stressed plants).

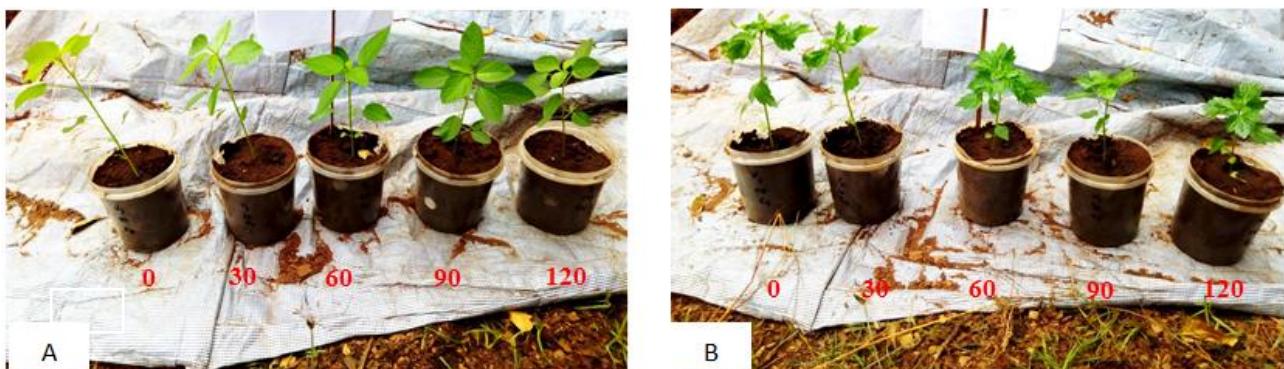


Fig. 6: Plants from cultivar *Ordinaire* (A) and cultivar *5-Doigts* (B) after two weeks under different NaCl concentrations.

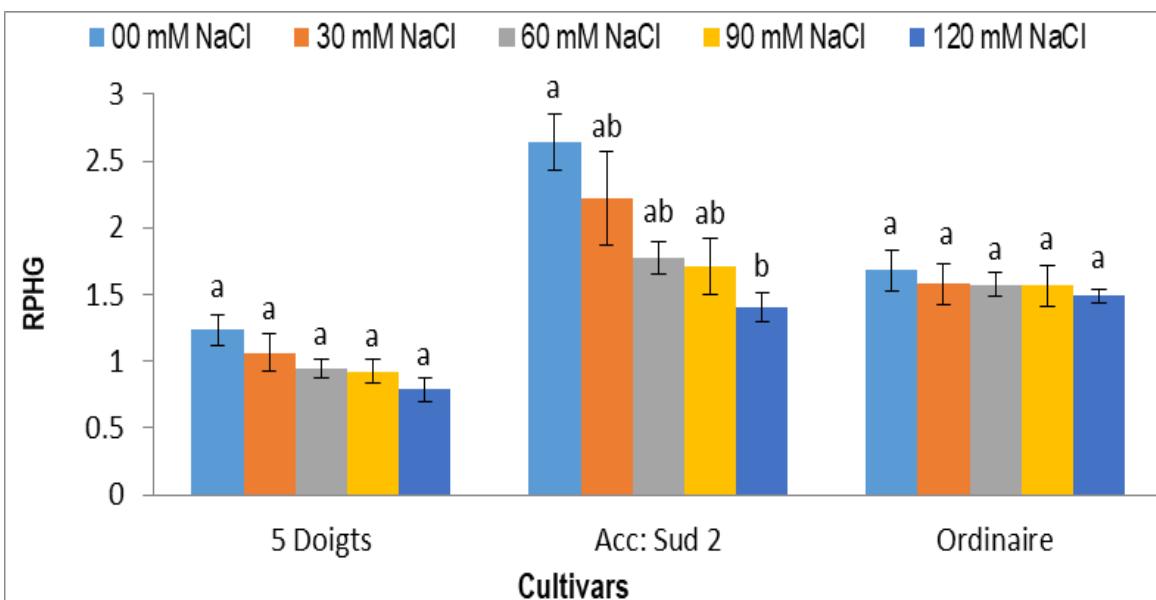


Fig. 7: Plant relative height growth (PRHG) of three tossa jute cultivars under different NaCl concentrations ($n = 4$; vertical bars are standard errors). Values within cultivar with same letter are not significantly different at $p \leq 0.05$.

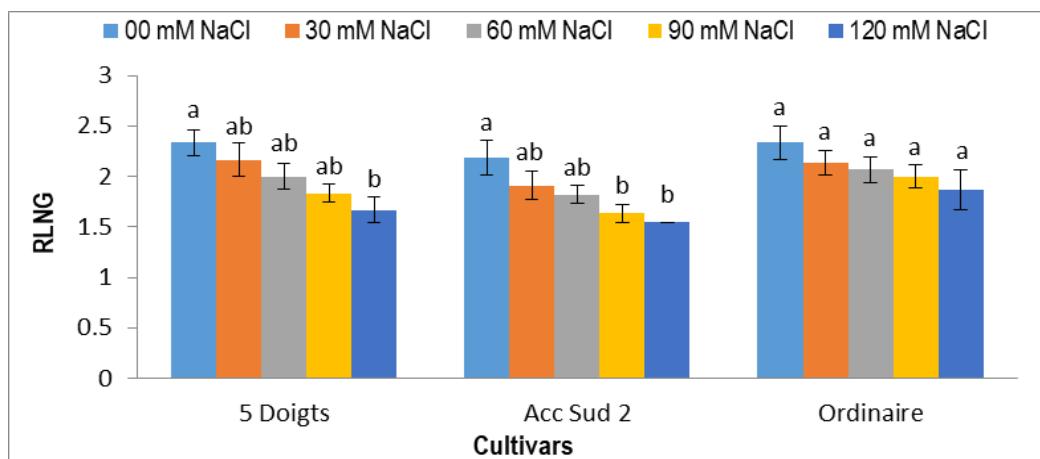


Fig. 8: Plant relative leaf number growth (RLNG) of three tossa jute cultivars under different NaCl concentrations ($n = 4$; vertical bars are standard errors). Values within cultivar with same letter are not significantly different at $p \leq 0.05$.

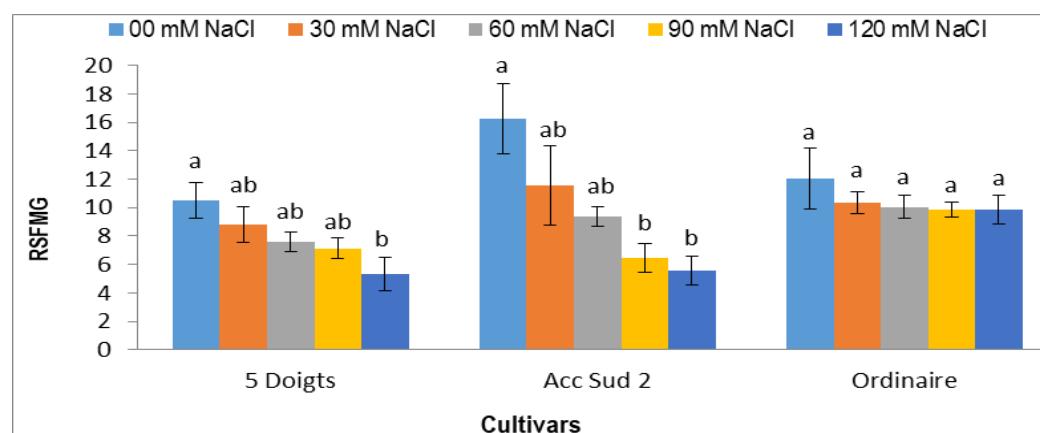


Fig. 9: Relative shoot fresh mass growth (RSFMG) of three tossa jute cultivars under different NaCl concentrations ($n = 4$; vertical bars are standard errors). Values within cultivar with same letter are not significantly different at $p \leq 0.05$.

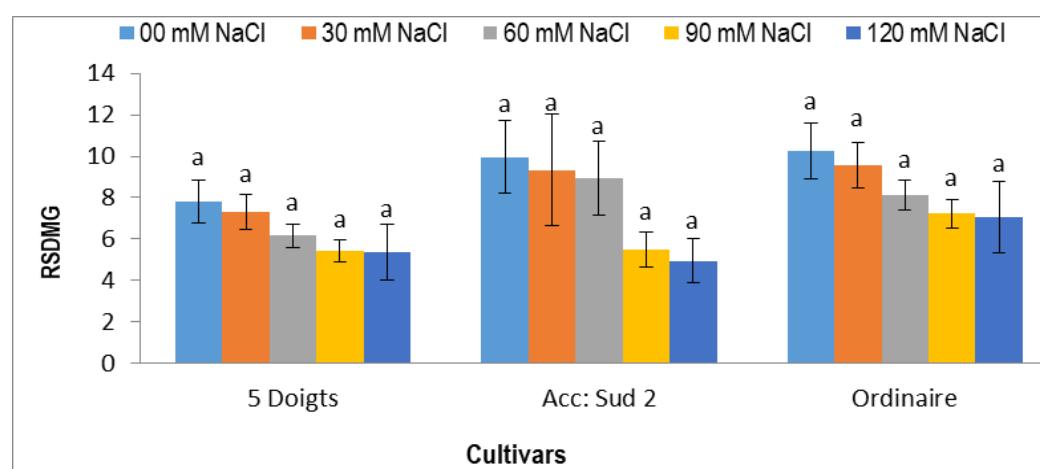


Fig. 10: Relative shoot dry mass growth (RSMDG) of three tossa jute cultivars under different NaCl concentrations ($n = 4$; vertical bars are standard errors). Values within cultivar with same letter are not significantly different at $p \leq 0.05$.

Table 1. Effect of different concentrations of NaCl salinity on germination index of three tossa jute cultivars.

Cultivars	NaCl concentrations (mM)				
	00	30	60	90	120
Ordinaire	8.780±0.12 ^a	8.966±0.28 ^a	6.528 ±0.32 ^b	4.969 ±0.07 ^c	4.294±0.42 ^c
5-Doigts	9.047±0.13 ^a	8.148 ±0.28 ^a	8.289±0.33 ^a	5.915±0.34 ^b	4.688±0.35 ^b
Acc : Sud 2	2.500±1.44 ^a	2.500±1.44 ^a	0.833±0.83 ^a	0.000 ±0.00 ^a	0.000 ±0.00 ^a

Values are means ± standard errors (n=4). Means with different letters were significantly different (P <0.05).

Table 2. Salt tolerance Index of three tossa jute cultivars at germination stage under five NaCl concentrations (0; 30; 60, 90 and 120 mM).

STI	Cultivars	Ordinaire	5-Doigts	Acc: Sud 2
	0.859±0.04 ^a	0.791±0.06 ^a	0.623±0.09 ^a	

Values are means ± standard errors (n=4). Means with different letters were significantly different (P <0.05).

Table 3: Effect of different NaCl concentrations (0, 30; 60; 90 and 120 mM) on root growth of three jute cultivars after two weeks of stress.

Cultivars	Growth parameters	Concentrations de NaCl (mM)				
		0	30	60	90	120
5 Doigts	RRLG	2.17±0.55 ^a	2.05±0.65 ^a	1.93±0.80 ^a	1.91±0.34 ^a	1.80±0.43 ^a
	RRFMG	7.71±1.15 ^a	6.05±0.43 ^a	5.67±1.36 ^a	4.68±0.65 ^a	3.93±0.47 ^a
	RRSDMG	3.58±0.76 ^a	2.33±0.28 ^a	2.04±0.57 ^a	1.92±0.32 ^a	1.62±0.29 ^a
Acc: Sud 2	RRLG	1.48±0.31 ^a	1.38±0.50 ^a	1.19±0.33 ^a	1.07±0.22 ^a	1.07±0.31 ^a
	RRFMG	20.69±3.66 ^a	16.28±4.86 ^a	12.17±1.45 ^a	9.84±2.40 ^a	7.69±1.80 ^a
	RRSDMG	17.12±9.08 ^a	7.75±2.80 ^a	5.37±1.76 ^a	4.37±1.44 ^a	3.75±0.94 ^a
Ordinaire	RRLG	4.92±0.63 ^a	4.53±0.36 ^a	4.48±0.63 ^a	3.85±0.59 ^a	3.85±0.64 ^a
	RRFMG	14.95±3.24 ^a	11.02±0.94 ^a	10.87±2.16 ^a	10.67±1.07 ^a	10.42±0.57 ^a
	RRSDMG	8.17±1.53 ^a	5.67±0.56 ^a	5.08±1.15 ^a	4.83±0.64 ^a	4.25±0.59 ^a

Values are means ± standard errors (n=4). Means with different letters were significantly different (P <0.05).

Table 4. Salt Tolerance Index (STI) of three tossa jute cultivars after two weeks under salt stress.

Cultivars	CRHP	CRNF	CRMFP	CRMSPA	CRLR	CRMFPR	CRMSPR
5 Doigts	0.76 ±0.06 ^a	0.83 ±0.04 ^a	0.67 ±0.04 ^{ab}	0.76 ±0.05 ^a	0.93 ±0.15 ^a	0.64 ±0.04 ^a	0.52 ±0.05 ^a
Acc: Sud 2	0.68 ±0.05 ^a	0.80 ±0.04 ^a	0.53 ±0.07 ^b	0.78 ±0.14 ^a	0.85 ±0.16 ^a	0.60 ±0.11 ^a	0.26 ±0.05 ^b
Ordinaire	0.68 ±0.03 ^a	0.87 ±0.04 ^a	0.85 ±0.08 ^a	0.77 ±0.05 ^a	0.84 ±0.07 ^a	0.73 ±0.09 ^a	0.58 ±0.05 ^a
Standard error	0.053	0.04784	0.07028	0.08537	0.13111	0.08579	0.05313

Values within columns with different letters are significantly different at p≤0.05.

Discussion

Effect of salinity on germination

Cultivar 5-Doigts reached its maximum germination by day 4 and cultivar Ordinaire at day 24 in the absence of stress. This indicates that the germination rate was faster in cultivar 5-Doigts. At the end of the experiment, cultivar Ordinaire showed the highest percentage of germination while Acc: Sud 2 showed the lowest. These results revealed a variability in germination capacity of

seeds of the three cultivars and cultivar Ordinaire has the greatest germination capacity and Acc: Sud 2 the weakest. Maximum germination in the presence of stress was obtained from the fourteenth (14th) day for cultivar Ordinaire, the twenty-sixth (26th) day for 5-Doigts and at the thirtieth (30th) day for Acc: Sud 2. These results showed that the effect of NaCl on the kinetics of germination depends on the cultivar and that within the limits of the concentrations and cultivars tested, a study on the effect of salinity on the germination of tossa jute cultivars must be

made at least over thirty days.

Seed germination of all cultivars was delayed by the effect of salinity more at the start of germination. Similar results were observed in several species such as watermelon (Hend et al., 2007), melon (Botia et al., 1998), chili (Kpinkoun et al., 2018), tomato (Kinsou et al., 2019), lettuce (Grahn et al., 2015) and cucumber (Zhang et al., 2014). In other jute cultivar, it was reported that salt stress delayed the initiation process and decreased significantly kinetics and rate of germination, which were severely limited at 9 and 10 g.l⁻¹ NaCl (Ben Yakoub et al., 2019). According to Ghrib et al. (2011), this delay could be due to the alteration of enzymes and hormones which are found in the seed whereas for Ben Miled et al. (1986), this could be explained by the time required for the seed to set up mechanisms allowing it to adjust its internal osmotic pressure. Further studies are needed to determine the exact cause of this germination delay. This delay in germination was reflected in the reduction of the germination index by salinity. Similar results have been reported in several species such as amaranth (Wouyou et al., 2016), chili (Kpinkoun et al., 2018) and cabbage (Gouveitcha et al., 2020). Our results showed that the reduction in the germination index is less noted in the cultivar Acc: Sud 2 compared to the two other cultivars but is more noted in the cultivar *Ordinaire*. The effect of NaCl also resulted in a reduction in the final germination percentage in the cultivars tested. The reduction in the final germination percentage by salt stress has been reported in several species including watermelon (Hend et al., 2007), cabbage (Gouveitcha et al., 2020), chili (Kpinkoun et al., 2018), peppers (Ertan et al., 2006), tomato (Kinsou et al., 2019) and other tossa jute genotype (Ben Yakoub et al., 2019). This reduction was more noted in cultivar Acc: Sud 2 and less noted in *Ordinaire*. However, the difference among the salt tolerance indices of the three cultivars was not significant indicating that the three cultivars are very similar in terms of level of resistance to salinity.

Our results indicate that the reaction of cultivars with respect to salinity at the germination stage depends on the criterion used. Considering the germination index, the cultivar Acc: Sud 2 appears to be the least affected and the *Ordinaire* cultivar

the most affected. Considering the final germination percentage, cultivar 5-Doigts was the least affected and the Acc: Sud 2 cultivar the most affected. Since the final germination percentage covers the entire duration of the experiment while the germination index only takes into account the first three days, the final germination percentage appears to be the most accurate parameter to assess the response of cultivars with respect to salinity. Thus, cultivar 5-Doigts appears to be the most resistant to salinity at the germination stage and Acc: Sud 2 the most sensitive; cultivar *Ordinaire* exhibits intermediary behavior.

Effect of salt stress on the growth of young plants

The effect of salinity was reflected in chlorosis and necrosis at the tips of jute plants leaves. Similar results have been reported by Ibn Maaouia-Houimli et al. (2011) on three pepper cultivars, and by Gandonou et al. (2011) on sugar cane.

The increasing salt concentrations gradually inhibited the growth of the aerial part and roots of the young plants of all three cultivars. Our results corroborated those of Ghosh et al. (2013) and Ben Yakoub et al. (2019) who reported that the growth of jute plants was inhibited by salt stress. Similar results were also reported in other vegetables such as amaranth (Wouyou et al., 2017); chili (Kpinkoun et al., 2019) and tomato (Kinsou et al. 2020). The results also revealed that from the seven growth parameters studied, three of the four parameters of the aerial part were significantly affected while none of the three roots growth parameters evaluated were significantly affected by the concentrations of NaCl used. These results indicated that the aerial part is more sensitive to salinity than roots. These results corroborated those of Kpinkoun et al. (2019) in chili who found that the aerial part is more affected by salinity than roots. Similar results have been reported in amaranth (Wouyou et al., 2017). On the other hand, an opposite trend has been reported in *vitis vinifera* (Hamrouni et al., 2011) where roots has been more affected by salinity than the aerial part. These observations indicated that the relative level of salinity sensitivity of aerial part and roots depends on the species.

The decrease in growth of the vegetative system

observed in plants can be explained by the fact that the NaCl acts by increasing osmotic pressure of the medium, which induced a reduction of water absorption by the root system (Ibn Maaouia-Houimli et al. (2011). Indeed, this developmental delay allows the plant to accumulate energy and resources to alleviate stress before the imbalance in the body increases to a point where the damage is irreversible. Furthermore, it has been reported that the reduction in plant growth, in particular in the accumulation of biomass, could be the consequence of water stress resulting from a decrease in the external osmotic potential and / or the accumulation of toxic ions (Odjegba et al., 2012). Further studies are needed to determine which of these physiological factors are preponderant in the tossa jute response to salinity.

It is well known in plants that there is substantial variation in resistance to salinity among cultivars of the same species (Lutts et al., 1995; Bhattacharjee, 2008; Gandonou et al., 2012; Wouyou et al., 2017). Our data confirm that this is also the case for tossa jute since a significant difference was observed among the salt tolerance indexes (STI) of cultivars at young plant stage. Indeed, the results revealed a significant difference among the STI of the three cultivars for the parameters shoot fresh mass and root dry mass. For all two parameters, cultivar *Ordinaire* exhibited the highest STI and therefore appears to be the most salt resistant cultivar. In contrast cultivar *Acc: Sud 2*, which has the lowest STI for these two parameters, appears to be the most salt sensitive; cultivar *5-Doigts* has an intermediary salt-resistance. These data revealed a variability in salt-resistance of the three jute cultivars tested at young plant stage as reported for other jute cultivars (Ghosh et al., 2013).

In several species, it has been reported that a cultivar resistant to the germination stage may appear to be susceptible to the growth stage of young plants and vice versa. This trend has been reported in sugar cane (Gandonou and Skali Senhaji, 2015), amaranth (Wouyou, 2017), wheat (Sahoo et al., 2018) and tomato (Kinsou et al., 2020). Our study revealed that cultivar *5-Doigts* which was the most salt resistant at germination stage appeared as an intermediary cultivar at young plant stage. In the same way, cultivar *Ordinaire* which was the most salt resistant at

young plant stage appeared as an intermediary cultivar at germination stage. Thus, salt resistance of a given tossa jute cultivar at germination stage does not secure its salt resistance at further growth stage. However, cultivar *Acc :Sud 2* maintained its status against salt stress either at germination stage or at young plant stage. These observations indicate that the responses of cultivars / varieties of the same species to salinity at different developmental stages depend not only on the species but also on the cultivars / varieties considered.

Conclusion

Salinity negatively affected seed germination and plant growth in the three tossa jute cultivars evaluated with a difference among them. Cultivar *5-Doigts* appeared as the most resistant to salt stress at germination stage; whereas cultivar *Ordinaire* followed by *5-Doigts* was the most salt resistant at young plant stage. Thus, for the first time, we have demonstrated that there is variability between the levels of salt resistance of the two local cultivars of tossa jute from Benin. Cultivar *Ordinaire* may be recommended to growers in salt affected areas while growers in other areas may produce any of the three cultivars.

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