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Physiological quality of yellow passion fruit seed produced under saline water, NPK and bovine biofertilizer

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Brazil is the largest producer of passion fruit, having the Northeast region as the main producing region, where orchards are formed almost exclusively from seed. This work aimed to evaluate the influence of different qualities of water and four levels of liquid manure applied to the soil in the absence and presence of mineral NPK fertiliser on the physiological attributes of yellow passion fruit seeds. The seeds were produced in a field experiment conducted in Jaçanã county, Rio Grande do Norte State-Brazil and seed quality was assessed in the Laboratory of Seed Analysis (LSA) from Agrarian Sciences Centre of Federal University of Paraíba in Areia County, Paraiba State, Brazil. In the laboratory, the experimental design was completely randomised with 16 treatments in four repetitions. The bovine biofertiliser inhibited the seed quality obtained for plants irrigated with non-saline water, but increased the viability of seeds in plants irrigated with saline water. Characteristics evaluated were the first count of normal seedlings, and speed index germination (SIG, dry matter weight of roots and shoot). The mineral fertilisation of the soil with NPK increased the seed viabilityin plants irrigated with both non-saline and saline waters.

Key words: *Passiflora edulis*, salinity, organic fertilization, mineral fertilisation, seed production

INTRODUCTION

The yellow passion fruit (*Passiflora edulis*) is a tropical fruit that has had a cultivation area which has enhanced quickly in recent years and has occupied a prominent place in tropical fruit production (Meletti, 2011).

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In 2013, the national production was of 420 tons, despite the occurrence of virus and successive droughts in the Northeast, which is the largest producer of the fruit (Fruit-growing Brazilian Yearbook, 2014).

Most commercial orchards of passion fruit are comprised of seedlings obtained from seeds. However, in order to produce quality seedlings by sexual processes, choosing a good reproductive material is essential. Seed quality is defined along two broad dimensions: seed quality per se and varietal quality, which refers to the genetics of the seed. Seed quality per se consists of the health, physiological and physical attributes, such as the absence/presence of disease, whether grains are fully mature, and the absence/presence of inert material such as stones or dust weeds. The physiological condition of a seed refers to the state of the embryo and its ability to grow (seed germination and development) (Walsh et al., 2014).

The production and physiological seed quality are influenced by the availability of nutrients to plants, by affecting the formation of the embryo and reserve organs, as well as the chemical composition and, consequently, metabolism and force (Carvalho and Nakagawa, 2000). This influence was observed in other agricultural crops, such as corn (Bono et al., 2008) and millet (Abrantes et al., 2010), subject to nitrogen fertilisation. Panaytov (2006) also noted this trend ofimprovement of the physiological quality of seeds when pepper plants were fertilised on a leaf with NPK.

It is known that the cultivation of yellow passion fruit in saline soils or in areas irrigated with saline water damages both the seedling formation quality (Mesquita et al., 2012) and the final quality of the fruit (Freire et al., 2014). It is possible that the quality of seeds from fruits harvested in plants subjected to salt stress during cultivation is also compromised. However, they are not checked frequently; in pertinent literature, studies have reported the effect of salt stress in mother plants regarding the seed quality. These data are of great importance, because producers and owners of nurseries in regions with a shortage of good quality water use seeds from plants produced under irrigation with saline water to produce seedlings.

The liquid biofertiliser obtained from the fermentation of fresh cattle manure has performed as a mitigating effects of salinity of substrates and the irrigation water used on seedlings production (Mesquita et al., 2010) and the cultivation of passion fruit plants (Dias et al., 2013) in semi-arid regions, where there is a predominance of sources of saline water; often, this is the only alternative to irrigation. It is necessary to determine whether the reducing effects extend to the seeds produced by plants subjected to salt stress. Bruno et al. (2007) assessed the physiological quality of carrot seeds under different fertiliser sources and found that the organic compound in the presence of biofertiliser resulted in more vigorous seeds compared to those without an organic compound.

Therefore, the objective of this work was to evaluate the physiological attributes of yellow passion fruit seeds produced from plants irrigated with saline and not saline water, with and without the liquid biofertiliser applied to the soil, in the presence and absence of mineral fertilisation with NPK.

MATERIALS AND METHODS

The experiment was conducted in Seed Analysis Laboratory (SAL) of Agrarian Science Center from Federal University of Paraiba, in Areia County Paraiba State, Brazil, during the period of June to December, 2013.

The seeds used in the experiment were collected from plants of yellow passion fruit subjected to 16 treatments applied to the soil, during the period March 2012 to May 2013, in Jaçanã County Rio Grande do Norte State, Brazil. The treatments were distributed in the field in three repetitions at random, using a factorial arrangement 2 × 4 × 2, referring to the two types of water: saline (CEa 4.5dS m^{-1}) and non-saline (CEa 0.35dS m^{-1}), four levels of bovine biofertiliser diluted in water in the proportions of 0, 33, 66 and 100%, and soil with and without mineral NPK; in total, there were 48 plots.

Seeds were collected in all treatments and replicates; in this way, the experimental design used to test the seeds in laboratory was the same used for the cultivation of plants. Therefore, 48 individual samples with approximately 400 seeds in each plot were obtained. The seeds were collected from ripe fruits, by removing all of the pulp, which was placed in a glass container and left to ferment without water in a shaded location (Rizzi et al., 1998). After three days, the pulp was placed on a sieve and washed in running water, which facilitated the removal of mucilage; later, the excess water was withdrawn and the seeds were placed on sheets of newspaper to dry in the shade. In the Seed Analysis Laboratory, 50 seeds were distributed in two paper towels and covered with one more moistened with distilled water, in the amount of three times the weight of the paper. The rolls were wrapped in transparent plastic bags, 0.04 mm thick, to avoid water loss through evaporation and taken to the germination plant with the temperature regulated between 20 and 30°C and a photoperiod of 8/16 h (light/dark).

Evaluation of the number of seeds germinated was performed seven days after sowing, repeating the count every three days, finishing at 28 days. The criterion used in the ratings was normal seedlings, according to the recommendations of RAS (Brasil, 2009). The first count was performed along with the test of twinning, computing the percentage of normal seedlings on the seventh day after sowing. The speed index Germination (SIG) was determined by daily counts of the number of germinated seeds, at seven to 28 days after sowing, the index of which was calculated according to the formula $GSI = (G_1/N_1) + (G_2/N_2) + ... + (G_n/N_n)$, as proposed by Maguire (1962). At final of the seed germination test (28 days), the emerged seedlings were separated into shoots and roots, and then the material was dried in an oven with forced air circulation, set at 65°C until a constant weight was reached. After drying, the material was placed on an analytical scale for determination of the dry matter of the shoots and roots. The data were submitted to variance analysis by F-test and data relative to water irrigation and mineral fertilisation were compared by Tukey's test with 5%probability; those related to doses of biofertiliser, were subjected to regression analysis. The software SAS was used for data analyses.

RESULTS AND DISCUSSION

The interaction between irrigation water salinity x mineral

Table 1. Summary of the analysis of variance for the first count number of normal seeds (FC), speed index germination (SIG), seed germination percentage (SG%), dry matter root (DM Root) and shoot (DM shoot).

FV	GL	Medium square and significance of variables									
		FC		SIG		SG%		DM Root		DM Shoot	
Water (W)	1	594.1406	**	0.3292	**	100.0000	**	0.0001	**	0.0015	**
Biofertilizer (B)	3	2076.0156	**	1.6120	**	253.9583	**	0.0000	**	0.0015	**
Fertilizer (F)	1	5531.6406	**	3.9551	**	600.2500	**	0.0001	**	0.0070	**
W * B	3	1644.1406	**	1.3214	**	537.7917	**	0.0002	**	0.0012	**
W * F	1	1.8906	ns	0.0834	NS	6.2500	NS	0.0000	NS	0.0016	**
B* F	3	1434.8906	**	0.9216	**	84.7917	**	0.0003	**	0.0024	**
W * B * F	3	1623.6406	**	0.6786	**	108.8750	**	0.0000	**	0.0006	**
Error	48	10.8698		0.0337		7.4375		0.0000		0.0000	
CV		5.5900		3.8900		2.9800		9.4100		6.9800	
Average		60.7656		4.5642		91.4375		0.0174		0.0640	

Significance level (**) 1%, and (*) 5% probability by F test.

fertilisation with NPK x bovine biofertiliser levels exercised significant effects on physiological quality in passion fruit seeds for all of the variables analysed (Table 1). It appears that in seeds that received mineral fertilisation with NPK, the values for the first count of normal seedlings were higher than those obtained in the treatments without fertilising. However, the seeds produced under irrigation with saline water (Figure 1B) showed higher values of the first count of normal seedlings when compared to those produced with good quality water (Figure 1A).

The increase in the levels of biofertiliser applied to soil reduced the first count values of normal seedlings of the seed obtained from irrigation with non-salinewater and without the supply of mineral fertilisation linearly from 80.04 to 16.41. However, with the application of NPK fertiliser, the first count of normal seedlings of yellow passion fruit increased until the level of 22.33% biofertiliser. For seedlings from plants irrigated with saline water (Figure 1B) treated with mineral fertilisation with NPK, the data of the first count did not fit any mathematical model, with an average of 54.6% germination. Already in the presence of fertiliser, the first count of normal seedlings had increased by 30.93% (Figure 1B).

The superiority of the saline water treatments, and that with biofertiliser and fertilisation with NPK, may be a reflection of the increase of nutrient levels, likeP provided by irrigation with saline water, fertiliser and biofertiliser application. Evaluating the mineral composition of yellow passion plants, irrigated with saline water and the application of biofertiliser, Freire et al. (2013) found that foliar phosphorus levels were higher in plants irrigated with saline water. Also, Nascimento et al. (2011) verified that the biofertiliser was associated with fertilisation with NPK, which increased the levels of phosphorus in the leaf dry matter of plants of the yellow passion fruit.

According to Taiz and Zeiger (2013), P is a vital nutrient in the composition of ATP, and in conditions of deficiency, plants have reduced growth. In seeds, it is estimated that 75% of P is in the form of phytic acid, providing P in the early stages of germination (Zucareli, 2011), which is of fundamental importance for the first count feature. However, answers to the application of P in the first count of seeds vary according to the species and even between varieties within the same species, as noted by Fidellis et al. (2013) in different rice cultivars, which showed different responses to the presence of phosphorus. Vasquez et al. (2014) also did not observe any differences in the physiological quality of seeds of C*rambe abyssinica* produced with phosphate fertilisation.

The germination speed index (SIG) of seeds produced under irrigation with good quality water (Figure 2A) was lower than that of seeds produced with saline water (Figure 2B). This result can be explained by the chemical quality of the water, which provided greater nutrient availability to plants, as reported by Freire et al. (2010) when they assessed the number of yellow passion fruit seeds of plants irrigated with saline water.

In spiteof the use of non-saline and saline water for the irrigation of yellow passion fruit, the seeds of plants that received NPK fertiliser presented more SIG, which is possibly due to the better nutritional conditioning of plants, which positively reflects on seed quality. Barbosa et al. (2011) observed an increase in the SIG seed bean along with the increase of doses of N, as well as Silva et al. (2011) working with P, also found increasing SIG in Sunflower culture (*Helianthus annuus* L.). The seeds produced from plants irrigated with saline water and without fertilising NPK, showed a reduction of SIG, with increased levels of bio-fertiliser applied (Figure 2A). For the seed produced under irrigation with saline water (Figure 2B), in the absence of NPK mineral fertiliser, the SIG presented a decrease to the level of 50% of the biofertiliser, which thereafter resumed growth. With the application of NPK mineral fertiliser, the SIG reduced

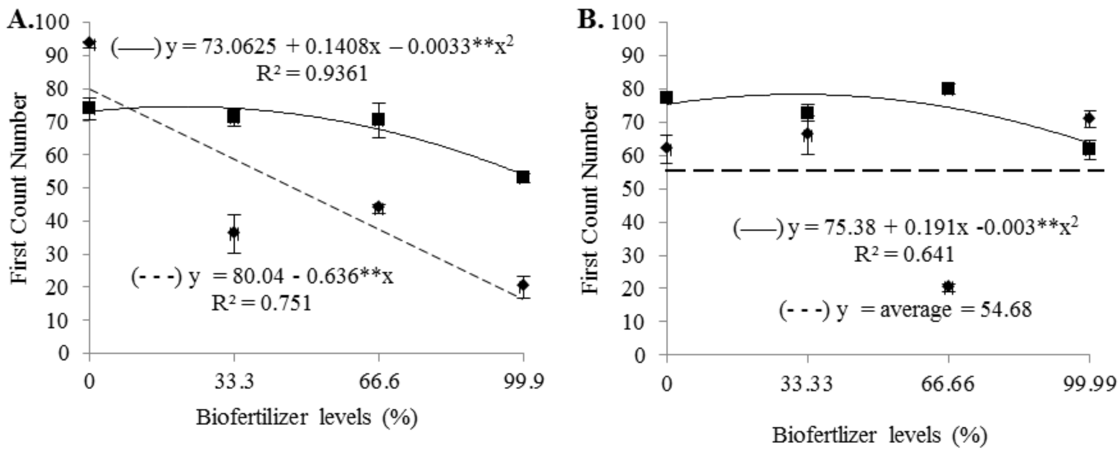

Figure 1. First count number of normal seedlings of yellow passion fruit irrigated with non-saline water (A.) and saline (B.) on presence (—) and absence (---) of mineral fertilizer NPK, as a function of bovine biofertilizer levels.

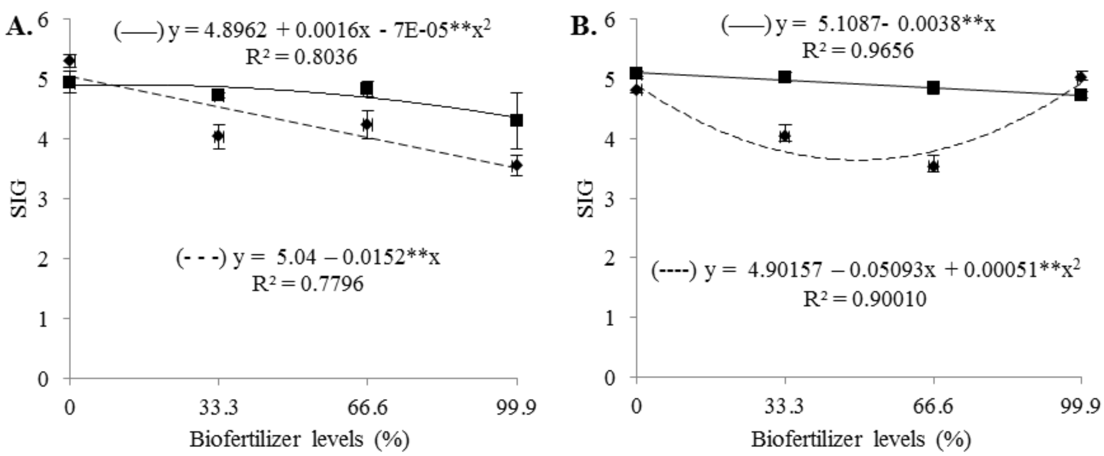

Figure 2. Speed Index germination (SIG) of seed yellow passion fruit irrigated with non-saline water (A.) and saline (B.) on presence (—) and absence (---) of mineral fertilizer NPK, as a function of bovine biofertilizer levels.

as the levels of biofertiliser applied to the ground increased.

Seed germination percentage of yellow passion fruit was influenced by the quality of irrigation water used on plants (Figure 3). The plants irrigated with good quality water produced seeds that showed a smaller percentage of germination than the seeds produced in plants irrigated with saline water (Figure 3A and B).

In plants irrigated with non-saline water, in the absence of mineral fertiliser, the seeds showed a linear reduction in seed germination percentage with increased levels of biofertiliser. In the presence of mineral fertilisation with NPK, the seeds showed a greater percentage of germination, although they followed the trend of reduction in increased levels of biofertiliser (Figure 3A). The germination of seeds produced in plants irrigated with saline water and who did not receive mineral fertilisation followed the same trend observed for the SIG, with reduced germination up to a level of 47% for biofertiliser and then a percentage increase (Figure 3B). For the seeds produced by mineral fertilisation, the data do not fit any mathematical model, with an average of 92.7% germination. Panaytov et al. (2006), working with pepper plants fertilised with NPK via the foliar route, obtained higher percentages of germination and dry matter weight with increasing doses of fertiliser, proving the relationship between plant nutrition and the vigour of seeds.

The results obtained, where the mineral fertilisation resulted in seeds with the highest percentage of germination in both cases, contrast with the other

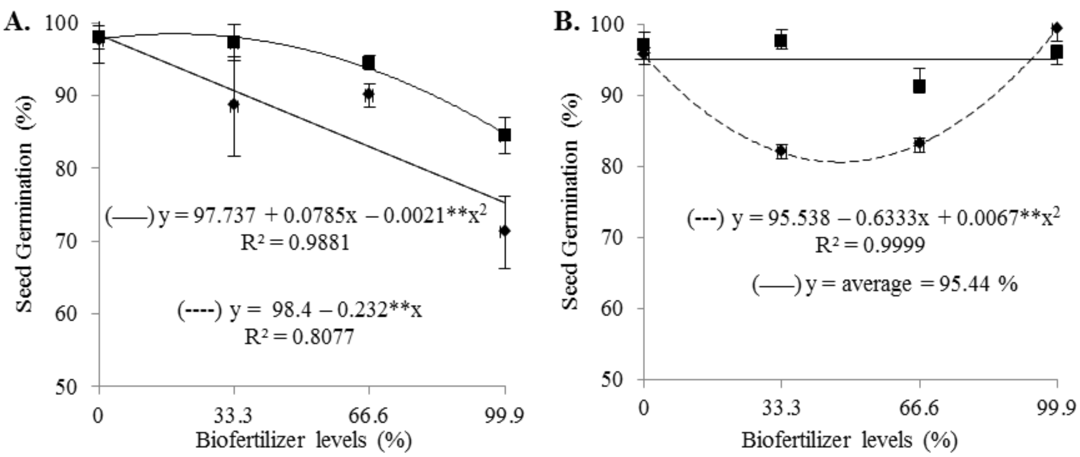

Figure 3. Seed germination percentage of yellow passion fruit underirrigated with non saline water (A) and (B) saline on presence (—) and absence (---) of mineral fertilizer NPK, as a function of bovine biofertilizer levels.

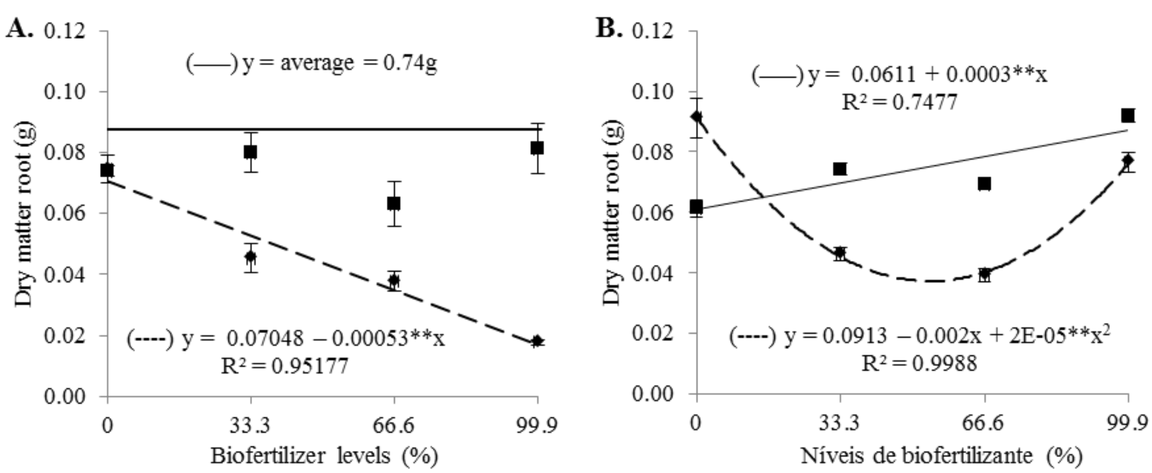

Figure 4. Dry matter root of yellow passion fruit seedlings irrigated with non-saline (A) and saline water (B.) on presence (—) and absence (---) of mineral fertilization with NPK, as a function of bovine biofertilizer levels.

projects developed using other cultures. Singh et al. (2013) observed that the germination of seeds of rice plants did not vary in plants grown under different nutritional conditions. However, Jevdovic et al. (2013) reported the greater percentage of germination in seeds of *Calendula officinalis* L. in plants receiving a higher dose of NPK. The dry matter of roots in plants irrigated with non-saline water and fertilised with NPK showed a reduction to the level of 67% for biofertiliser. In the treatments without mineral fertilisation, the data do not fit any mathematical model, showing an average of 0.017 g (Figure 4A). The root dry matter of seedlings from plant seeds irrigated with saline water, in the absence of mineral fertilisation, presented the same trend of shoot dry matter, with a reduction to the level of 37.5%, and then an increase (Figure 4B). Plant seeds produced on NPK fertiliser as soon as the biofertiliser levels increased had an increased root dry mass index (Figure 4B). Bruno et al. (2007), working with carrot, found that the organic compound applied along with the biofertiliser promoted more vigorous seeds when compared to seeds produced in plants without the application of biofertiliser. Already, Freire et al. (2011) found no significant differences in dry matter in the roots of coffee plants when the mother plants were fertilised with different levels of fertiliser via fertigation.

The biofertiliser presented results that were more expressive of seed quality in yellow passion fruit plants, when the mineral fertilisation was used concomitantly, irrespective of water quality. There are no published

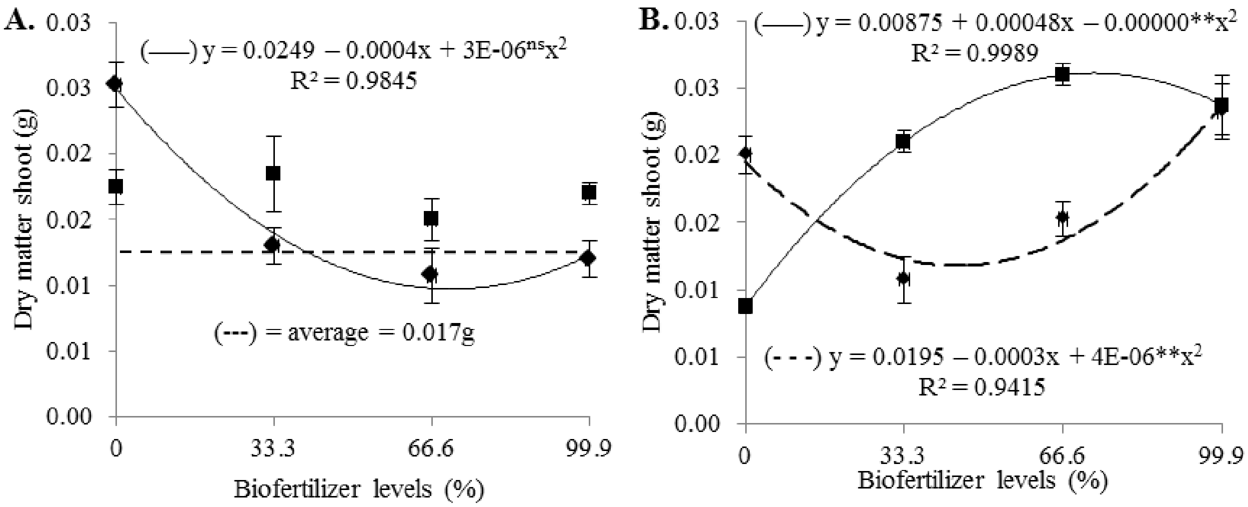

Figure 5. Dry matter shoot of yellow passion fruit seedlings irrigated with non-saline (A.) and saline water (B.) on presence (—) and absence (---) of mineral fertilization with NPK, as a function of bovine biofertilizer levels.

works correlating the application of biofertiliser with the physiological quality of passion fruit seed; however, other works with the culture of passion fruit and irrigation with saline water demonstrate that there is a synergism between mineral fertilisation, irrigation and biofertiliser with saline water, as shown by Campos et al. (2007) and Nascimento et al. (2011) on fruit quality and yellow passion fruit plant nutrition, respectively.

The dry matter of shoots was the highest in seeds from plants irrigated with saline water (Figure 5A and B). For the seeds produced under irrigation with good quality water, in the presence of mineral fertilisation with NPK, the data do not fit any mathematical model, with an average of 0.0745 g (Figure 5A). For the seeds produced without fertilisation, the shoot dry mass was reduced with increasing levels of bio-fertiliser applied. Probably because the bovine biofertiliser is a bioactive compound from microorganisms, which once provided on the ground, without fertilisation, spawn competition between microorganisms and plants for the nutrients present, reducing the amount of reserve that can be translocated to the future seeds, causing a loss of seedling vitality.

The shoot dry matter obtained from seedlings of plants irrigated with saline water on treatments without fertilisation with NPK presented a reduction to the 50% level of biofertiliser, with growth after this point (Figure 5B). In the presence of mineral fertilisation, the shoot dry matter presented increments with increased levels of biofertiliser applied to the mother plants. Dutra et al. (2012) did not observe any responses to dry matter in cowpea (*Vigna unguiculata*) seeds when the mother plants were fertilised with N. However, Toledo et al. (2007), observed an increase in the dry mass of shoots of plants of Guinea sorghum (*Sorghum bicolor*) when seeds were derived from plants fertilised with N.

Conclusions

(i) The bovine biofertilizer inhibits the seed quality in plant irrigated with non-saline water but it increases seed quality in plants irrigated with saline water;
(ii) The mineral fertilization of the soil with NPK increases the seed quality in plants irrigated with both types of water, non-saline and saline water.

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