AGRIVITA Journal of Agricultural Science. 2020. 42(1): 110–119

AGRIVITA
Journal of Agricultural Science
www.agrivita.ub.ac.id

Effect of Vermicompost and Nitrogen on N, K, Na Uptakes and Growth of Sugarcane in Saline Soil

Djajadi Djajadi[1*], Roni Syaputra[1], Sulis Nur Hidayati[1] and Yaumil Khairiyah[2]

[1] Indonesian Sweetener and Fiber Crops Research Institute, East Java, Indonesia
[2] Universitas Brawijaya, East Java, Indonesia

ARTICLE INFO

Keywords:
Nitrogen
Saline soil
Sugarcane
Vermicompost

Article History:
Received: September 18, 2019
Accepted: December 13, 2019

*) Corresponding author:
E-mail: jaydjajadi61@gmail.com

ABSTRACT

Areal cultivation of sugarcane in Indonesia is expanded to soil with high salt content. There is an urgent need to find an appropriate soil amendment fertilizer to minimize negative effect of saline soil on sugarcane growth. The objective of the research was to determine the effect of vermicompost and nitrogen on N, K and Na uptakes and growth of sugarcane grown in saline soil. The treatments consisted of three rates of vermicompost (equivalent to 0, 10, 20 t/ha) and three rates of nitrogen fertilizer (equivalent to 50, 75 and 100 kg N/ha). Nine combinations of treatments were arranged in randomized block design with four replicates. Sugarcane commercial variety of 'Bululawang (BL)' was planted for 4 months in soil with Electrical Conductivity (EC) of 4.12 dS/m. Results showed that interaction between vermicompost and nitrogen fertilizer rate increased N, K uptakes and growth of sugarcane in saline soil. Addition amount of vermicompost and nitrogen reduced soil EC and Na/K ratio uptake of sugarcane. In this study, addition of 20 t vermicompost together with 50 kg N/ha induced sugarcane production with the highest biomass during 4 month planted in saline soil.

INTRODUCTION

Expansion sugarcane cropping area in Indonesia is directed to marginal land because the available arable land is mainly used for food crops. One of the marginal land which is used for sugarcane plantation is saline soil which is spread out along the north coastal region of Java Island (Sembiring, Gani, & Iskandar, 2008). High concentration of salt in soil solution has a negative effect on growth and development of sugarcane. To minimize the negative effect of high salt concentration on sugarcane growth, management of saline soil becomes the essential factor in the success of the expansion sugarcane cultivation area in the saline soil. As part of production management, the effort is subjected by using soil amendment combined with plant nutrition, especially nitrogen.

Sugarcane has been classified as moderate to moderately sensitive to salinity (Hussain et al., 2019; Nelson & Ham, 2000). The deleterious effects of salt concentration on growth and yield of sugarcane have been reported by many researchers (Cavalcante Granja et al., 2018; Lingle & Wiegand, 1997; Rai & Singh, 2013). Hussain, Khan, Ashraf, Rashid, & Akhtar (2004) noted that growing media with medium salt concentration reduced growth of two sugarcane tested cultivars. Previously, Joshi & Naik (1980) reported that excess of salt had negative effect on sugarcane which was indicated by inhibition of growth, reduced chlorophyll synthesis, and decreased uptake of K^+ and Ca^{++}. Furthermore, Anitha, Mary, Savery, Sritharan, & Purushothaman (2015) found that elevation of salt concentration of the shoot reduced in root length, leaf area, total chlorophyll, and cell membrane stability of both varieties CoC 671 and CoC 24 of sugarcane.

High salt content in soil elevates high osmotic potential of the soil solution that inhibits water and nutrient uptake (Maie Mohsen, Abo-Kora, & Abeer Kassem, 2016). Many researchers reported the role of vermicompost in alleviating negative characteristics of degraded saline soil

ISSN: 0126-0537 Accredited First Grade by Ministry of Research, Technology and Higher Education of The Republic of Indonesia, Decree No: 30/E/KPT/2018

Cite this as: Djajadi, D., Syaputra, R., Hidayati, S.N., & Khairiyah, Y. (2020). Effect of Vermicompost and Nitrogen on N, K, Na Uptakes and Growth of Sugarcane in Saline Soil. *AGRIVITA Journal of Agricultural Science*, *42*(1),110–119. http://doi.org/10.17503/agrivita.v41i0.2364

(Deng, Meng, Li, Wu, & Li, 2018; Oo, Iwai, & Saenjan, 2015; Sandoval, Martínez, & Torres, 2015) which resulted in increasing growth of many crops (Akhzari, Pessarakli, & Khedmati, 2016; Elayaraja & Singaravel, 2017 Thiruneelakandan & Subbulakshmi, 2014).

Saline soil influences available soil nitrogen for supporting growth of plant due to depression of N mineralization (Pathak & Rao, 1998). The mineralization of nitrogen in saline is low because the microbial community and activity are inhibited (Hassan, Abd, & Ahmed, 2016; Singh, 2016). Addition of vermicompost to such degraded soil has been proved to increase nitrogen mineralization (Flores-Sanchez, Pastor, Rossing, Kropff, & Lantinga, 2016; Walpola & Wanniarachchi, 2009).

Nitrogen is an essential nutrition required by sugarcane for supporting its growth and yield (Wiedenfeld & Enciso, 2008). Addition of nitrogen and vermicompost may have synergistic effects on sugar cane grown in saline soil. The objective of the research was to measure the effects of vermicompost and nitrogen on N, P, K, Na uptake, and growth of sugarcane in saline soil.

MATERIALS AND METHODS

The experiment was conducted at Malang Research Station of Indonesia Research Institute for Sweetener and Fiber Crops with altitude of 534 m above sea level and average temperature of 27-29°C from May up to December 2018. Commercial sugarcane variety of ‘Bululawang (BL)’ was planted in the saline soil with EC of 4.12 dS/m.

The saline soil for planting media was chosen from sugarcane expansion cultivation area of Lamongan District, East Java with coordinate of 06°54’41,10”S and 112°11’46”E. Soil was collected randomly from 10 points by digging them at the depth of 20 cm, and then the soil was air dried in the soil preparation room. Dried soil was sieved in 2 mm filter to remove gravels. Finally, 20 kg of the sieved soil was placed in the plastic pot (30 cm in diameter and 38 cm in depth). About 200 g of the dried sieved soil was taken to be analyzed in order to determine the characteristics of the saline soil.

The treatments consisted of two factors, i.e.: (1) Vermicompost and (2) Nitrogen fertilizer. Three rates of vermicompost tested were (1) 0 t/ha, (2) 10 t/ha (equivalent to 100 g/pot), and (3) 20 t/ha (equivalent to 100 g/pot). The rates of nitrogen fertilizer with source of Amonium Sulpathe (ZA) were (1) 50 % recommended N rate (2.50 g/pot), (2) 75% recommended N (3.75 g/pot), (2) 100% recommended N rate (5 g/plot). Those treatments were arranged using Randomized Block Design with four replicates.

Sugarcane was planted in the pot using one bud set. Vermicompost was mixed thoroughly five days prior to planting. Nitrogen fertilizer (ZA) was added twice, half doses at one month after planting and the rest was applied 2 month after planting. Addition of P fertilizer (SP36) was conducted at one month after planting, while K fertilizer (ZK) was applied at 2 months after planting.

Irrigation was done using tap water with interval 5 days. Volume of water added was based on soil field capacity. Hence, pot plus soil was weighed to calculate the difference between water content of the media and water content of soil field capacity to determine volume of water added. Weeding was done manually when necessary.

Measurement of growth parameters was started at 2 months after planting and to be repeated with interval of one month until 4 months after planting. The observed growth parameters were stem height, stem diameter and number of tillers. Changes of soil media EC was monitored once a month started at 2 months after planting. Soil sample of each treatment was taken at the depth of 10 cm and then it was analyzed for EC. Biomass of sugarcane (stem, leave and root) was collected at 4 months after planting. Fresh weight of biomass was measured by digital scales. After that, fresh biomass was dried using oven at 120°C for 4 days. Dried biomass was then weighted using digital scales. N uptake by plant was analyzed using Kjeldahl method, P uptake was analyzed using Olsen method, while K uptake was measured by flame photometer.

The collected data were analyzed using ANOVA to determine the effect of the treatments being applied. The mean comparisons were conducted using Least Significant Differences at p = 0.05.

RESULTS AND DISCUSSION

The soil used as a sugar cane growing media has very low in soil organic content, low content of total nitrogen and available P (Table 1). In contrast, the soil contains very high EC (4.12 dS/m) and exchangeable sodium (1.68%). The high EC value of the soil might be due to irrigation or intrusion of sea water. The site of collected soil sample is part of northern Java Sea and the distance is about 0.5 km from the sea.

Very high content of EC and exchangeable Na of the soil might not suitable for sugarcane because high salt content in soil cause inhibition of growth, chlorophyll synthesis, PEPC ase activity, and decreased the uptake of K^+ and Ca^{++} ions of sugarcane (Joshi & Naik, 1980). In addition, Cruz, da Costa Ferreira Júnior, & dos Santos (2018) found that Na accumulation declined plant growth and elevated electrolyte leakage with destruction to the photochemical part of photosynthesis.

Addition of vermicompost, nitrogen fertilizer, and the interaction between vermicompost and nitrogen had significant effect ($p < 0.05$) on soil EC, N and K uptakes, and Na/K ratio. In general, application of vermicompost together with nitrogen fertilizer was able to eliminate the negative effect of saline soil, hence they induced the growth of sugarcane after 4 months planting.

The interaction between vermicompost and nitrogen rate had significant effect on EC. Addition of vermicompost together with nitrogen significantly decreased EC value of the soil (Fig. 1). Elevating N rates at the same amount of vermicompost did not effect on EC value at every month of measurement. However, increasing addition of vermicompost rates at the same rate of nitrogen decreased EC content of the soil at each month of observation. At 2 and 3 months observation, the lowest EC value was found at the soil with addition of 20 t vermicompost and 75 kg N/ha, i.e. 3.39 dS/m and 3.11 dS/m, respectively. After 4 months planting, the lowest value of EC (3.04 dS/m) was detected at additional 20 t vermicompost and 50 kg N/ha.

Table 1. The characteristics of the saline soil used for sugarcane growing media

Soil characteristics	Content/value	Category
EC (dS/m)	4.12	Very high
pH	7.10	Neutral
Organic-C (%)	0.98	Very low
Total N (%)	0.13	Low
Availaible P (ppm)	8.61	Low
Exchangeable K (me/100 g)	0.40	Medium
Exchangeable Na (me/100 g)	1.68	Very high
Cation Exchange Capacity (me/100 g)	37.8	High
Sand (%)	9	
Silt (%)	20	Clay
Clay (%)	71	

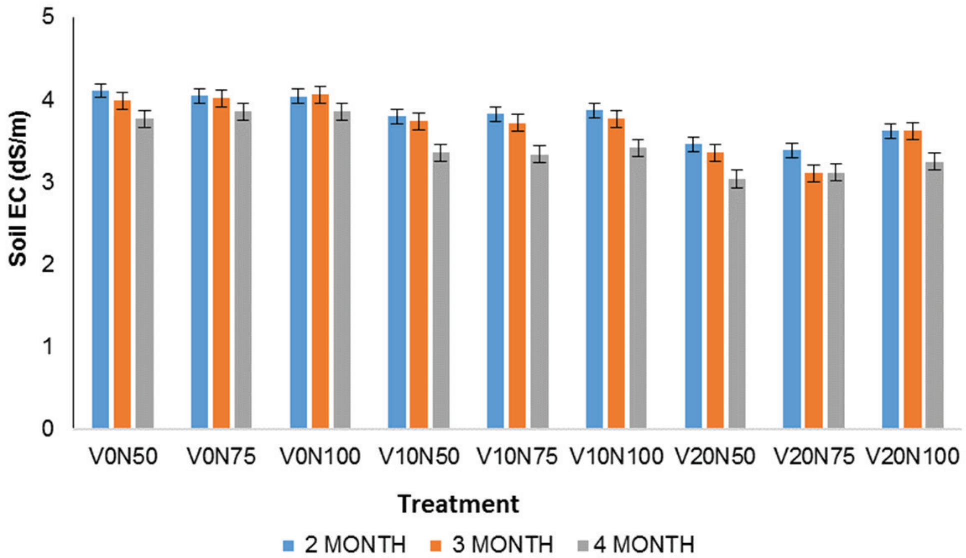

Fig. 1. Effect of interaction between vermicompost and nitrogen rate on soil EC at 2, 3, 4 months after planting of sugarcane (V= Vermiompost, V0 = 0 t/ha, V10 = 10 t/ha, V20 = 20 t/ha, N50 = 50 kg N/ha, N75 = 75 kg N/ha, N100 = 100 kg N/ha)

N, K Uptakes and Na/K Ratio

Interaction of vermicompost and nitrogen fertilizer had significant effect on N, K uptakes, and Na/K ratio. Addition of vermicompost and nitrogen in saline soil significantly effected N uptake by sugarcane after 4 months planting. In the absent of vermicompost (V0), the increase of N fertilizer rate significanly declined the amount of N taken up by sugarcane. However, when the amount of vermicompost increased, the amount of N absorped by sugarcane were accordingly escalated (Fig. 2). Similar finding was also reported by Yourtchi, Hadi, & Drazi (2013) that confirmed the nitrogen of potato tuber treated with vermicompost and nitrogen in the soil was higher than that with no vermicompost application.

After 4 months planting, the highest N uptake (2.77 g/plant) was observed in sugarcane planted for 4 month in saline soil which was added with 20 t vermicompost plus 50 kg N/ha (V20N75), while the lowest N uptake (1.54 g/plant) was found at sugarcane with no addition of vermicompost 75 kg N/ha (V0N75).

K uptake of sugarcane planted in saline soil for 4 months was significantly affected by interaction of vermicompost and N fertilizer (Fig. 3). The highest value of K (0.31 g/plant) taken up at 4 months was found at sugarcane treated with 20 t vermicompost and 40 kg N/ha (V20N50). In contrast, addition of N fertilizer at the rate of 75 kg N/ha with no vermicompost (V0N75) caused the least K uptake (0.16 g/plant). Similar results were also reported by Kandan & Subbulakshmi (2015) and Mahmud, Shamsuddoha, Issak, Haque, & Achakzai (2016). These conditions were usually attributed to chemical content of vermicompost which are rich in nutrients.

Na/K ratio in sugarcane planted in saline soil was significantly influenced by interaction of vermicompost and N fertilizer rate. The different effects of the treatments being applied on Na/K ratio were presented in Fig. 4. The highest Na/K ratio (18.4) was observed on the plants treated with 75 kg N/ha and absent of vermicompost (V0N75). The application of vermicompost was appeared to minimize Na/K ratio. Hence, the lowest value of Na/K ratio (9.7) was noted at the treament of saline soil with addition of 20 ton vermicompost and 50 kg N/ha (V20N50). Kopittke (2012) reported that addition of K^+ was observed to alleviate the toxic effects of Na^+ on root elongation of cowpea (*Vigna unguiculata* L.). In present study, Na/K ratio in sugarcane biomass decreased due to addition of vermicompost and N fertilizer might have positive effect on inducing the growth of sugarcane.

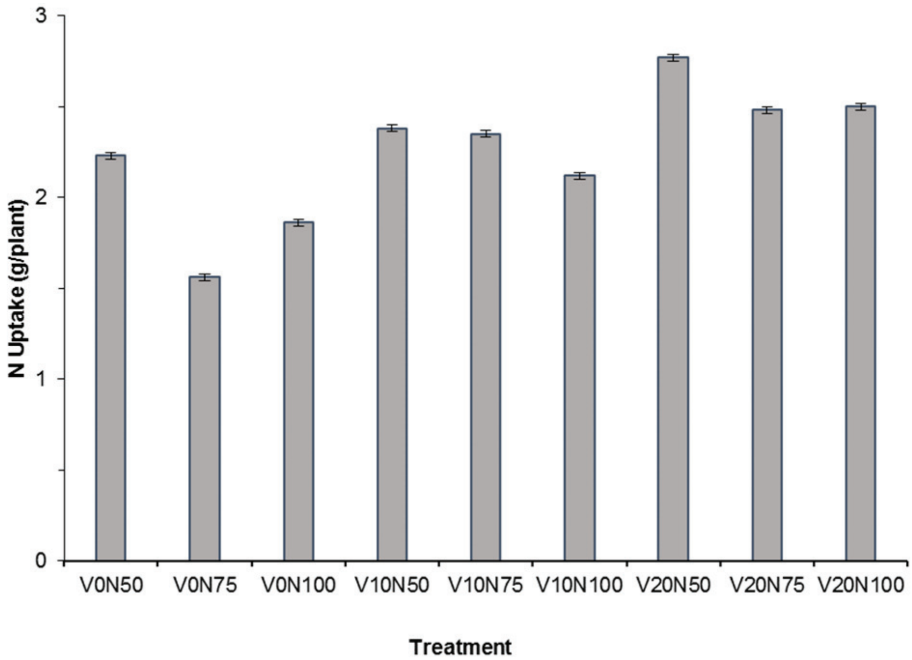

Fig. 2. Effect of interaction beween vermicompost and nitrogen rate on N uptake of sugarcane (V= Vermiompost, V0 = 0 t/ha, V10 = 10 t/ha, V20 = 20 t/ha, N50 = 50 kg N/ha, N75 = 75 kg N/ha, N100 = 100 kg N/ha)

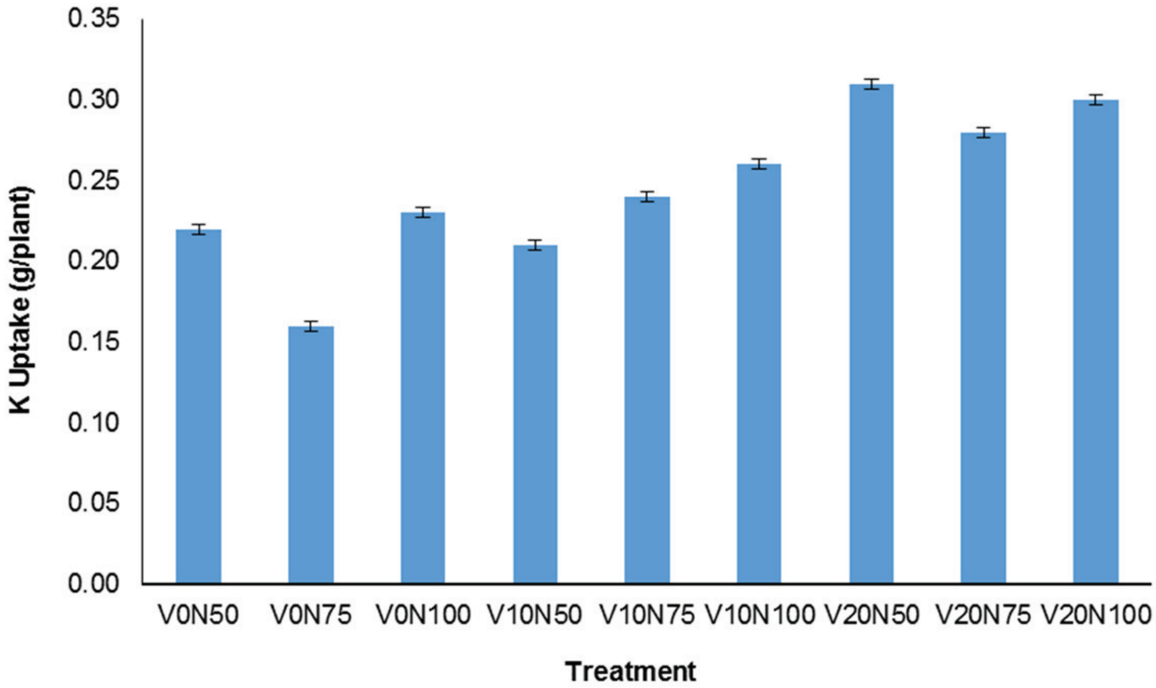

Fig. 3. Effect of interaction between vermicompost and nitrogen rate on K uptake of sugarcane (V= Vermiompost, V0 = 0 t/ha, V10 = 10 t/ha, V20 = 20 t/ha, N50 = 50 kg N/ha, N75 = 75 kg N/ha, N100 = 100 kg N/ha)

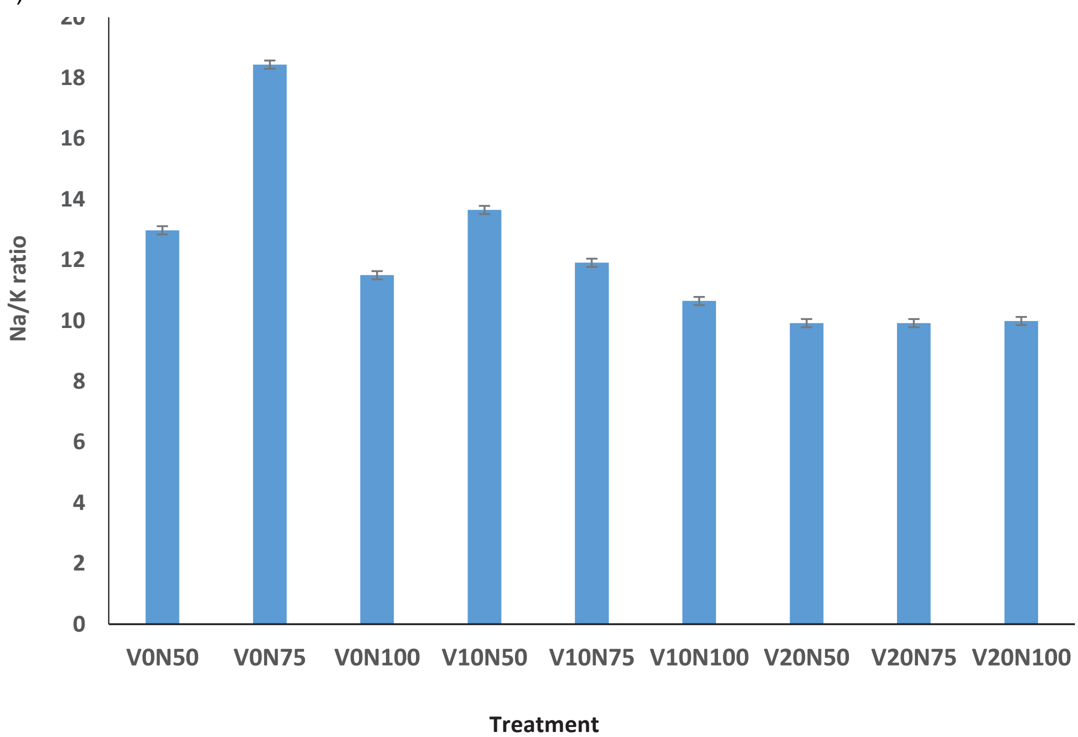

Fig. 4. Effect of interaction between vermicompost and nitrogen rate on Na/K ratio of sugarcane (V= Vermiompost, V0 = 0 t/ha, V10 = 10 t/ha, V20 = 20 t/ha, N50 = 50 kg N/ha, N75 = 75 kg N/ha, N100 = 100 kg N/ha)

Sugarcane Growth

Addition of vermicompost, nitrogen, and their interactions had significant influence ($p < 0.05$) on plant growth of sugarcane which were reflected from stalk length, number of tillers, and stem diameter of sugarcane after 2, 3 and 4 months planting. At 2 months, the application of both vermicompost and nitrogen increased stalk length (Fig. 5). The longest stalk of sugarcane (10.71 cm) was observed on the plants treated with 20 t vermicompost and 75 kg N/ha. After 3 and 4 months, sugarcane which had the longest stalk was detected on the plants supplemented with 20 t vermicompost and 50 kg N/ha with the value of 16.72 and 17.12 cm, respectively.

At the present study, number of tillers of sugarcane was significantly affacted by interaction of vermicompost and nitrogen rate. Number of tillers was increased significantly in accordace with the increase of the amount of vermicompost and nitrogen fertilizer, especially after 3 months planting (Fig 6). At 4 months, the highest number of tillers (11.27) was obtained from the plants treated with 10 t vermicompost and 75 kg N/ha, while the lowest number of tillers (1.01) was noted at those with only 45 kg N/ha with no vermicompost.

Interaction of vermicompost and N fertilizer had a significant effects on stem diameter of sugarcane which was planted in saline soil after 2, 3, and 4 months. Increasing the amount of vermicompost and N fertilizer resulted in the increase of stem diameter. Plants with biggest stem diameter were found in saline soil treated with 20 t vermicompost and 75 kg N/ha (V20N75) with values of 8.56 mm (2 months), 11.88 mm (3 months) and 18.06 mm (4 months) (Fig. 7). In contrast, the smallest stem diameter of sugarcane at 2, 3 and 4 months were observed in saline soil added with 50 kg N/ha only.

Biomass of sugarcane accumulated during 4 months grown in saline soil was significantly affected by interaction of vermicompost and N fertilizer rate. Increasing amount of vermicompost and N fertilizer induced sugarcane to accumulate more fresh and dried biomass (Fig. 8). Treatment of 20 t vermicompost and 50 kg N/ha (V20N50) yielded the weighest fresh (77.67 g) and dried biomass (29.2 g) of sugarcane after 4 months. Treatment of additional 10 t vermicompost and 100 kg N/ha (V10N100) was not significantly different to the treatment that produced the weighest biomass (V20N50).

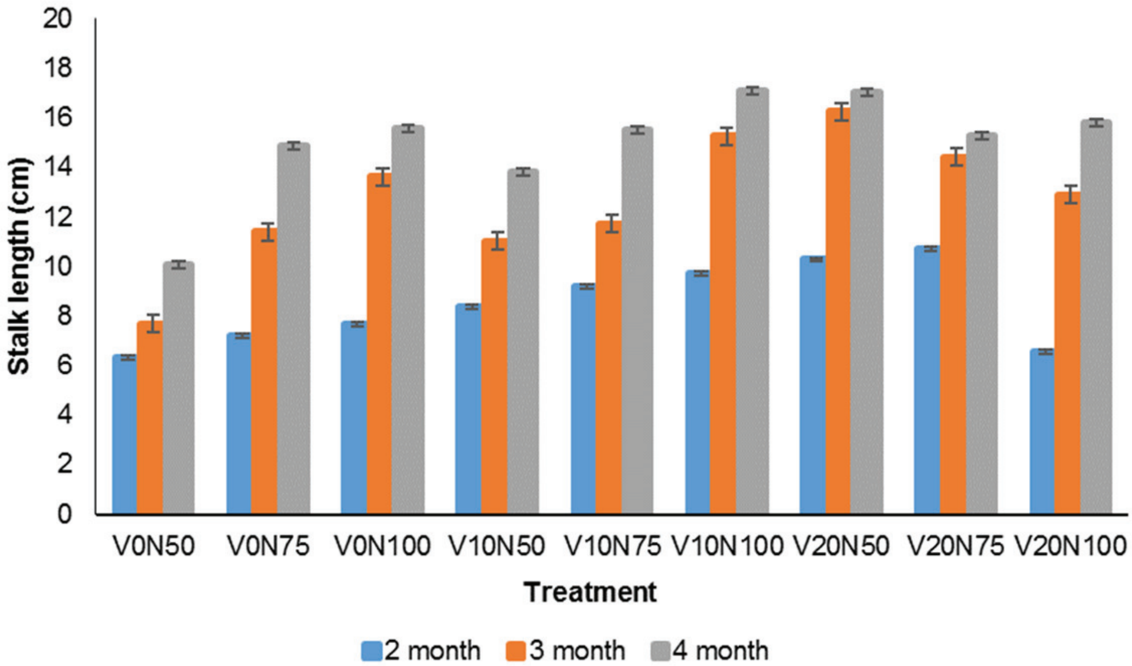

Fig. 5. Effect of interaction between vermicompost and nitrogen rate on stalk length of sugarcane at 2, 3, 4 months after planting (V= Vermicompost, V0 = 0 t/ha, V10 = 10 t/ha, V20 = 20 t/ha, N50 = 50 kg N/ha, N75 = 75 kg N/ha, N100 = 100 kg N/ha)

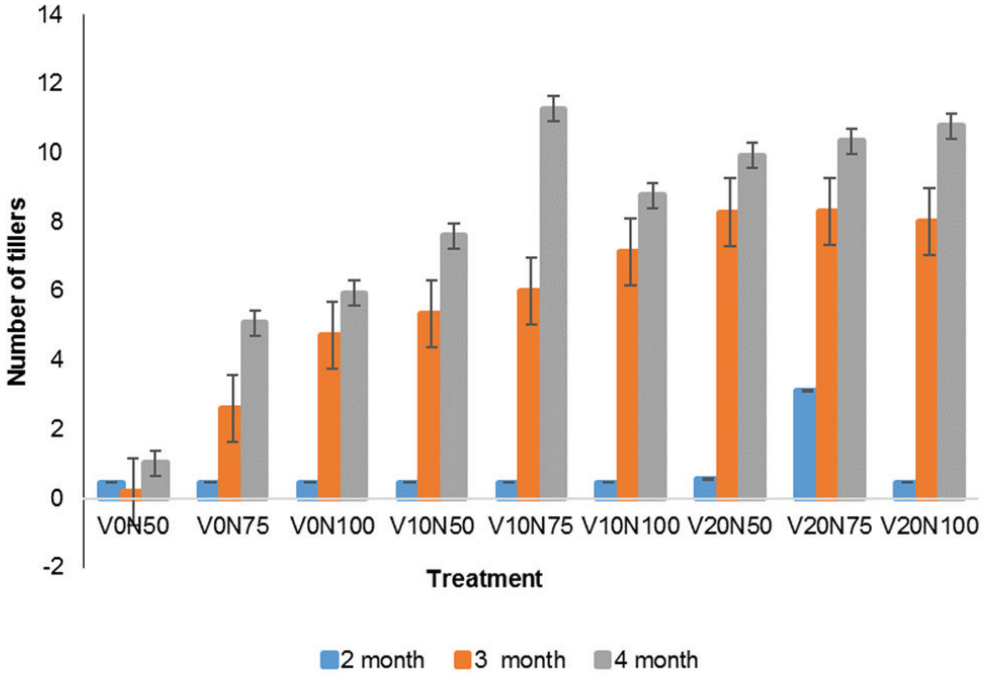

Fig. 6. Effect of interaction between vermicompost and nitrogen rate on number of tiller of sugarcane at 2, 3, 4 months after planting (V= Vermicompost, V0 = 0 t/ha, V10 = 10 t/ha, V20 = 20 t/ha, N50 = 50 kg N/ha, N75 = 75 kg N/ha, N100 = 100 kg N/ha)

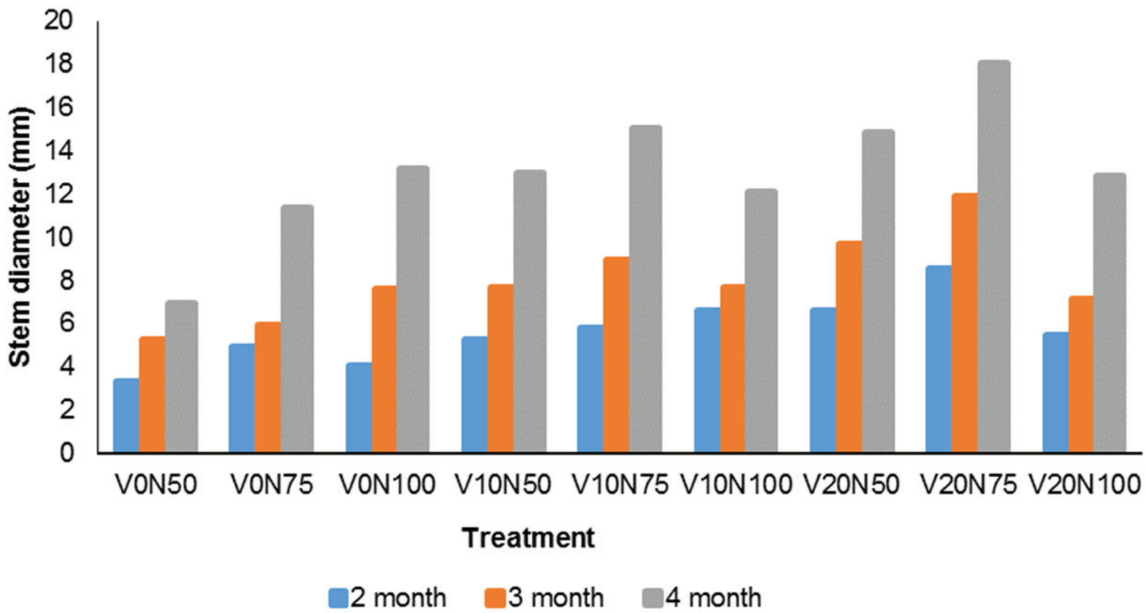

Fig. 7. Effect of interaction between vermicompost and nitrogen rate on stem diameter of sugarcane at 2, 3, 4 months after planting (V= Vermicompost, V0 = 0 t/ha, V10 = 10 t/ha, V20 = 20 t/ha, N50 = 50 kg N/ha, N75 = 75 kg N/ha, N100 = 100 kg N/ha)

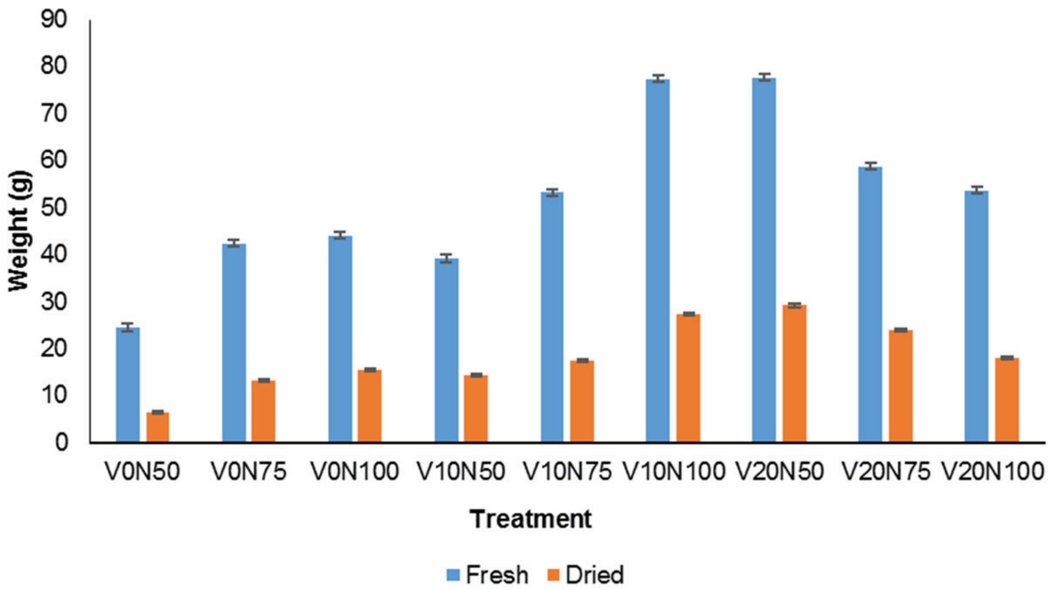

Fig. 8. Effect of interaction between vermicompost and nitrogen rate on biomass weight of sugarcane at 4 months after planting (V= Vermicompost, V0 = 0 t/ha, V10 = 10 t/ha, V20 = 20 t/ha, N50 = 50 kg N/ha, N75 = 75 kg N/ha, N100 = 100 kg N/ha)

CONCLUSION

Addition of vermicompost together with N increased N and K uptakes, and growth of sugarcane in saline soil. Application of 20 t vermicompost and 50 kg N/ha induced highest N and K uptakes by plants and biomass of sugarcane after 4 months planting.

REFERENCES

Akhzari, D., Pessarakli, M., & Khedmati, M. (2016). Effects of vermicompost and salinity stress on growth and physiological traits of *Medicago rigidula* L. *Journal of Plant Nutrition*, *39*(14), 2106–2114. https://doi.org/10.1080/01904167.2016.1193609

Anitha, R., Mary, P. C. N., Savery, M. A. J. R., Sritharan, N., & Purushothaman, R. S. (2015). Differential responses of sugarcane (*Saccharum officinarum* L.) varieties exposed to salinity under a hydroponic system. *Plant Archives*, *15*(2), 1055–1060. Retrieved from http://plantarchives.org/pdf 15-2/1055-1060 (3068).pdf

Cavalcante Granja, M. M., Lacerda e Medeiros, M. J., de Araújo Silva, M. M., Camara, T., Willadino, L., & Ulisses, C. (2018). Response to *in vitro* salt stress in sugarcane is conditioned by concentration and condition of exposure to NaCl. *Acta Biológica Colombiana*, *23*(1), 30–38. https://doi.org/10.15446/abc.v23n1.63513

Cruz, F. J. R., da Costa Ferreira Júnior, D., & dos Santos, D. M. M. (2018). Low salt stress affects physiological parameters and sugarcane plant growth. *Australian Journal of Crop Science*, *12*(8), 1272–1279. https://doi.org/10.21475/ajcs.18.12.08.PNE999

Deng, X., Meng, X., Li, Y., Wu, C.-Y., & Li, Q.-F. (2018). Effect of vermicompost on the physicochemical properties of coastal saline soil. In *Proceedings of the 2017 3rd International Forum on Energy, Environment Science and Materials (IFEESM 2017)* (pp. 1019–1023). Atlantis Press. https://doi.org/10.2991/ifeesm-17.2018.188

Elayaraja, D., & Singaravel, R. (2017). Effect of vermicompost and micronutrients fertilization on the growth, yield and nutrients uptake by sesame (*Sesamum indicum* L.) in coastal saline soil. *International Journal of Agricultural Sciences*, *13*(2), 177–183. https://doi.org/10.15740/has/ijas/13.2/177-183

Flores-Sanchez, D., Pastor, A., Rossing, W. A. H., Kropff, M. J., & Lantinga, E. A. (2016). Decomposition, N contribution and soil organic matter balances of crop residues and vermicompost in maize-based cropping systems in Southwest Mexico. *Journal of Soil Science and Plant Nutrition*, *16*(3), 801–817. https://doi.org/10.4067/s0718-95162016005000057

Hassan, K. U., Abd, W. M., & Ahmed, F. W. (2016). Study of microbial biomass activity in saline soils. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, *7*(1), 390–395. Retrieved from https://www.rjpbcs.com/pdf/2016_7(1)/[56].pdf

Hussain, A., Khan, Z. I., Ashraf, M., Rashid, M. H., & Akhtar, M. S. (2004). Effect of salt stress on some growth attributes of sugarcane cultivars CP-77-400 and COJ-84. *International Journal of Agriculture & Biology*, *6*(1), 188–191. Retrieved from http://www.fspublishers.org/Issue.php?y=2004&v_no=6&categoryID=23

Hussain, Sajid, Shaukat, M., Ashraf, M., Zhu, C., Jin, Q., & Zhang, J. (2019). Salinity stress in arid and semi-arid climates: Effects and management in field crops. In S. Hussain (Ed.), *Climate Change and Agriculture* (Ch. 12). IntechOpen. https://doi.org/10.5772/intechopen.87982

Joshi, G. V., & Naik, G. R. (1980). Response of sugarcane to different types of salt stress. *Plant and Soil*, *56*(2), 255–263. https://doi.org/10.1007/BF02205854

Kandan, T., & Subbulakshmi. (2015). Chemical nutrient analysis of vermicompost and their effect on the growth of SRI rice. *International Journal of Innovative Research in Science, Engineering and Technology*, *4*(6), 4382–4388. Retrieved from http://www.ijirset.com/upload/2015/june/115_Chemical.pdf

Kopittke, P. M. (2012). Interactions between Ca, Mg, Na and K: Alleviation of toxicity in saline solutions. *Plant and Soil*, *352*(1–2), 353–362. https://doi.org/10.1007/s11104-011-1001-x

Lingle, S. E., & Wiegand, C. L. (1997). Soil salinity and sugarcane juice quality. *Field Crops Research*, *54*(2–3), 259–268. https://doi.org/10.1016/S0378-4290(97)00058-0

Mahmud, A. J., Shamsuddoha, A. T. M., Issak, M., Haque, M. N., & Achakzai, A. K. K. (2016). Effect of vermicompost and chemical fertilizer on the nutrient content in rice grain, straw and post harvest soil. *Middle East Journal of Scientific Research*, *24*(2), 437–444. Retrieved from https://www.idosi.org/mejsr/mejsr24(2)16/34.pdf

Maie Mohsen, M. A., Abo-Kora, H. A., & Abeer Kassem, H. M. (2016). Effect of vermicompost and calcium silicate to reduce the soil salinity on growth and oil determinations of marjoram plant. *International Journal of PharmTech Research*, *9*(5), 235–262. Retrieved from https://www.researchgate.net/publication/304953422_Effect_of_vermicompost_and_calcium_silicate_to_reduce_the_soil_salinity_on_growth_and_oil_determinations_of_marjoram_plant

Nelson, P. N., & Ham, G. J. (2000). Exploring the response of sugar cane to sodic and saline conditions through natural variation in the field. *Field Crops Research*, *66*(3), 245–255. https://doi.org/10.1016/S0378-4290(00)00077-0

Oo, A. N., Iwai, C. B., & Saenjan, P. (2015). Soil properties and maize growth in saline and nonsaline soils using cassava-industrial waste compost and vermicompost with or without earthworms. *Land Degradation and Development*, *26*(3), 300–310. https://doi.org/10.1002/ldr.2208

Pathak, H., & Rao, D. L. N. (1998). Carbon and nitrogen mineralization from added organic matter in saline and alkali soils. *Soil Biology and Biochemistry*, *30*(6), 695–702. https://doi.org/10.1016/S0038-0717(97)00208-3

Rai, R. K., & Singh, P. (2013). Sodium salt induced utilization of phosphorus in sugarcane leaf laminae reduces sucrose contents. *Sugar Tech*, *15*, 165–176. https://doi.org/10.1007/s12355-012-0190-9

Sandoval, J. P. M., Martínez, A. E., & Torres, D. G. (2015). Effect of application of vermicompost on the chemical properties of saline-sodic soil of Venezuelan semiarid. *Acta Agronomica*, *64*(4), 301–306. https://doi.org/10.15446/acag.v64n4.47115

Sembiring, H., Gani, A., & Iskandar, T. (2008). Implications of salinity research in Aceh for Indonesia rice growing. In *International Workshop on Post Tsunami Soil Management* (pp. 97–113). Bogor, Indonesia: Balai Penelitian Tanah. Retrieved from http://balittanah.litbang.pertanian.go.id/ind/dokumentasi/prosiding/post tsunami/9hasil sembiring.pdf

Singh, K. (2016). Microbial and enzyme activities of saline and sodic soils. *Land Degradation and Development*, *27*(3), 706–718. https://doi.org/10.1002/ldr.2385

Thiruneelakandan, R., & Subbulakshmi, G. (2014). Vermicomposting: A superlative for soil, plant, and environment. *International Journal of Innovative Research in Science, Engineering and Technology*, *3*(1), 930–938. Retrieved from http://www.rroij.com/open-access/vermicomposting-a-superlative-for-soil-plantand-environment.pdf

Walpola, B., & Wanniarachchi, S. (2009). Microbial respiration and nitrogen mineralization in soil amended with different proportions of vermicompost and coir dust. *Bangladesh Journal of Agricultural Research*, *34*(4), 537–543. https://doi.org/10.3329/bjar.v34i4.5830

Wiedenfeld, B., & Enciso, J. (2008). Sugarcane responses to irrigation and nitrogen in semiarid South Texas. *Agronomy Journal*, *100*(3), 665–671. https://doi.org/10.2134/agronj2007.0286

Yourtchi, M. S., Hadi, M. H. S., & Drazi, M. T. (2013). Effect of nitrogen fertilizer and vermicompost on vegetative growth, yield and NPK uptake by tuber of potato (Agria CV.). *International Journal of Agriculture and Crop Sciences*, *5*(18), 2033–2040. Retrieved from https://pdfs.semanticscholar.org/8e2b/ea9751e01ba256be02382eb2cae139124151.pdf